Canadian Nuclear Safety Commission | Commission canadienne de sûreté nucléaire

CMD 26-H7.39-Ref3

Date: 2026-08-12

Reference from the Canadian Environmental Law Association

In the matter of

Ontario Power Generation

Application to refurbish Pickering Nuclear Generating Station and to renew licences for the Pickering Nuclear Generating Station and Waste Management Facility

Commission Public Hearing
Part 2

October 2026

Référence de l'Association canadienne du droit de l'environnement

À l'égard de

Ontario Power Generation

Demande concernant la réfection de la centrale nucléaire de Pickering et le renouvellement de ses permis pour la centrale et l'installation de gestion des déchets

Audience publique de la Commission
Partie 2

Octobre 2026

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VOLUME 3

Canadian Environmental Law Association
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DURHAM NUCLEAR AWARENESS, SLOVENIAN HOME ASSOCIATION & THE CANADIAN ENVIRONMENTAL LAW ASSOCIATION

APPENDIX B: SUPPORTING DOCUMENTS FOR SUBMISSION TITLED:
"***Comments on the Ontario Power Generation's Application to Refurbish Pickering Nuclear Generating Station Units 5–8 and to Renew the Pickering Nuclear Generating Station and Pickering Waste Management Facility Operating Licences"***

(Ref. 2026-H-7)

August 12, 2026

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Emergency Planning at the Pickering Nuclear Generating Station



Submission by Canadian Environmental Law Association

Theresa McClenaghan, Executive Director and Counsel

May 3, 2013

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Hearing Ref. 2013-H-03

Pickering Day Two Hearing to renew and merge the Pickering A and B operating licences

Canadian Environmental Law Association: Review and Submissions on Emergency Planning at the Pickering Nuclear Generating Station

May 3, 2013

Dear Ms. Levert:

The Canadian Environmental Law Association requests to Intervene at the Day Two Hearings in the above-referenced matter. Please find attached our submissions in respect of our review of emergency planning at the Pickering Nuclear Generating Station.

Theresa A. McClenaghan

Executive Director and Counsel

Canadian Environmental Law Association

Overview of Contents:

Summary of Recommendations

A. Introduction

B. Review of Emergency Planning Issues At Pickering

C. Safety

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E. Siting

F. Community Engagement

G. Regulatory Oversight / Decision of the CNSC

H. Conclusion and Recommendations

I. Decision Requested

SUMMARY OF RECOMMENDATIONS:

- **RECOMMENDATION 1:** CELA submits that this licence should not be granted until all of the measures list by OPG in its application in Appendix 6, along with other recommendations made by the 2011 IRSS Report, the 2011 CNSC Fukushima Task Force and recommendations herein are actually in place and demonstrated to the regulator, with evidence, to be effective. CELA also submits that it is critical that this evidence be made public. Members of the surrounding communities must be able to understand what is in place; how effective it is; what has changed; and on what basis the regulator is judging the emergency plans to be in place.

- **RECOMMENDATION 2:** CNSC should require multi-unit severe accident planning to be demonstrated by OPG, along with the effectiveness of off-site emergency response in such a case. Similarly, CNSC should ensure, contrary to previous practice, that extreme natural hazard initiated events and "gross human error" are also examined in terms of presenting an emergency planning basis, and that the on-site and off-site emergency preparedness and planning are demonstrated to be sufficient and reliable to respond to all of these undesirable scenarios in the event that they lead to severe offsite releases.

- **RECOMMENDATION 3:** CELA recommends that this post-accident source term information be required by the CNSC as a condition of licensing and that the CNSC require OPG to upgrade their capacity to provide source term information and its basis, for multi-unit accidents, as a condition of the Pickering NGS licence. This should include reassessment of plume and dose modelling for multi-unit accidents at the Pickering NGS as recommended by the Fukushima Task Force.

- **RECOMMENDATION 4:** CELA recommends that the CNSC should require the licensees to demonstrate that there are, in place, properly resourced, sufficiently detailed emergency planning and preparedness plans that would address Chernobyl–size accidents or Fukushima–size accidents. The basis for this recommendation includes world-wide experience with these catastrophic accidents. This recommendation is independent of particular event sequences and rather takes account of the myriad ways that things that can go wrong resulting in an accident and resulting in a serious breach of containment, regardless of how caused. It also includes consideration of the fact that among the events that may initiate a catastrophe at a CANDU are those that are beyond the control of the operator such as hostile action or unforeseen external weather events or unforeseen combinations of failures including human error.

- **RECOMMENDATION 5:** The authority of Toronto Emergency Planning Officials to immediately initiate the Public Alerting System upon receipt of a notification from OPG for a general emergency with an imminent or ongoing emission should be clearly specified. If it is not intended that this authority be provided to Toronto's officials under the TNERP, this should be stated with a rationale for the discrepancy compared to the DRNERP.

- **RECOMMENDATION 6:** CELA recommends that the CNSC refuse further extension of Pickering's operating licence without the 3 km and 10 km alerting systems fully functional, both within the Region of Durham and within the City of Toronto, with robust evidence that they have been fully tested and are effective to meet the objectives specified in the PNERP, 2009.

- **RECOMMENDATION 7:** CELA also recommends that the emergency response plans time-frames be compressed so as to provide alerts to the public, and instructions to the public on protective actions required in as short a time frame as possible, preferably less than 30 minutes from the onset of the accident. Methods to compress this time frame should be considered and tested, and their efficacy should be one of the points of evaluation by the CNSC in the licence applications by the operators.

- **RECOMMENDATION 8:** CELA recommends that as an interim measure, the CNSC should require that OPG in conjunction with the City of Toronto, conduct outreach and

notification to members of the public resident in Toronto (at a minimum within the Primary Zone), as to the availability of KI and provide advice as to where it may be obtained.

- **RECOMMENDATION 9:** The applicability of Durham's Annex D to the residents of Toronto in the Primary Zone must be clarified. Alternatively, the same provisions for KI distribution, consent and information letters for school age children, and other matters dealt with in Annex D must be specified in the TNERP.

- **RECOMMENDATION 10:** CELA recommends that the CNSC should require the operator to systematically evaluate and report back to the CNSC the percentage of households within the 10 km Primary Zone, both within the Region of Durham and the City of Toronto, who have obtained KI tablets in advance, as well as the percentage of institutions covered by the plan who have them on hand in sufficient quantities to cover all of their residents or students. Based on this evaluation, CELA recommends that the CNSC require the approach that was taken in France be taken in Canada for the 10 km zone around each operating nuclear generating station, to undertake and ensure 100% pre-distribution of KI tablets to the residents in the Primary Zone and that this requirement be included in the licensing conditions for the Pickering NGS.

- **RECOMMENDATION 11:** CELA recommends that the CNSC require OPG to include in its outreach material to the public, in conjunction with regional emergency response officials, explanations about the capability of sheltering and its limitations as described in the IAEA Guide GS-G-2.1 and to reinforce instructions as to steps to take for rapid and effective evacuation in the case of notification of a significant emergency.

- **RECOMMENDATION 12:** CELA recommends that the Pickering Operating licence should not be extended without the Provincial Radiation Health Response Plan and the municipal Radiation Health Response Plans in place.

- **RECOMMENDATION 13:** CELA recommends that in view of the experience at Chernobyl and Fukushima, the CNSC should request that the province immediately revisit the 50 km secondary ingestion zone with a recommendation to change it to 100 km. This should be done as part of detailed planning for severe offsite accidents so that appropriate monitoring of food, agricultural products, milk, and water is established and in place in the event of such an accident.

- **RECOMMENDATION 14:** CELA recommends that the CNSC require that the nuclear emergency planning zones be expanded. CELA submits that the 10 km Primary zone should be extended to 30 km and the 50 km Secondary zone should be extended to 100 km.

- **RECOMMENDATION 15:** CELA recommends that the CNSC should require OPG to work with the local municipalities to ensure the public clearly understands what plans are in place to assist them with evacuation from the Primary Zone if they do not have their own transportation. The details of those plans should be clearly specified in the Durham and Toronto Nuclear Emergency Plans, and widely communicated to the public in outreach and education.

- **RECOMMENDATION 16:** CELA recommends that the CNSC should require OPG to communicate to the public in annual outreach and education, the fact that the nuclear emergency response plans expect the public to make their own arrangements in the event of evacuation, and for those who cannot, what is expected to be provided by the municipalities. The appropriateness of this approach should further be discussed with the public in terms of future nuclear emergency planning.

- **RECOMMENDATION 17:** CNSC should require OPG to conduct studies and to work with offsite emergency responders, the municipalities and the Province to ensure that there are realistic evacuation plans in the case of a severe accident with early large release, as well as in the case of plans for twenty kilometer and 50 kilometer evacuation zones around the Pickering NGS.

- **RECOMMENDATION 18:** CELA recommends that the CNSC require the applicant to conduct a study as to the awareness of the Pickering Nuclear Plant of people beyond the Primary Zone at Pickering, and as to their likely response in the event that a general emergency is declared and the Primary Zone is evacuated. The CNSC should require the applicant to evaluate the impact of increased evacuation zones of twenty and fifty kilometers on evacuation time estimates, as well as any other needed adjustments that would result from larger evacuation zones to the emergency plans surrounding Pickering such as locations of Emergency Workers Centres, numbers of emergency workers required for evacuation management, traffic routes, size of evacuation centres, and locations and capacity of Decontamination and Monitoring Units, and to report its findings to the CNSC and to the provincial EMO, the City of Toronto, and the Region of Durham.

- **RECOMMENDATION 19:** CELA recommends that CNSC direct the applicant to work with the municipalities to consult with the surrounding communities on specific plans for family reunification following evacuation in the event of a severe nuclear emergency.

- **RECOMMENDATION 20:** Explanations about what “self-decontamination” means; how to do so; and a statement as to its efficacy should be included in the Toronto Nuclear

Emergency Response Plan and in outreach and education to the public about implementation of the plan.

- **RECOMMENDATION 21:** The CNSC should confirm that OPG's automatic gamma monitoring is in place at Pickering, and require the automatic exchange of its data with the regulator as suggested by the IRSS and Fukushima Task Force reports.

- **RECOMMENDATION 22:** CELA recommends that the CNSC request that the Provincial Nuclear Emergency Plan expand its monitoring provisions and ingestion control zones to a distance of 100 km from the NGS, and that the province undertake appropriate measures to ensure that monitoring can be done following an accident within that 100 km zone for agricultural produce, foodstuffs, milk and water.

- **RECOMMENDATION 23:** CELA recommends that the DNERP, 2011 should explicitly outline the measures in respect of controlling ingestion food and water that may be required in the case of a severe nuclear emergency of the type outlined in ICRP Publication 109.

- **RECOMMENDATION 24:** Risks of exceeding maximum exposure limits must be discussed with workers in advance of any accident. Methods to review risks and obtain consent to exceed those limits should be explicitly clarified in the Durham Plan. Similar provisions must be included in the Toronto Plan if it is intended that there may be emergency or other workers who volunteer to exceed maximum exposure limits during an emergency.

- **RECOMMENDATION 25:** The Fukushima Task Force / IRSS recommendations to establish additional dose limits for workers during and following nuclear emergencies in Canada should be addressed by the CNSC as soon as possible.

- **RECOMMENDATION 26:** CELA recommends that the CNSC should require annual conduct of exercises dealing with full scale severe event multi-unit accident scenarios along with conclusive demonstration of their effectiveness as a licence condition for the Pickering NGS. Furthermore, the CNSC should require inclusion of members of the surrounding community and public interest organizations so as to increase input into and confidence in the results. CELA also recommends that their results should be made public, along with lessons learned, and improvements recommended as a result of the exercises; and that the CNSC should require reporting of implementation of those improvements on an annual basis as part of the oversight that it should undertake with respect to offsite emergency planning.

- **RECOMMENDATION 27:** The response times required by these IAEA Safety Requirements and Guideline documents GS-R-2 and GS-G-2.1 should be included in the Provincial and municipal emergency plans for Pickering. In particular, the CNSC should require that these response times are met and demonstrated as part of its licensing decision for the Pickering NGS.

- **RECOMMENDATION 28:** CELA submits that the CNSC should not grant the licence to OPG beyond the current licence period without verifying "through tests and assessments" the adequacy of the emergency plans in place for the Pickering NGS, both on-site and off-site, to respond to severe nuclear emergencies.

- **RECOMMENDATION 29:** CELA submits that even without additional regulatory amendments recommended by the Fukushima Task Force and the IRSS, the CNSC already has jurisdiction to consider the adequacy of the emergency plans in place at Pickering in deciding whether to issue the licence requested, and/or whether to impose additional requirements by way of licence conditions to better protect health, safety and the environment. (Sections 3, 9, 24 of the *Nuclear Safety and Control Act*, S.C., 1997, c. 9)

- **RECOMMENDATION 30:** CELA urges that the Fukushima Task Force recommendations for CNSC oversight of the offsite nuclear emergency response plans be pursued forthwith by way of amendment of the CNSC regulations and requirements there-under. This particularly includes the recommendation for description of the regulatory requirements to address radioactive hazards during an emergency **in greater detail**. This also includes the recommendation of the Task Force to enhance regulatory oversight with periodic safety reviews and to increase requirements for "requirements and expectations for both design basis and beyond design basis accidents``.

A. INTRODUCTION

This application concerns a request by Ontario Power Generation to the CNSC to renew its operating Pickering NGS licence for five years, as a combined licence for Pickering A and Pickering B. This time frame will take the plant beyond its design life for the Pickering B units. These are the oldest operating nuclear power reactors in Canada. The original Pickering Generating Station licence application to operate Unit 1 was submitted to the then Atomic Energy Control Board on August 14, 1970; the construction permit had been issued February 24, 1966. The original application to operate Unit 5 was

submitted to the then Atomic Energy Control Board on May 6, 1980; the original construction permit had been issued July 19, 1974.

In this submission, CELA reviews the proposal to extend the Pickering Nuclear Power Plant station operating licence for the next five years, and in particular, the proposal to extend its operations beyond the design life of the pressure tubes (and other components) which is intended by OPG for this licence term and one more licence term thereafter. CELA's focus is on the question of whether the CNSC should grant this licence in light of the question of the adequacy of emergency planning at the Pickering site, and in light of the size of the population in the vicinity of the Pickering site. In particular, CELA will compare both emergency planning and siting issues to international nuclear standards and guidance, as well as to international experience and independent reviews as to the requirements for emergency planning. Some of the post-Fukushima lessons learned that are so far available will be particularly important in CELA's review.

CELA will also provide comments on the role of the CNSC as regulator in respect of emergency planning in response to Nuclear Power Plant threats and will urge the CNSC to exercise a stringent oversight role as to whether emergency planning and preparedness has been proven prior to exercising its discretion to provide a further operating licence to the Pickering NGS. In particular, CELA will submit that emergency planning and preparedness has not been sufficiently demonstrated with any adequate amount of detail in respect of severe "Beyond Design Basis Accident" offsite accidents that may occur at the Pickering NGS such as occurred at Fukushima and Chernobyl. While effort and planning has been expended in respect of "Design Basis Accidents", there is a long history of downplaying the likelihood of very severe accidents that may result in serious and extensive offsite contamination and consequences. Accordingly the level of emergency planning and preparedness is insufficient, with only very generalized plans so far in place, in particular beyond the 3 and 10 km response zones. Furthermore, even within the 10 km zone which has traditionally been considered in the Pickering emergency planning, CELA will submit that the level of response and preparedness is inadequate.

For example, the requirements for alerting are not even fully in place in that 10 km zone despite decades of plant operation, and there has not been sufficient preparation for the evacuation that would certainly occur "voluntarily" (as the industry puts it), beyond the 10 km zone. Even for the population within the 10 km zone, the time frame for evacuation, depending upon sector and scenario extends between 4 and 37 hours for complete evacuation. In the case of early large release of radionuclides in a severe accident, we argue this extended evacuation time frame would cause an unacceptable impact to people in terms of the gamma radiation and other potential radiation exposure while the evacuation is underway. In the meantime, "sheltering in place" would provide only limited assistance, depending on the radionuclide release scenario, time frame for the release of a radioactive plume, and type of building that people are "sheltering" inside. Another example of the insufficiency of preparedness for a severe

accident is the lack of pre-distribution of KI, and the insufficient quantities of KI in stock compared to the population even within the 10 km zone.

CELA will also argue that the population in the vicinity of the NGS, both within 10 km, as well as within 20 km and 30 km must be much more engaged, informed, and involved in all aspects of emergency planning in respect of accidents that could occur at the Pickering NGS. For example, it has been CELA's anecdotal experience that many residents of Durham region are unaware of provisions in the Nuclear Emergency Response Plan that anticipate that they will find their own accommodation with friends and family in case of evacuation; that they may be asked to "self-decontaminate" in some scenarios, and what that means; that KI is effective only if taken before or immediately upon commencement of a release; they are unaware of the transportation plans that would be available if they do not have their own vehicles; and they are concerned about family reunification in the event of evacuation scenarios in which members of their family are evacuated separately from the family such as from schools and long term care institutions.

In preparation for this review, and building upon detailed review of emergency planning for the Darlington refurbishment, CELA has collected and collated an extensive collection of relevant emergency planning standards, guides and documents from international, national, provincial and municipal sources. These materials will be available in the library of the Resource Library for the Environment and the Law, housed at CELA's offices after the May, 2013 Day Two Hearing of this Application. They are indexed and catalogued and the catalogue will be available online at www.ecolawinfo.org. In addition this particular index of nuclear emergency planning standards and documents will also available online on CELA's website at www.cela.ca . CD's of these documents and hard copies are now housed in the library which is open to the public (prior contact with CELA is advised to ensure that the library is not in use for meetings at the time of the visit).

CELA undertook this project after finding in earlier work that the necessary documents pertaining to emergency planning for nuclear power plant accidents are widely scattered and it did not appear that there was any single location where they were all housed together. The assembly of these materials, from international through to local, permits us to provide more comprehensive and documented comment on the sufficiency of emergency planning for the Pickering life extension. However, CELA also wanted to build on the work it earlier did for the Darlington refurbishment EA on the topic of emergency planning, and in turn, this collection will assist greatly in future comment on this topic in other licence applications relating to nuclear power plant operations. This work was supported by an award by a CNSC funding panel for this Application. This allowed CELA to undertake a short term contract with project counsel Kyra Bell-Pasht to examine and obtain the international, U.S., Canadian, provincial and municipal emergency planning standards and guidance documents. CELA is also in the process of supplementing this collection of current materials with historical materials as to some of the origins of the decisions relating to emergency planning preparedness in Canada and in Ontario in particular. This

latter process will be ongoing beyond the timeframe of this hearing into the current Pickering NGS licence application, but we believe it is of assistance to attempt to discover why some of the historical decisions were made as they continue to significantly influence current approaches to emergency planning (despite the lessons of Chernobyl and Fukushima).

CELA hopes that future approaches to emergency planning and preparedness in Canada will be significantly augmented in light of the Fukushima accident, and one of the early lessons from that accident which has been widely noted by Japanese officials and others, is that very severe accidents were not given sufficient credit and thus were not taken seriously; a state which strongly influenced emergency planning. Several of the reviews of the accident so far, including the review of the Japanese Diet Independent Commission noted that the lack of sufficient emergency planning was a significant contributor to the consequences of the accident.

CELA wishes to point out that in our opinion there are significant comparables between the regulatory and industry environment and attitude in Japan pre-Fukushima and elsewhere among "western" nuclear power operating states, including Canada. One of the significant findings of the Fukushima accident which was echoed in a recent IAEA conference on nuclear regulation post Fukushima (hosted in Ottawa by the CNSC) was that public confidence in the industry and the regulator are essential, but these were severely harmed during that accident by lack of transparency and credible information.

It is ironic that in building the repository of historical documents as to the basis of the emergency planning basis in Ontario, CELA had been advised by Emergency Measures Ontario that it must seek certain requested historical documents (i.e. Working Group #3 Report on the basis of emergency planning) through Ontario's Freedom of Information and Protection of Privacy Act. This would certainly have delayed provision of these documents beyond the time frame of this licence hearing. Fortunately colleagues at Greenpeace Canada were able to obtain copies of the Working Group 2 and Working Group 3 reports from their storage for CELA. CELA objects to the position taken by Emergency Measures Ontario which directed us to use FOI to obtain this document which is an integral aspect of understanding the basis for emergency planning in Ontario. Furthermore it is explicitly referenced in the current Provincial Nuclear Emergency Plan, 2009 as providing the basis for the Protection Action Levels set out in that Plan.

CELA is of the view that this issue of the basis for emergency planning is of significant public import and will persist in seeking additional historic materials and will include them in the emergency planning document collection that will be available in our library.

B) REVIEW OF EMERGENCY PLANNING AND PREPAREDNESS ISSUES AT PICKERING

1. Emergency Planning Introduction

The necessity for sufficiently detailed Emergency Planning and Preparedness is the reality that if there were a catastrophic accident at one of Ontario's nuclear power plants, widespread health, safety and environmental consequences would be expected unless immediate and effective steps were taken for public protection. For example, as long ago as 1988, Commissioner Kenneth Hare reported in The Safety of Ontario's Nuclear Power Reactors (Ontario Nuclear Safety Review, 1988) that the health effects from a catastrophic accident at the Pickering nuclear power plant could amount to 37.5 prompt fatalities; 6011 early injuries; and 9,700 cancer deaths if most of the fission product inventory escaped[1] and a plume was directed across Metropolitan Toronto (at page 162, Table 15). In such a catastrophic scenario these numbers would be increased today as a result of population growth.

The aim with emergency planning and preparedness should be to avoid as many of these health effects as possible[2]. This can only be accomplished if the emergency planning is designed and implemented so as to be effective in such a catastrophic case. Hare stated on this point that "the most significant result {from the sensitivity analysis of the accident scenarios discussed} was that "prompt use of emergency measures, such as evacuation, greatly reduces both health and economic consequences." (At page 163)

For the reasons that follow, CELA has serious concerns about the sufficiency of the emergency planning and preparedness in place surrounding the Pickering NGS.

[1] The Hare report also describes the assertion that the "probability of losing a high fraction of radioactive inventory from a CANDU reactor core is much lower" than from a Pressurized Water Reactor; however the report also notes that "there may be other beyond-design-basis accidents that will involve serious consequences going well beyond those discussed in this chapter." At page 163, Hare, Vol. 1, 1988

[2] A very surprising, and in CELA's view, unacceptable, additional justification of nuclear emergency response planning and preparedness in Ontario was set out in the 1987 Ministry of the Solicitor General Brief to the Hare Commission, which stated that in addition to safeguarding health, safety and well-being of the people of Ontario in the event of a nuclear accident, the other reason was "To protect Ontario's large investment in its nuclear industry by, firstly contributing to the maintenance of public support for the program, and secondly, in case of an accident, minimizing the possibility of adverse public reaction afterwards, by demonstrating and ability to effectively protect people from harm and risk." (Hare Commission, 1988, Vol. 1 at 227)

2. **Size of Accident and Basis of Emergency Planning at Ontario's Nuclear Power Plants including the Pickering NGS**

- CELA submits that the CNSC should require and verify that Ontario's nuclear emergency planning and preparedness will be sufficient to respond to, and significantly mitigate the consequences of a catastrophic accident such as those that occurred at Fukushima in 2011 or Chernobyl in 1986. It is important that OPG be able to plan for its on-site response in the case of a catastrophic accident in order both to undertake significant accident management and undertake mitigation, but also to work with offsite authorities in supporting the emergency response off-site.

- The reason that the size of the accident matters as a design basis for emergency planning is that the calculated consequences to be averted are wildly divergent in a catastrophic scenario compared to the Design Basis Accident scenario. This directly affects emergency planning decisions and whether specific emergency preparation and planning measures are considered "worthwhile" by the planners. Accordingly if a lower size accident is used for planning, fewer resources, less detail, and less preparation results. This has been the case in the past in Ontario's nuclear preparedness. Post-Fukushima it is essential that changes be made forthwith to this approach.

- A stark example of the difference in consequences that may be calculated depending on the size of the accident assumed for emergency planning was demonstrated in the Hare Commission Report (Ontario Nuclear Safety Review 1988) noted above.[3] The lower releases predicted by the design basis scenario result in far lower consequences and we submit, appear to have motivated the operator, provincial authorities and even the regulator to accept planning for a far less serious accident than the catastrophic scenario.

[3] Other estimates demonstrate an even greater range depending upon the scenario. Peter M. Fraser, in Vol. II, App. II to the ONSR, "A Review of the Design-related Aspects of the Safety of Ontario Hydro's Nuclear Generating Station", reviewed the Lonergan et al and the Ontario Hydro estimates of possible consequences that had been commissioned and submitted to the ONSR. He summarized, after comparing assumptions, rebuttals etc., that depending upon weather conditions, prompt fatalities from a severe accident could range from zero to a few thousand; latent cancer could range from a few hundred to as many as 13,000; and economic damage could range from a low of $100 million in favourable weather conditions to as high as $12 billion (and he noted that this figure is consistent with Ontario Hydro estimates); the figure would be higher if stricter decontamination levels were used. (at II/138) (Figures 1987 dollars.)

- The International Atomic Energy Agency conducts regular "missions" among regulators of nuclear power around the world, reviews their regulatory programs, and makes recommendations to the regulator. There was an IAEA Integrated Regulatory Review Service (IRSS) review conducted in Canada from November 28-December 9, 2011 (this was a follow up to an earlier mission)[4]. That IRRS 2011 report noted (page 63) that a post-Fukushima task force established by the CNSC examined accidents more severe than those previously considered credible by CNSC and that accordingly the design basis for certain stations needs to be updated. It stated with approval that the task force made 13 recommendations dealing with defence in depth and emergency preparedness. (The Fukushima Task Force[5] recommendations will be further reviewed and referenced herein.)

- OPG indicates it is required to maintain an emergency response plan for an on-site response to a Design Basis Accident – this is defined as a "loss of coolant accident with one contaminated casualty" – see Document P-Corr-00531-03669, the December 21, 2011 Sustainable Operations Plan for Pickering A and B.[6] The May 30, 2012 Ontario Power Generation document, "Emergency Response Organization Staffing Basis for Responding to Design Basis Accidents" outlines some of the history of the selection of a "design basis" for emergency planning at the Pickering NGS (as well as Darlington). It reinforces the point that the emergency planning approach by OPG (formerly OH) has for decades been to respond to a design basis accident (although the authors failed to find a documented rationale for the choice of accident). Much of the history reveals that OPG, and before it OH, was of the view that emergency planning on-site for a severe accident beyond design basis was unnecessary because of the "low probability" of such accidents; furthermore much of the history demonstrates that OH was making submissions and representations that it was not necessary to plan for a beyond design

[4] IAEA-NS-IRSS-2011/08 Report of Integrated Regulatory Review Service (IRRS) Follow Up Mission to Canada, November 28 – December 9, 2011 (Department of Nuclear Safety and Security, IAEA).

[5] CNSC Fukushima Task Force Report INO 0824 (CNSC, October, 2011).

[6] Ontario Hydro 1993a Materials Relating to Environmental and Health Effects of Nuclear Generation. Ontario Hydro, and Ontario Hydro 1993b Overview of Ontario Hydro's Nuclear Generation Program, Appendix 4 prepared for Nuclear Liability Act trial, 1993.

basis accident. See Document N-REP-03490-0432605 and the literature review conducted therein.[7]

- The tendency of public authorities to accept that accident planning proceed on the basis of less severe accidents was evident in the 1988 Hare report when the Commissioner reported that there was a "widely shared belief that a severe accident in Ontario is unlikely and that money should not be spent in large amounts on structures that will probably never be used." (Hare, 1988, Vol. 1 at 169) Commissioner Hare continued in his comments to disagree with this view and to state that "a severe accident is indeed unlikely, but the province must equip itself to deal with the possibility--and with the overspill from any severe accident on the US side of the border." (Ibid p. 169)[8]

[7] See also Overview of Ontario Hydro's Nuclear Generating Program, May 1, 1993, Appendix 4, "Emergency Preparedness." (Ontario Hydro, 1993, Prepared for Nuclear Liability Act trial). That document noted that "the most common approach in establishing a basis {for emergency preparedness} is to estimate the consequences of postulated accidents and then introduce an emergency preparedness safety factor. Ontario Hydro evaluated the consequences of postulated accidents in a report entitled "The Assessment of Radiation Dose to the Public Arising from Postulated Accidents at Pickering NGS as an input to Emergency Planning." – (cited in the footnote as Dinnie, K.J., et al, Ontario Hydro Nuclear Studies and Safety Department, Report No. 85088, Feburary 1985.) CELA will obtain this document to include in its archive of Nuclear Emergency Planning documents as part of the history of the basis for nuclear emergency planning in Ontairo.

[8] This was still an issue for Dr. Paul Rosenberg when he testified in 1993 in evidence at a trial dealing with the federal Nuclear Liability Act that Working Group 8 had been called to consider greater accidents than the "maximum planning accident" post Chernobyl, and to make recommendations about the planning basis. They considered the "worst credible radioactivity emission" and recommended it be the basis for planning, not for long term consequences, but for early response. Dr. Rosenberg stated that the decision rested with the Solicitor General of Ontario and cabinet, to increase the design accident, and as of that date (1993) that had not happened. He also stated that Ontario Hydro had actively resisted increasing the planning basis and they had argued that due to the low probability they calculated (less than one in a million reactor years), resources be better used for primary prevention, operator safety and the response and planning already done. At page 939-40 of Dr. Rosenberg's testimony Nov. 3, 1993. (Working Group #8 was established by the Ontario cabinet, to advise on an upper limit for detailed emergency planning and preparedness in Ontario, whether any consequence mitigation measures needed to be adopted as a result of the upper limit recommended in addition to the PNERP, and in recommending an upper limit to consider "not only a scientific assessment of the risks of various types of accidents, but also risk, such as those due to hostile action, which cannot be scientifically assessed... probably effectiveness of emergency improvisation, safety margins, and any other factors..." Working Group #8, 1988 at 12). It appears to CELA on the basis of documentation we have been able to find, obtain and examine, that even Working Group 8`s recommendations never were adopted by the Ontario cabinet; and the province continued its planning based on a less severe accident as planning basis.

- The Provincial Nuclear Emergency Response Plan, 2009, uses as a "Basis of Planning" a "basic offset effect to serve as the main basis for nuclear emergency management." It states that the rationale is because of the "inverse relationship between the probability of occurrence of an accident and the severity of its likely consequences" and that "judicious choice must be made" to select the basis of planning since resources are not available for all possible events. (At 2.3) The basic offsite effect accident is described in the PNERP, 2009, as characterized by one or more of : i) a warning period before offsite effects occur; ii) main hazard from external exposure and inhalation of radionuclides; iii) doses would be low (not over 250 mSv at plant boundary); iv) very low level environmental contamination; v) low level radioactive emissions to environment over some time – days or weeks; vi) impact confined to the Primary Zone (10 km). (At 2.3.3 (b)) The PNERP, 2009, states that "**detailed** planning and preparedness shall be carried out in Ontario for dealing effectively with the basic offsite effect of a nuclear installation accident. The aim of this is to ensure, to the extent possible, that no person offsite will be exposed to intolerable levels of radiation as a result of such an accident." (At 2.3.3. (c)) (emphasis added).

- The PNERP, 2012 states that, with low probability, an accident could occur "which could result in a more severe offsite effect." It is defined as one or more of: i) the time between the accident and release of radioactivity may be generally limited {also sometimes described in other regulatory and industry documents as "early release"}; ii) radiation doses could be high, greater than 250 mSv at the plant boundary; iii) radioiodines and particulates could form a component of the radioactive emission; iv) environmental contamination could be significant; v) area affected could be larger than for the basic offsite effect. (At 2.3.3 (d)). For these more severe but less probable accidents, the province outlines a limited number of issues for which to undertake preparedness: " i) timely public alerting and direction; ii) prioritizing evacuations for those closest to the hazard; iii) radiation monitoring and if necessary, decontamination; if needed, medical assessment, treatment and counselling." (At 2.3.3.(e)) The PNERP states that the detailed planning and preparedness "will establish an effective basis to deal with an emergency caused by any type of nuclear installation accident." Despite this provision, CELA is concerned that this detailed planning is not yet in place for a very severe catastrophic accident as discussed throughout this submission. For example, the inability to assess the extent to which the province and emergency responders are prepared to deal with item iv) because of the lack of available Radiation Health Plans is one indicator that the province still does not have that capability in place. This is discussed further later in this submission.

- This level of planning for less severe accidents arose as a result of the recommendations of Working Group #3, tasked by the Solicitor General in Ontario to advise on the "extent to which planning should be conducted, in any detail, in preparation for an accident at a nuclear generating station as a result of which radioactive material in excess of normal amounts is emitted from the station." Working Group #3 stated that it had not "attempted to define the worst possible accident", saying that "worse accidents appear so unlikely that it would appear to be uneconomical to plan for them." (at 4) It is important to note expressly that Working Group #3 took comfort from the lack of empirical data with few observed accidents to that point with severe radiological consequences – as it met in 1984, its deliberations preceded the Chernobyl accident of 1986, and of course, the Fukushima accident of 2011. Working Group #3 noted at that time that "no one can put hard numbers on probabilities of accidents with severe consequences; and that risk estimates are just that – estimates." (at 5)[9] It is also critical to notice that Working Group #3 stated that its comments that the Ontario plants were performing "better than design basis" were made at a time when there was not yet experience with aging and that Ontario would have to "watch the situation closely and if it appears necessary modify its plans accordingly." (at 11) Furthermore, Working Group #3, on which PNERP, 2009's Protection Action Levels is stated to be based, turns out to have based its assumptions on more optimistic views of worldwide nuclear reactor safety than reality. It stated that "we recommend 250 mSv at the plant boundary, recognizing the experience in the future may cause this to be modified either way." (at 14)

[9] Now that we have unfortunately had world-wide empirical evidence as nuclear power plant accidents, there is an empirical basis for estimation of the observed frequency of severe accidents with offsite consequences. CELA submits that the observed frequency of severe catastrophic accidents overwhelms the justification to base emergency planning on the severe accident "probability" calculations which are inherently fraught. With this level of **observed** severe accident frequency, it is imperative that any jurisdiction choosing to continue operating nuclear power plants is obligated to provide accident planning and preparedness that would realistically respond to such accidents with sufficient resources, specificity and realism to be effective at significantly reducing consequences. Continued reliance on the argument that such accident planning should not be pursued because it is costly must be discontinued. Arguments that such planning is not "cost-effective" relies on probability estimates that have been proven false given empirical accident experience. Continued maintenance of such arguments unsupportably places the real risks of serious harm from such accidents on innocent bystander members of the public.

- CELA submits that the acceptance of less severe accidents as an emergency planning basis for detailed planning is a fundamental error in energy policy and regulatory oversight. It was based in part on early operating experience when the plants were newer and there were fewer "reactor years" of operation, and in part on questionable probability calculations. CELA submits that the planning basis must now be revised based on real-world experience. CELA requests the CNSC to require detailed emergency planning and preparedness, including requiring the operator and emergency planning authorities to undertake updated severe accident consequence calculations, with the emergency plans to be submitted to the CNSC for evaluation as to their effectiveness in a catastrophic scenario, along with a judgment as to whether to approve continued operation of the site in accordance with that evaluation. At this time, and until such emergency plans are in place and proven to be effective for a catastrophic accident, the site should not be licensed for continued operation.

- The attitude in which lower levels of preparedness have until this point been accepted in Ontario is reminiscent of that described at an IAEA Regulator`s Conference hosted by the CNSC in Ottawa in April 2013, at which Toshimitsu Homma of the Japan Atomic Energy Agency stated in a Conference Panel on Emergency Management that the most important lesson of Fukushima was that before the accident, ``There was an implicit assumption that such a severe accident could not happen and thus insufficient attention was paid to such an accident by authorities.``[10]

[10] It is all the more concerning that a less severe accident - i.e. the LOCA with one contaminated casualty, as opposed to a severe offsite or catastrophic accident – has been used as the basis for detailed emergency readiness by OPG and emergency planners in Ontario given that almost identical statements were made by the Porter Royal Commission on the Electric Power Planning in the Commissioner's concluding report where under the title of "Mind-Set Syndrome", he quoted the Presidential Commission on the Three Mile Island accident which occurred in 1979. The TMI Commission noted that "the belief that nuclear power plants are sufficiently safe grew into a conviction.... The Commission is convinced that this attitude must be changed to one that says nuclear power is by its very nature potentially dangerous, and therefore, one must continually question whether the safeguards already in place are sufficient to prevent major accidents." The Porter Commission went on to state that "This syndrome, we believe applies in some degree to Ontario Hydro." These statements by the TMI Commission and the Porter Commission were made in 1979 and 1980. The lessons that were supposed to be learned at that time, according to the comments of Mr. Homma of Japan had apparently been forgotten, if they were ever truly internalized. Similar sentiments about Ontario Hydro's mind-set were expressed by Dr. Paul Rosenberg in his 1993 testimony when he testified that the first thing Ontario Hydro might do "would be to change their approach or their attitude towards serious accidents because they consistently use the maximum planning accident as the basis for their discussion with the regions, the municipalities, the province, and assure us that things are well planned for and under control." (at page 941). CELA has an ongoing concern that this type of "mind-set syndrome"

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2. **Current State of Emergency Planning Readiness at the Pickering NGS**

- In the July 4, 2012 OPG Application at issue here, Attachment 6 outlines the Fukushima Project Update. It indicates that "significant work" is proceeding to upgrade emergency planning in response to severe accidents, including multi-unit scenarios; further exercises are planned; "coordination enhancements" continue; Severe Accident Management Guidelines are being implemented in phases through 2014 and 2015, among other things;
  - OPG is working to establish a Regional Emergency Response Support Centre with "industry partners"
  - They are working on a mutual assistance agreement between utilities.
  - They have initiated planning for enhanced communication capabilities to support emergency response (with interim steps having been taken).
  - Drills are being planned to "ensure capability and readiness" to respond beyond design basis accidents, including severe accidents. (Attachment 6 to July 4, 2012 Application)

  This list indicates that a great deal of work remains to be done in order that OPG be in a position to respond to very severe accidents in terms of emergency planning and preparedness.

- A similar concern exists with respect to whether there is confidence in the ability of offsite emergency responders to respond to severe accidents with offsite consequences. For example the IAEA's Integrated Regulatory Review Service (IRRS) report post Fukushima (November – December 2011) called on the CNSC to do a "national assessment of nuclear power plant off-site emergency plan that includes all relevant organizations". (at page 10) It made a specific recommendation: "**The Government of Canada should assure** that the review and assessment of off-site emergency plans for nuclear power plants includes all relevant authorities, are comprehensive, and that the relevant organizations which implement those plans are capable of performing the assigned duties." (IRSS at Recommendation RF7). (emphasis added)

- **RECOMMENDATION:** CELA submits that this licence should not be granted until all of the measures list by OPG in its application in Appendix 6, along with other recommendations made by the 2011 IRSS Report, the 2011 CNSC Fukushima Task Force and recommendations herein are actually in place and demonstrated to the regulator, with evidence, to be effective. CELA also submits that it is critical that this evidence be made public. Members of the surrounding communities must be able to understand what is in place; how effective it is;

what has changed; and on what basis the regulator is judging the emergency plans to be in place.

- These issues are discussed further in subsequent sections of this submission.

3. **Level of Detail, Size of Accident, & Lack of Multi-Unit and Externally Initiated Event Nuclear Emergency Planning**

- The level of detail of Ontario's emergency planning and preparedness is a significant issue. CELA submits that the CNSC must ensure a level of detail with specified time frames, tested and verified, to respond to large offsite severe accidents. CELA submits that the current level of planning in Ontario beyond the 10 km zone has hardly exceeded what Commissioner Hare in 1988 called "a conceptual framework" that would "enable a response to be improvised should an emergency occur before all preparations are complete." (Hare, Vol. 1, 1988, p. 230)[11]
- As described earlier, beyond the "Basic offset accident" for which detailed planning is to be done, PNERP, 2009 provides that "appropriate additional planning and preparedness" shall be in place for the more severe offsite effects described in paragraph 2.3.3. (d) of the plan, namely: i) timely public alerting and direction; ii) prioritizing evacuations for those closes to the hazard; iii) radiation monitoring and, if necessary decontamination; iv) if necessary medical assessment, treatment and planning. (At 2.3.3. (e)). However, this is not detailed planning for a large scale accident, rather the Plan indicates that the detailed planning (presumably for the basic offsite effect accident) will

[11] The Working Group #3 report (1984) is explicitly referenced in PNERP, 2012 as the basis for selection of Protection Action Levels. That report was described in the Working Group # 8 report (1988) as background that had been conducted pre-Chernobyl. They stated that Working Group #3 recommended that "in the case of accidents which were in fact more severe than the MPA {Maximum Planning Accident}, authorities should be able to cope by improvising on the plans which would already be in existence based on the MPA." The MPA was recommended to be one that "gives a dose to an unsheltered person 1 km from the nuclear station (that is, the assumed boundary fence). The 25 rem {250 mSv} was stated to be based on the assumption of good engineering practice and the operating experience to that time, together with the particular properties of CANDU reactors, especially that the moderator could act as an additional heat sink in case of failure of both the normal and the emergency cooling systems (and so prevent severe core damage), and the belief that detailed planning was unnecessary for events of probability less than once per million reactor years in situations where there are about 10 reactors per power station." (Working Group #8 at 8-9, describing Working Group #3's recommendations).

"establish an effective basis to deal with an emergency caused by any type of nuclear installation accident."

- The CNSC Fukushima Task Force, 2011, confirmed that the PNERP, 2009 is "based on a single-unit accident and does not consider multi-unit accidents." (At 45.) The issue of the adequacy of the current emergency planning basis in Ontario was briefly discussed on December 3, 2012 hearings before the CNSC on the Darlington refurbishment application, when a witness[12] from Emergency Measures Ontario discussed their desire to have "a greater inclusivity of events beyond the normal planning horizon". Although they indicated they were satisfied with the responses provided by CNSC staff prior to that hearing in response to a letter[13] they had submitted to the CNSC, they also recognized "this isn't the last time we will be sitting here" and it was not the only opportunity they would have to continue to push what EMO thinks is really important regarding emergency management in terms of how to plan and how to exercise and how to modify the nuclear emergency plans going forward. She stated that they had discussed their concerns with CNSC and that they were "comfortable and were monitoring." In response to a question by the CNSC President about what EMO would be able to do by 2014 for the refurbishment continued operations licence, the witness further stated that they are in a process of evolution – and would want to present a provincial position that represents various aspects of planning that goes well beyond traditional planning scenarios. She commented that they would be working with all partners in that expanded view of the world. She looked forward to being able to speak to that at subsequent hearings and being able to identify any areas of concern as well as hopefully areas of significant progress.

- CELA has not seen evidence that more severe, beyond design basis severe accidents, initiated by a variety of severe external events such as hostile action, extreme weather events and others have been considered in Ontario as a basis

[12] Alison Stuart, ADM and Chief EMO, December 3, 2012, Darlington Refurbishment Hearing before the CNSC

[13] The letter is attached to CMD 12-H13.A in the Darlington Refurbishment and Continued Operations EA CNSC hearing.

for emergency planning[14]. Similarly, CELA has not seen evidence that the consequences of multi-unit events have been considered in Ontario as a basis for emergency planning. To the contrary, the CNSC Fukushima Task Force Report 2011 stated that none of the nuclear power plant operators in Canada had at that time considered `multi-unit accident scenarios in development of their emergency plans``. (at 37) The Task Force stated that it was confident that the operators could respond to a beyond design basis accident ``**provided they are single-unit accidents only**. `` (at 37, emphasis added).

- **RECOMMENDATION:** CNSC should require multi-unit severe accident planning to be demonstrated by OPG, along with the effectiveness of off-site emergency response in such a case. Similarly, CNSC should ensure, contrary to previous practice, that extreme natural hazard initiated events and "gross human error" are also examined in terms of presenting an emergency planning basis, and that the on-site and off-site emergency preparedness and planning are demonstrated to be sufficient and reliable to respond to all of these undesirable scenarios in the event that they lead to severe offsite releases.

- A related concern is that raised by the Fukushima Task Force Report (2011) that OPG can perform "post-accident source term estimation" – however "these are designed for **an accident in only one unit**." (emphasis added) (At 38). As the Task Force noted, this is important information to be able to provide to offsite authorities in the case of a nuclear accident.

- **RECOMMENDATION:** CELA recommends that this post-accident source term information be required by the CNSC as a condition of licensing and that the CNSC require OPG to upgrade their capacity to provide source term information and its basis, for multi-unit accidents, as a condition of the Pickering NGS licence. This should include reassessment of plume and dose modelling for multi-unit accidents at the Pickering NGS (see Task Force Report at 38).

- For severe accident emergency planning, twenty-five years after the Hare commission, CELA is of the view that Ontario still has a "conceptual framework"

[14] Even consideration for Severe Accident Management (i.e. on site response) was not adequately considered, analyzed, nor incorporated into licensing requirements in Canada pre-Fukushima. See Fukushima Task Force, CNSC INFO-0824, October 2011 at 35.

allowing for "improvisation" in the event of a catastrophic accident at Ontario nuclear power plants, including the Pickering NGS. It appears to CELA, that the pre-Chernobyl, pre-Fukushima recommendation of Working Group #3 as to a Maximum Planning Accident has held sway in Ontario for at least the past twenty-nine years, despite all of the recommendations, Commissions, and world-wide accident experience that would suggest that planning for more severe accidents is required. Post Fukushima there has been some discussion about increasing the basis for accident planning, and recommendations to do so, but changes in the Plans, in emergency preparedness on the ground, and in detail of planning are not yet evident or proven. CELA recommends to this Commission that now is the time to end the situation of operating the nuclear power plants without sufficient detailed emergency planning in place. CELA recommends to the CNSC that it deny OPG its operating licence to operate the Pickering reactors beyond their design life unless and until serious, capable, detailed offsite emergency planning for catastrophic accidents is finally in place.

- **RECOMMENDATION:** CELA recommends that the CNSC should require the licensees to demonstrate that there are, in place, properly resourced, sufficiently detailed emergency planning and preparedness plans that would address Chernobyl–size accidents or Fukushima–size accidents. The basis for this recommendation includes world-wide experience with these catastrophic accidents. This recommendation is independent of particular event sequences and rather takes account of the myriad ways that things that can go wrong resulting in an accident and resulting in a serious breach of containment, regardless of how caused. It also includes consideration of the fact that among the events that may initiate a catastrophe at a CANDU are those that are beyond the control of the operator such as hostile action or unforeseen external weather events or unforeseen combinations of failures including human error. There is no policy justification for excluding these types of events from emergency planning and preparedness since it is amply demonstrated (Three Mile Island, Chernobyl, Fukushima, 9/11) that all of them may occur in the real world, with disastrous consequences.[15]

[151515] CELA notes that the Working Group #8 Report included a concept of Worst Credible Radiation Emission in its 1988 report, which it described as "the very worst that could happen: the maximum effects possible from any accident, however caused or however developed" and that it would thus encompass accidents including those that could not be calculated due to lack of quantifiable data as well as those with very low probabilities. For this accident that the Working Group #8 styled "WCRE", it recommended that planning be done to prevent "the worst

4. **PATHWAYS OF EXPOSURE TO RADIATION AND EMERGENCY RESPONSE MEASURES**

- The appropriateness of emergency planning and preparedness must be judged on its ability to avoid health and safety consequences to members of the public in addition to on-site workers and first responders, in a severe accident scenario from impacts in a variety of pathways. They include general gamma radiation from the plume of radioactive materials airborne or deposited on ground and buildings; inhalation of radioactive substances with subsequent radiation from internally deposited materials; skin deposition from externally deposited radioactive material on skin, hair, and clothes; and ingestion of deposited radioactive material as contaminated food and water enter the food chain and water supplies leading to additional exposures from eating and drinking. In the event of a severe nuclear reactor accident the doses and exposure pathways are stated by the ICRP (International Commission on Radiological Protection) Publication 109[16] to likely consist of "an initial, relatively high dose rate, inhalation component from inhalation of short-lived beta/gamma emitters during dispersion of the plume." The ICRP also states that "for a reactor accident, this is likely to be followed by a time period lasting days or weeks when I-131 {a form of radioactive iodine} dominates the exposures, through external irradiation from contamination deposited in the environment and from direct contamination on crops and in milk. In the longer term, external radiation from radioactive isotopes of caesium and ruthenium is likely to become dominant, together with longer term contamination of foodstuff with these radionuclides." (At 61.) Without protective measures taken, the ICRP states that the largest component of projected dose would likely be received from contaminated foods.

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consequences" of this type of accident; namely early morbidity or mortality. Their rationale was that the most severe consequences are "extreme enough to warrant consideration in planning" "however remote their likelihood." Working Group #8 also based this recommendation in part on the fact that provincial and other authorities, when interviewed at this time (1988) , were of the view that their ability to "improvise" for such a severe accident would begin after 24 hours, but "immediate and effective improvisation was not thought to be possible" before 24 hours in the case of a larger than anticipated event. (At 28.) The Working Group decided that "in general no probability could be associated with the WCRE... it represents the bounding case which subsumes all events, however low their probability." (At 62.) The WCRE would result from the "failure of a large number of fuel elements in a short period of time, with a simultaneous breach of containment."

[16] See International Commission on Radiological Protection (ICRP) Publication 109, "Application of the Commission's Recommendations for the Protection of People in Emergency Exposure Situations", 2008 at 62-63.

- The point of emergency planning and preparedness is to implement those measures that would avoid the health and safety consequences of exposure to these radioactive substances, through these pathways. Without any emergency response or protective actions (such as, to move people from those locations where they may be exposed, or to decontaminate or to avoid ingestion), negative health consequences may result.[17] The Province of Ontario's Nuclear Emergency Response Plan (PNERP) (2009) provides that methods of protection from radiation exposure and external contaminating can include "creating distance, by limiting the duration of exposure, and/or by shielding." It states that methods of minimizing or eliminating internal contamination can include preventing ingestion and inhalation. (PNERP, 2009 at 2.2)

- In the following sections, CELA has reviewed material relevant to specific emergency response measures and provides comments in respect of each. The IAEA Standard GS-G-2.1[18] sets out that the "urgent protective measures and counter measures" (GS-G-2.1 at Para. 4.13) include:
    - Isolation of contaminated area
    - Prevention of inadvertent ingestion
    - Evacuation
    - Sheltering
    - Respiratory protection and protection of skin and eyes
    - Decontamination of individuals
    - Prophylaxis with stable iodine
    - Protection of the food supply and prevention of the consumption of significantly contaminated foodstuffs and water

[1717] These potential negative health consequences from ionizing radiation were described in the 1984 Provincial Working Group #8 Report: "Nuclear radiation is potentially hazardous because it has the ability to ionize, and thus to break-up molecules, some of which may be of biological importance. If very many are broken, there may be, within days or weeks, clinical symptoms which, in the worst cases, may result in death. Below these high doses which may result in early morbidity (illness) or mortality (death), nuclear radiation may so disrupt molecules that latent cancer is induced, with the possibility of overt cancer, and possible resulting death, some decades later." (at 3).

[18] International Safety Guide, IAEA GS-G-2.1, Arrangements for Preparedness for a Nuclear or Radiological Emergency, 2007

- Management of the medical response
- Protection of international trade

5. Alerting

- One of the first necessary steps in a nuclear generating station emergency with potential for or actual release of radio-nuclides to the surrounding environment will be the necessity of alerting the public, in addition to notification of necessary authorities. Reviewing the provisions of International Safety Guide, IAEA GS-G-2.1, Arrangements for Preparedness for a Nuclear or Radiological Emergency, 2007, Table 12, Response Time Objectives[19] provides the following objectives relevant to alerting:
  - Classify / Declare the emergency and notify local authorities – within 15 minutes of the time at which conditions indicating that emergency conditions exist are detected
  - Recommend urgent protection action to the public on the basis of the emergency classification – within 30 minutes of the time at which the emergency is classified / declared
  - Initially warn and inform the public within the PAZ and UPZ of urgent protective actions required – less than 1 hour from the time at which initial notification to local authorities was given by the facility

- The PNERP, 2009 contains requirements which could, if effectively implemented, ensure that IAEA GS-G-2.1 is met in terms of alerting times. However, as discussed further below, these requirements are not yet fully in place for the area surrounding the Pickering NGS. The PNERP, 2009 requires that the operator notify the offsite authorities within 15 minutes "of the requirement for notification being recognized". (PNERP, 2009, 4.1) The PNERP, 2009, also requires that the alerting systems must be such as to ensure that "the Primary Zone population that may be required to undertake the initial protective measure of sheltering, evacuation, and/or ingestion of KI can be alerted within 15 minutes of initiation of the system. (PNERP, 2009, 5.7.1.a).

[19] See also IAEA, Updating IAEA-Tecdoc-953, "Method for Developing Arrangements for Response to a Nuclear or Radiological Emergency", (IAEA, October, 2003) at Appendix 10, Response Time Objectives.

- As to the question of how much time might elapse between the operator notification of offsite authorities and a decision to "initiate" the system for alerting, both the Toronto Nuclear Emergency Plan, (TNERP) 2012 and the Durham Region Nuclear Emergency Response Plan, (DRNERP) 2011, Annex A Durham Region Nuclear Notification Procedures, indicate that the Provincial Emergency Operations Centre (PEOC) must decide within 15 minutes of the receipt of an initial notification from the operator, what initial response level to adopt. In the case of "Full Activation" it appears that the intent is that the municipalities will be immediately notified to commence their public alerting system in accordance with the TNERP or the DNERP. [20](TNERP, 2012, page 23; DRNERP, 2011, Annex A, section 3.3)

- The PNERP, 2009 has further detailed requirements in that the operator must provide resources to the municipalities to ensure that the public alerting system in the Contiguous Zone (0 to 3 km) "must provide, within 15 minutes of initiation, warning to practically 100% of the people in the Contiguous Zone at that time, whether they be indoors or outdoors, and irrespective of the time of day or year." (PNERP, 2009, 5.7.2.b). It further requires that the public alerting system in the Primary Zone (3 to 10 km) will be provided, "within 15 minutes of initiation, warning on an area-wide basis to the population in all of the response sectors within that part of the Primary Zone." (PNERP, 2009, 5.7.2.c)

- The Durham Region Nuclear Emergency Response Plan (DRNERP), 2011 at section 4.3 contains the public alerting provisions as are set out in the PNERP, 2009. One distinction of note is that section 4.3.6 states that "In the case of a nuclear emergency with an ongoing or imminent emission of radioactivity the Region is authorized to **immediately** initiate the public alerting system. The PEOC will issue the appropriate Emergency Bulletin." This is further confirmed in the Durham Region Nuclear Notification Procedures, Annex A to the DRNEP, which state that when the notification from OPG is for a general emergency, and there is either an imminent or ongoing emission, Durham "shall **immediately** initiate the Public Alerting System for the appropriate sectors and

[20] In the case of "Partial Activation" by PEOC it is less obvious as to whether and the timing of any public alerting that would occur – this would be in the case of an onsite emergency with no emission occurring - and it appears to be discretionary on the part of the PEOC in that it states that "Consideration shall be given to issuing an Emergency Bulletin and/or news release." (TNERP, 2012, p. 18)

Contiguous Zone." (Emphasis added). (Annex A at 4.4) It is not clear whether provision has been made in the Toronto Nuclear Emergency Response Plan, 2012, for immediate initiation of the public alerting system upon receipt of a similar notification from OPG. This should be clarified.

- **RECOMMENDATION:** The authority of Toronto Emergency Planning Officials to immediately initiate the Public Alerting System upon receipt of a notification from OPG for a general emergency with an imminent or ongoing emission should be clearly specified. If it is not intended that this authority be provided to Toronto's officials under the TNERP, this should be stated with a rationale for the discrepancy compared to the DRNERP.

- In its July 4, 2012 Application for this licence, OPG indicated that additional sirens had been added in 2011 within the 3 km zone when testing indicated that they did not have sufficient coverage to reach all recipients within that zone; subsequently it was determined that even more additional sirens were needed (p. 132). At the time of the preparation of CNSC staff submission CMD 13-H2, the additional sirens were not yet fully in place. In its application, OPG also indicated it was working with Durham Nuclear Emergency Management to update telephone data within the 3 km to ensure indoor alerting (p. 132) OPG also indicated in its application that it was working with a "working group" **toward** arriving at the 10 km notification required by the 2009 Provincial NERP. (p. 132)
- Despite the fact that public alerting requirements were strengthened in the 2009 PNERP, it is nevertheless surprising that this level of public alerting is still not in place since the Pickering NGS has been operating since the 1970's. The requirements for public alerting have been widespread and well understood in jurisdictions operating nuclear power for decades. For example, in the NUREG – 0654 – Rev. 1 (1980), the U.S. guidance included provision that the alerting system be evaluated and that it be capable of alerting the population with both an alert system and with a broadcast message within 15 minutes within a range of 10 miles; while the system should ensure direct immediate coverage of 100% of the population within 15 minutes. (Appendix 3 at 3-3). Similarly, the 1988 Working Group 8 recommendations made twenty-five years ago included ensuring provision of early warning systems for the public. (at (iv))[21]

[21] (Oddly, the 1984 Working Group #3 had initially been asked to make recommendations alerting, but in its report, stated that the province had "intimated" that it do not need to address offsite alerting. (at 30).)

- The urgency of the requirements for public alerting cannot be over-stressed. In the course of the notification and public alerting timeframes, in the event of early release, a considerable amount of population exposure may have occurred, before protective actions may begin to be taken to reduce those exposures.

- **RECOMMENDATION:** CELA recommends that the CNSC refuse further extension of Pickering's operating licence without the 3 km and 10 km alerting systems fully functional, both within the Region of Durham and within the City of Toronto, with robust evidence that they have been fully tested and are effective to meet the objectives specified in the PNERP, 2009.

- **RECOMMENDATION:** CELA also recommends that the emergency response plans time-frames be compressed so as to provide alerts to the public, and instructions to the public on protective actions required in as short a time frame as possible, preferably less than 30 minutes from the onset of the accident. Methods to compress this time frame should be considered and tested, and their efficacy should be one of the points of evaluation by the CNSC in the licence applications by the operators. Reasons for further compression of the time frames for instructions to the public for protective actions are further discussed in the submissions regarding KI distribution, sheltering, and evacuation below.

6. Potassium Iodide (KI) Distribution

- Potassium Iodide (KI) is important because its ingestion helps to block uptake of radioactive iodine in case of a severe offsite accident. Radioactive iodines are among the earliest radionuclides emitted from a nuclear power plant in case of breach of containment or in controlled venting following an accident. Emergency response to protect against radioactive iodine is needed since iodine "concentrates in the thyroid gland... a quarter of all ingested iodine goes to the thyroid under normal circumstances. As a result, when iodine is ingested the thyroid receives a very large dose compared to the rest of the body (roughly 1000 times as much)"[22]. Health Canada states that: "Once in the bloodstream,

[22] Working Group #8, 1988 at 4; see also IAEA Guide GS-G-2.1 at V.17 which states that "The thyroid gland absorbs and concentrates iodine once it has been inhaled or ingested; thus the potential exists for large thyroid doses following the occurrence of severe core damage at a large reactor. A large dose to the thyroid can result in

about 20% of the iodine is absorbed by the thyroid.... It is particularly susceptible to beta and gamma irradiation from radioisotopes of iodine, especially I-131." (Health Canada Guidelines for Intervention During a Nuclear Emergency, 2003 at 21).

- The ICRP notes that Iodine Thyroid Blocking is primarily intended as a short term measure to reduce uptake of radioiodines by the thyroid from inhalation over a few days. The prevention of uptake by ingestion should primarily be accomplished by controlling foodstuffs, milk and water that may be contaminated. (ICRP Publication 109 at 65). IAEA Guide GS-G-2.1 states that radioiodine uptake by the thyroid gland following an accident can be reduced by taking stable (non-radioactive) iodine. It outlines that "to achieve maximum effectiveness, stable iodine must be administered before or soon after the intake of radioiodine. The effectiveness of the measure decreases rapidly with delay, and can be reduced to 50% or less if administered 6 hours after a single intake of radioactive iodine." (at Appendix V, V.15) The IAEA Guide states that its reduction of dose is only 20% 10 hours after the intake of radioiodine and almost zero 24 hours after. (Ibid, V.15) ICRP publication 109 reinforces this – if stable iodine is taken up to 6 hours **before** the intake of radioactive iodine, "the protection provided is almost complete"; if at the time of radioiodine inhalation, its effectiveness is 90%; and 50% within a few hours. The ICRP stated that "to obtain the maximum reduction of the radiation dose to the thyroid, stable iodine should be administered **before** any intake of radioiodine or **as soon as practicable thereafter**." (At 65.) (emphasis added)

- As long ago as 1984, the province of Ontario's Working Group #2 to the Ontario Nuclear Emergency Plan (established by the Solicitor General to make recommendations on the use of stable iodine in case of a nuclear emergency) recommended pre-distribution of KI because it must be ingested very early in or prior to a release from an accident in order to be effective. The Working Group #2 also reviewed the reasons for ingestion of KI for thyroid blocking as a significant preventive measure for public health to prevent early thyroid injury

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deterministic effects in the thyroid gland and radiation induced thyroid cancer. In the event of **actual or possible** core damage, stable iodine prophylaxis should therefore be used: to prevent deterministic effects in the thyroid gland (e.g. hypothyroidism; to reasonably reduce the risk of stochastic effects (e.g. radiation induced thyroid cancer) from the inhalation of radioiodine within or near the facility." (emphasis added).

or longer term thyroid cancer risks. The Working Group stated that "The Group recognized that the cost-benefit ration was high, but that it would be prudent to consider pre-distribution." (at Recommendation #3) Provincial Working Group #2 also stated in 1984 stated that "if there is any use at all by KI as a blocking agent it would have to be by pre-distribution to an area considered to be at risk." – this was based on the time frame in which KI must be taken to be effective, and that if the warning time available before release is as little as thirty minutes, then "that will not be sufficient for house-to-house distribution from a central stockpile." (At 6).

- CELA submits that KI MUST be pre-distributed because it must be ingested before or shortly after a radioactive release, and if necessary during a release[23]. It would not be reasonably feasible to quickly obtain KI after such a severe accident that requires ingestion of potassium iodide. In that scenario people will likely be required to shelter in place and/or evacuate so it will not be possible to attend pharmacies to obtain it, nor would it be practical to have extensive distribution at that time.[24] In any event there is no possibility this could happen on time for the affected population numbers if there was not adequate pre-distribution. The IAEA Guide GS-G-2.1 stresses that other organs (bone marrow, lungs and other organs) are not protected by KI and therefore "sheltering or evacuation of people at risk of life threatening doses should not be delayed for the provision of stable iodine prophylaxis." (at V.21)

- There is a further concern about the adequacy of KI availability. This is highlighted by comparing the numbers of KI pills available. The CNSC staff submission noted that there is an inventory of 325,000 potassium iodide tablets for residents of the 10 km zone around Pickering (page 62 of the CNSC's submission CMD 13-H2.) This compares to the population of approximately 260,000 in the 10 km zone[25] but does not take account of the potential

[23] IAEA Guide GS-G-2.1 at V.19; See also Working Group #8, 1988 at 6.

[24] Linda Harvey, Physicians for Global Survival, personal communication with Janet McNeil of Durham Nuclear Awareness, April 2013; see also Working Group #8 Report 1988 where it notes that Emergency Planning Ontario considered the lower Protection Action Level for thyroid blocking to be "only for advising persons already in possession of potassium iodide pills to ingest them." (at 19)

[25] DRNERP 2011 and TNEP 2012 sources for total population numbers within 10 km of the Pickering NGS.

necessity for repeat doses nor for provision beyond the 10 km primary zone to the high populations in Scarborough and Pickering in the event of an offsite emergency requiring broader KI distribution.

- People may voluntarily attend one of five pharmacies at any time to request KI pills, and there has been pre-distribution to institutions.[26] The pharmacies are listed in Annex D to the DNERP. Companies may call the Region for additional quantities. None of the five pharmacies listed in the DNERP, 2011 are in the City of Toronto; the TNERP, 2012 does not list pharmacies available for the public to obtain KI and presumably Toronto residents may attend at one of the pharmacies in Pickering to do so. This should be clarified and Toronto area pharmacies should be added to the distribution channels, particularly in Scarborough. Annex D of the DNERP requires of the Durham Emergency Measures Office is to place public notices in local media twice per year about the availability of KI. No similar provision appears in the TNERP, 2012. Oddly, the TNERP, 2012 deals with thyroid blocking only in respect of its own City of Toronto staff. (4.5.4 (d))

- **RECOMMENDATION:** CELA recommends that as an interim measure, the CNSC should require that OPG in conjunction with the City of Toronto, conduct outreach and notification to members of the public resident in Toronto (at a minimum within the Primary Zone), as to the availability of KI and provide advice as to where it may be obtained.

- While Annex D to the DRNERP contains a provision for a KI information letter and consent form to be sent every year to every parent of all of the school children in the Primary Zone, there is no comparable provision in the TNERP and it should be clarified if Durham's Annex D is meant to apply to the City of Toronto residents and institutions within the Primary Zone, or if there are alternate provisions and requirements, and where they are located. This concern is applicable to all of the provisions in Annex D including pre-distribution to institutions. Durham's Annex D on its face does not appear to apply to City of Toronto (Scarborough) residents and this gap must be addressed by comparable provisions for them.

[26] CNSC Staff Submission CMD 13-H2 at 62; See Annex D to the DNERP, 2011, "Potassium Iodide Distribution Procedures."

- **RECOMMENDATION:** The applicability of Durham's Annex D to the residents of Toronto in the Primary Zone must be clarified. Alternatively, the same provisions for KI distribution, consent and information letters for school age children, and other matters dealt with in Annex D must be specified in the TNERP.

- The lack of a comprehensive KI pre-distribution approach at Pickering could be compared to the approach taken by France as described by J.C. Niel[27], in Ottawa during remarks made on April 10, 2013 during a session on Emergency Management. He stated that the approach taken by France for KI distribution was first to mail all of the residents in the protective action zone coupons to redeem at local pharmacies for KI for the household, at no charge. After finding that the uptake was insufficient, they then mailed every single household the KI doses needed to ensure that they would have them on hand in the event of a severe accident.

- The CNSC Fukushima Task Force Report, 2011 noted that the effectiveness of the approach of stocking the KI tablets at local pharmacies, as opposed to pre-distribution to all households "has not been confirmed." (at 52) It is notable that the CNSC 2011 Fukushima Task Force reported that Ontario is the only nuclear province in Canada that does not pre-distribute KI to the residents in the surrounding planning zones. (at 47)

- **RECOMMENDATION:** CELA recommends that the CNSC should require the operator to systematically evaluate and report back to the CNSC the percentage of households within the 10 km Primary Zone, both within the Region of Durham and the City of Toronto, who have obtained KI tablets in advance, as well as the percentage of institutions covered by the plan who have them on hand in sufficient quantities to cover all of their residents or students. Based on this evaluation, CELA recommends that the CNSC require the approach that was taken in France be taken in Canada for the 10 km zone around each operating nuclear generating station, to undertake and ensure 100% pre-distribution of KI

[27] J.C. Niel, of the Autorite' de surete' Nucle'aire (ASN) at the IAEA International Conference on Effective Nuclear Regulatory Systems hosted by the CNSC in Ottawa, April 8-12, 2013.

tablets to the residents in the Primary Zone and that this requirement be included in the licensing conditions for the Pickering NGS.

7. Re sheltering in place and evaluation of its effectiveness

- Sheltering is not defined specifically in the PNERP, 2009 Glossary, nor in the Glossary to the IAEA Safety Guide GS-G-2.1. However, it is listed in the latter as one of the urgent protective measures to consider following a nuclear emergency. That Guide GS-G-2.1 states that "substantial sheltering is provided by large multi-story structures without any special features." (Table 13). The Guide states that sheltering will provide "some protection against all of the major exposure pathways during the early phase of an emergency"; but that the "effectiveness of sheltering varies greatly." Variables cited include the type of release, the type of construction of the building, and the exposure pathway. However, it also notes that after a few hours the reductions in doses are no longer evident and after that time, doses may become greater than those outside if some of the contaminants from the plume are "trapped in the shelter"; if the plume has passed it states that the shelters may then need to be aired out. (at Appendix V, V.3)

- IAEA Guide GS-G-2.1 reviews the protection available with different types of shelters. It states that "typical European and North American homes and their basements" "may not provide adequate protection". Within the first 3 km from the site in particular this type of shelter may not be able to reduce "the risk of severe deterministic effects." The IAEA guide indicates that sheltering in this type of structure should be used if evacuation is impossible or while preparing to evacuate. The Guide states that "substantial" shelter may be provided inside the halls of "large multi-storey buildings or large masonry structures away from walls or windows" which may provide a ten-fold reduction in external and inhalation dose. The Guide states this type of protection can be used for short periods, for up to a day, subject to monitoring. (At Table 11, Page 97) "Special shelters" are defined as those designed specifically to provide dose reduction "by a factor of more than 100".

- ICRP Publication 109 also states that buildings constructed of wood or metal (as opposed to solidly constructed buildings) "are not generally suitable for use as protective shelters against external radiation, and buildings that cannot be made substantially airtight are not effective in protecting against any exposures." (at 65) Accordingly, ICRP Publication 109 implies that for these

types of buildings the main utility is to advise people to "go inside and listen to their radios for further instructions." (at 66) Health Canada's Guidelines for Intervention During a Nuclear Emergency (H46-2/03-326E, 2003) state that sheltering should only be used for one day and should not extend beyond two days. (at 18)

- Given the significant limitations of sheltering, CELA observes that there must be significant planning, attention and resources in order to ensure rapid, timely evacuation. In the time frames required for evacuation, however, there may nevertheless be significant exposures to the public whether trying to evacuate or sheltering in place, but taking many hours to do so. This is further discussed in our comments on evacuation. It is very important that emergency planning officials and the public understand that, for example in large early release scenarios, it may not be possible to prevent all of the exposures to the public from those releases because sheltering will not be fully effective and evacuation takes time.

- The DNERP, 2011 provides for sheltering at section 4.7.1 without acknowledging the limitations set out by the IAEA Guide or the ICRP Publications reviewed above. On the contrary, the description implies that sheltering will be effective without any discussion as to the type of building, time frame etc. It does provide direction to close doors, dampers and windows and to turn off furnaces and air conditioners, and does recommend going to a basement or ground floor room with no windows.

- **RECOMMENDATION:** CELA recommends that the CNSC require OPG to include in its outreach material to the public, in conjunction with regional emergency response officials, explanations about the capability of sheltering and its limitations as described in the IAEA Guide GS-G-2.1 and to reinforce instructions as to steps to take for rapid and effective evacuation in the case of notification of a significant emergency.

8. Medical treatment and availability

- The IAEA Safety Guide GS-G-2.1 states that there should be a referral hospital outside of the ``UPZ`` (Urgent Protective Zone – analogous to Ontario`s Primary Zone) that can provide "highly specialized treatment for a limited number of exposed and/or contaminated persons..." (at 4.46)

- The PNERP 2009 states that the Ministry of Health and Long Term Care will develop a Radiation Health Response Plan. (At 5.1.0). It is to be an Implementing Plan to the PNERP, 2009. Emergency Measures Ontario advises CELA that this Plan is not yet completed as of April, 2013.[28] The TNERP, 2012, does not indicate what the referral hospital for its residents would be in case of a severe accident; rather it refers to their Radiation Health Response Plan. (TERP, 2012 at 4.5.6) Toronto Emergency Measures also advises CELA that this Plan is not yet ready as of April, 2013. The Implementation Plan for the Pickering Nuclear Generating Station under the PNERP, 2009 (to which the reader is referred in TNERP, 2012 at 2.3 regarding Protective Measures), does not have any additional specificity on this question.
- It is not currently possible for CELA to evaluate or comment on the level of treatment available to the public and the level of protection arising there-from on the question of treatment for contaminated persons after a nuclear emergency. Nor is it possible for CELA to evaluate whether the treatment available in the event of an accident at the Pickering NGS is in compliance with IAEA GS-G-2.1 as the provincial plans and Toronto`s and Durham`s Radiation Safety plans are apparently not completed on this issue.

- Valid questions which we have not been able to answer based on the available materials include:
  - Are there in place plans for treating members of the public, either injured or suffering from radiation syndromes beyond decontamination and assessment centres? This is not evident. Provincial Working Group # 9 (another document which CELA will be seeking to obtain for our emergency planning archive) apparently recommended that there be capacity to assess a thousand members of the public and treat for radiation syndromes up to 50 members. In referring to this in 1993 testimony, Dr. Paul Rosenberg stated that there was a lack of readiness in

[28] We have not so far been able to obtain any current version of this plan. It would appear that it is in the process of being updated according to an overview presented by the MOHLTC in December, 2012 where it stated `` In 2012, the MOHLTC undertook a major update to the Radiation Health Response Plan (RHRP), a plan required by the Provincial Nuclear Emergency Response Plan. This health plan describes how Ontario's health system responds to a radiological/nuclear incident of a deliberate or accidental nature and the conditions under which precautionary and protective actions are ordered for the general public and health workers. The update includes a major review of roles and responsibilities, hospital response and resources, evacuation planning, occupational health and safety, monitoring and decontamination units, use of potassium iodide and communications. Technical/expert working groups focusing on these various issues were convened from across the health system. Their input has ensured that a robust plan will be released in early 2013.``

place for that number of people. CELA notes that currently there still does not appear to be such a capability as we have seen no reference in emergency planning documentation to any capacity to handle these numbers of contaminated victims.

- Does the primary hospital for Pickering or Toronto have sufficient response capacity which would not be overwhelmed by a few injured and contaminated patients? Which hospitals are designated for this response capacity?
- Are arrangements for treating more seriously radiated or injured workers, as well as members of the public, adequately in place? We have not seen evidence in the emergency plans that this has been addressed.
- CELA submits that these are the types of questions which must be asked, and answered satisfactorily, with proof, before the CNSC continues with the Pickering licensing application beyond the design life of the plant.[29]

- The concern about the ability to handle the medical treatment of injured and contaminated members of the public is not alleviated by examining the provisions of the Durham Region Nuclear Emergency Plan. The Durham Region Nuclear Emergency Plan contains a brief reference to monitoring at decontamination centres and issuance of instructions to the public. It has a generalized direction if unable to attend at decontamination centres, to "go to a destination of their choice, shower and bag their clothes." It also states that "Details of personal decontamination procedures will be provided through Emergency Bulletins from the PEOC as will the locations of MDUs when they are operational." (at page 31) It is further stated in that Emergency Plan that if there is "a reasonable possibility of significant radiation exposure, the Ministry of Health and Long-Term Care (MOHLTC) will implement the Provincial Radiation Health Response Plan. This includes monitoring for internal contamination, maintaining a database of potentially affected people, counselling and public health information program". However, as noted earlier, the Provincial Radiation Health Response Plan is apparently not complete according to advice provided by EMO to CELA in April, 2013.

[29] Evidence of Dr. P. Rosenberg, Nov. 3, 1992, pages 922-932 ; See also the Recommendation of Working Group #8, 1988 that the province take appropriate measures to provide "the need for adequate medical facilities to deal with possible acute radiation exposure." At 90.

- There are also serious questions to ask about whether the emergency plan has contemplated enough ambulance transport to transport more than two or three workers; and about whether it has contemplated the consequences of taking ambulances out of service after transport due to radioactive contamination. Another concern is whether the ambulance crews would accept a contaminated worker given workplace standards for workplace safety in Ontario. This should be explicitly addressed in the planning, and ambulance worker safety also addressed. There is also a concern about whether there is provision for transporting members of the general public who have received an initial dose of radiation that would require treatment (because the planning accident has until now assumed there would not be any people in that situation). These questions cannot be evaluated at present without the Provincial Radiation Health Response Plan and this is a significant deficiency in the Emergency Planning presently in place in Ontario, and therefore in the ability to respond adequately to a severe offsite nuclear accident at the Pickering NGS.

- **RECOMMENDATION:** CELA recommends that the Pickering Operating licence should not be extended without the Provincial Radiation Health Response Plan and the municipal Radiation Health Response Plans in place.

9. Size of emergency planning zones

- IAEA Safety Guide GS-G-2.1 at 75-78 – provides that the UPZ (Urgent Protection Action Planning Zone) radial distance could be between 5 and 30 km. The reason for this zone is to be able to shelter, monitor, take protective actions and evacuate to significantly reduce risk of doses.

- The same emergency planning zone radii have been in place since the 1988 Working Group #8 report (a 10 km primary zone to plan to prevent plume exposure including evacuation; a 3 km contiguous zone with increased level of planning and preparedness; and a 50 km secondary zone (re ingestion control from contaminated food and water).[30] In Ontario, the 50 km secondary ingestion zone was recommended by Working Group #8 on the assumption that the accident of concern would be a “puff” release. (At 24.)

[30] Working Group #8, 1988 at 18

- **RECOMMENDATION:** CELA recommends that in view of the experience at Chernobyl and Fukushima, the CNSC should request that the province immediately revisit the 50 km secondary ingestion zone with a recommendation to change it to 100 km. This should be done as part of detailed planning for severe offsite accidents so that appropriate monitoring of food, agricultural products, milk, and water is established and in place in the event of such an accident.

- These zones in general appear to have originated in untested assumptions such as those set out in the U.S. Nuclear Regulatory Commission's "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants", (U.S. NRC / FEMA 1980), NUREG-0654; FEMA-REP-1 Rev. 1. This document stated that "The choice of the size of the Emergency Planning Zones represents a judgment on the extent of detailed planning which must be performed to assure an adequate response base." (at 11) NUREG-0654 described an NRC / EPA Task Force on Emergency Planning (NUREG-0396 1978) which had "selected a radius of about 10 miles for the plume exposure pathway and a radius of about 50 miles for the ingestion exposure pathway." (at 11) This Report asserted that projected doses from the traditional design basis accidents would not exceed Protective Action Guide levels outside the {10 mile} zone" and the same for "projected doses from most core melt sequences"; that immediate life threatening injuries from worst core melt sequences would generally be inside that zone; and that detailed planning within that 10 mile zone would provide "a substantial base for expansion of response efforts in the event that this proved necessary." (at 12)

- These zones have not been altered despite the experience of Chernobyl, or now Fukushima, to this date. In other words, emergency planning zones in Ontario and specifically around the Pickering NGS have not been re-examined in light of actual experience with severe nuclear power plant accidents in which radionuclides breached containment. The Fukushima Task Force Report (CNSC, 2011) noted that at day 5 after the onset of the Fukushima accident, authorities extended the evacuation zone to 30 km around the plant. One month later, some residents at even greater distances were moved as a result of discovering higher levels of radiation in those areas. (at p. 8)

- Dr. Robert Goble, 1993[31] modelled cases which varied in estimating where population dose fell, depending on weather conditions – in some scenarios most of the dose occurred within 100 km of the reactor while in others over 50% occurred beyond 100 km. These scenarios illustrate the necessity to seriously consider and provide detailed plans for emergency planning zones well beyond the 10 km Primary zone and the 50 km ingestion zone currently contemplated.

- **RECOMMENDATION:** CELA submits that it is now incumbent on the CNSC to require that the emergency planning zones be expanded before proceeding with licensing of the Pickering NGS since it is evident on the experience of Fukushima, that evacuation well beyond 10 km is required in certain serious accident scenarios. CELA submits that if emergency planning were undertaken for severe offsite multi-unit accidents, as recommended by the CNSC Fukushima Task Force report (at page 39), it would be evident that emergency planning zones must extend significantly beyond their current limits. CELA submits that the 10 km Primary zone should be extended to 30 km and the 50 km Secondary zone should be extended to 100 km. (By way of comparison to Ontario, the Fukushima Task Force Report indicated that Quebec's Ingestion Control Zone is 70 km. (at 47))

10. **Evacuation**
    - Evacuation is one of the most immediate actions to be taken in the event of a general emergency at a Nuclear Generating Station. ICRP Publication 109 indicates that the purpose of evacuation is to provide "rapid, temporary removal of people from an area to avoid or reduce short-term radiation exposure in an emergency exposure situation." ICRP states that it is "most effective if it can be taken as a precautionary measure before there is any significant release of radioactive material." (at page 66)

    - Health Canada's Guidelines for Intervention indicate that "the goal of evacuation is to avert elevated short-term doses arising mainly from the radioactive plume (external irradiation and inhalation) and from radionulides deposited on the ground (external irradiation). Evacuation has the potential to avert most or all doses if carried out in the pre-release phase of an accident.

[31] Goble 1993 Report for NLA Trial, April 1993 "Potential Consequences of Severe Accidents at Canadian Nuclear Power Plants – Implications for Nuclear Liability Act."

Evacuation is effective for reducing exposures in cases where the release is of uncertain size or duration." (at 18) The Health Canada Guidelines indicate that evacuation should not last more than one week; if conditions prevent return after a week, then the next measure would be longer term relocation. (p. 19) (Relocation, which is not addressed in this submission by CELA, is indicated by the Health Canada Guideline to be a longer term action from weeks to months to avert doses occurring over that time frame.) The Health Canada Guideline states that "If times longer than a year are indicated, then permanent resettlement would need to be considered." (p. 19))

- The Pickering A Safety Report noted that a 50 km radius of Pickering includes almost all of Metro Toronto, the southeast part of the Regional Municipality of York and the Regional Municipality of Durham. In 2001, 3.2 million people lived with 40 km of the Pickering plant. (At p. 40) The population within the 10 km primary zone for the Pickering NGS totals 256,361 people, (2006 population numbers), approximately 60,000 of whom live within the City of Toronto sectors of the primary zone. When Pickering NGS employees are included, the total is 260,861. (The numbers are somewhat less during evenings after 6 pm and nights). These population figures do not include the 15 km or 20 km population numbers in the event that evacuations were ordered for those distances. Nor do these figures include significant numbers of "shadow evacuations", meaning people choosing voluntarily to leave the area beyond the officially declared evacuation zone. (See further comments below on shadow evacuations.) By 2026, the population of Durham Region is projected to be 949,100 according to the Pickering A and B Safety Reports[32].

- A critical issue to determine, then, in order to evaluate effectiveness of evacuation as a protective measure in various scenarios is the time required for evacuation. Just within the 10 km zone, the highest times to evacuate, with last vehicle to clear the Primary Zone, are estimated in the Durham Region Nuclear Emergency Evacuation Information, Annex B to the DRNERP. (Annex B is dated 2008.) The highest times to evacuate vary by scenario and range from 4.77

[32] Figure 2-3 in the Pickering B Safety Report, 2012 NK30-SR—1320-00001 Rev. 4 shows the population trends of Metro Toronto and Durham Region since the 1970s when the plant was originally sited. (P. 88 of 110)

hours up to 36.58 hours in one scenario; several scenarios exceed 20 hours. In other words, on the assumptions made for that study, the residents of Durham Region within 10 km of the Pickering NGS could evacuate over times ranging from just under 5 hours, to almost 37 hours, depending on circumstances. Variables include weather, time of year, time of day. (at p. 89) Times for lesser percentages of the population to evacuate will be less; for example the times for 50% of the population to evacuate may be calculated as was done in the Evacuation Time Estimates Technical Support Document for the Pickering B Refurbishment application (2008)[33]. In that study, based on the population and employment numbers in 2006, it was estimated that the various protective zones could evacuate 50 per cent of their population to the edge of the 10 km zone in times ranging from one hour 10 minutes to two hours 45 minutes. (Table 7-1A). However, that table did not include the combination of midweek evening poor (rain or snow) time estimates in that OPG study. Times increased for the calculation of clearing 100% of the evacuating population, to a high of six hours 30 minutes, but again did not include the midweek evening poor road conditions scenario in the relevant table (Table 7-1D). Table 2-1 which outlines the Evacuation Scenario Definitions for that study did not include a winter, evening rain or snow scenario, which appears to be a significant omission in that during early evening, roads may be already congested at the outset of an emergency. This may explain the discrepancy we note below.

- CELA observes that there are highly significant discrepancies between the highest time to evacuate scenarios contained in the Durham Region Evacuation Information Annex and the 2008 OPG Technical support document just referenced. The CNSC staff submission CMD 13-H2 indicated that CNSC obtained an independent expert review of the 2008 study and based on that review, "it can be conservatively estimated that the 10 km zone could be evacuated in less than 13.5 hours using projected regional data." Meanwhile, the OPG CMD 13-H2.1 claimed evacuation of the primary zone within 6 to 7.5 hours (and 9 hours by the year 2025) taking account of weather and time of day. (At 65). CELA notes that there remains a significant discrepancy between both of these estimates as well as between these estimates and the DNERP Annex B and requests that the CNSC require the applicant to outline a comparison between the factors affecting the time estimates contained in the DRNERP and

[33] Evacuation Time Estimates Technical Support Document for Pickering B Refurbishment for Continued Operation Environmental Assessment NK30-REP-07701-00016, September 2008

the 2008 study and subsequent peer review results. In particular, it is not evident that the 2008 study included any particular consideration of evacuation from institutions; compared to the DNERP, 2011, which does include a listing of institutions such as schools, long term care facilities, hospitals, and others, in each sector. The 2008 OPG study appears to be based on car traffic and also does not indicate what assumptions were made in the study for evacuation of people without household automobiles; if they were included it was not explicitly stated.

- The Pickering Implementation Plan under the PNERP provides that both Toronto and Durham are to provide for mass transportation. The TNERP states that evacuees who require transportation to leave the Primary Zone will be assisted "according to the Mass Evacuation Transportation OSF" operational support function. CELA has not yet been able to obtain this Plan under the TNERP and presumes that it is not ready yet since Toronto EMO sent CELA the available Operational Support Function plans and Annexes in April, 2013, along with the advice that the rest of them are not yet ready. Similarly, the DNERP, 2011 states that "Durham Region must have a plan for the pickup of people without vehicles and their transportation out of the PZ." It is not evident in the Durham Plan what those plans are or where those plans would be located by members of the public.

- **RECOMMENDATION:** CELA recommends that the public should clearly understand what plans are in place to assist them with evacuation from the Primary Zone if they do not have their own transportation. What those plans are should be clearly specified in the Durham and Toronto Nuclear Emergency Plans, and widely communicated to the public in outreach and education. It is not clear from the 2008 OPG Pickering evacuation time estimates study that transit dependence was calculated.

- The ability of people without cars to evacuate is a significant concern. The U.S. Nuclear Regulatory Commission requires explicit calculation of numbers of households with no vehicles; with unsupervised latchkey children; with one vehicle at work that would not return; with residents who have limitations on driving such as elderly who do not drive at night; with specialized transportation needs such as wheelchair vans or ambulances. It also specifies that a summary of the total number of vehicles available to support evacuation of transit

dependent residents, and people with accessibility needs must be done.[34] A related question is the sufficiency of arrangements for transportation of residents of special facilities (institutions) and schools during an evacuation. The same US Evacuation Time Estimate Criteria provides that the numbers of residents and students should be calculated and numbers of bus runs should be calculated in evacuation time estimates. (At 14-15)

- The Durham Region Nuclear Evacuation Information Annex B, Jan. 2008, does provide this type of information (although it likely should be updated at this point, five years later). For each sector, it lists the special care facilities (child cares, retirement homes), schools, all with numbers of residents, students, staff, as well as recreation centres, parks, and locations of emergency services, works, services, and vital services such as health centres. It also notes motels and hotels when present in the sector. It may be that this information was utilized in the time estimates to evacuate each sector contained in that plan, and that should be explicitly stated.

- It is not apparent that the Toronto Nuclear Emergency Response Plan has collected comparable information for these populations of vulnerable residents, and this should be done. The Toronto NERP states that the City is to assist the School Boards to develop their emergency plans for movement of students to pre-arranged host schools and if necessary to Monitoring and Decontamination Units; and that Long Term Care Facilities are to have pre-arranged reciprocal arrangements with like facilities outside the "Hot Zone" to accommodate their residents. (at 4.7.3) Students are to be the responsibility of their school staff until collected from the host school by their guardians / parents. CELA questions whether parents in the Primary Zone are aware of these arrangements, and reminded of them periodically. Questions as to methods of transportation for those lacking personal vehicles, or whose household vehicles cannot return due to the evacuation should be answered clearly, to provide advance information to parents as to how they will be able to collect their

[34] NUREG/CR-7002, "Criteria for Development of Evacuation Time Estimate Studies", 2011 at 14.

children. It is not evident in the Toronto NERP if all of these arrangements are currently in place[35].

- The Durham Emergency Evacuation Information, Appendix A, notes an optimal evacuation route for each sector. The Toronto Emergency Response Plan states that there is to be a Joint Traffic Control Plan developed by a Joint Traffic Control Committee as provided for in the Pickering Implementation Plan under the PNERP, 2009 (referenced at 4.6.3 of the Toronto plan.) However, it is not apparent whether the Joint Traffic Control Plan is completed yet as it was not among the TNERP documents sent to CELA by Toronto EMO in April, 2013. It is supposed to provide for priority evacuation of any Response Sectors and timing and order of sector evacuations is to be determined by the PEOC in conjunction with the Joint Traffic Control Committee. (4.9.3, 4.9.4 of the Toronto Plan).

- In the event of Full Activation of the emergency plans, both the Toronto and Durham plans note that the main road and rail routes through the Primary Zone will be closed to through traffic: Highway 401, Highway 2, CN Rail and CP Rail. (TNERP at 4.6) In addition the Lake Sectors in the Primary Zone will be cleared of boats through Canadian Coast Guard and Toronto and Durham Police marine units.

- It is not clear that members of the public know in general that in the event of an evacuation they are expected to "make their own arrangements for food and lodging" and that the host communities will make arrangements for those "without resources". (DNERP, 2011 at 4.8.4 and 4.8.7; TNERP, 2012, at 4. 7.1 (e)).

- **RECOMMENDATION:** CELA recommends that the CNSC should require OPG to communicate to the public in annual outreach and education, the fact that the nuclear emergency response plans expect the public to make their own arrangements in the event of evacuation, and for those who cannot, what is expected to be provided by the municipalities. The appropriateness of this

[35] The Child Care Nuclear Emergency Response Guidelines, Annex F to Part II of the DRNEP, 2007 says it was divided into two parts; CELA was so far unable to obtain and review the second part being the child care Evacuation and Sheltering Guide described.

approach should further be discussed with the public in terms of future nuclear emergency planning.

- As noted earlier under the topic of sheltering, a significant issue of ongoing concern with all of the evacuation time estimates is that in the event of an early release, there would be considerable periods of exposure to the evacuating public. This is not acknowledged by OPG in its CMD13-H2.1 in which it states that the time estimates are "well within the anticipated "hold-up" of radionuclides within station containment following a nuclear event." (at 65) This is no doubt due to OPG's continued assumption that there will not be a severe catastrophic accident with early release and it does not use such an accident in its emergency planning basis as discussed earlier in this submission.

- **RECOMMENDATION:** CNSC should require OPG to conduct studies and to work with offsite emergency responders, the municipalities and the Province to ensure that there are realistic evacuation plans in the case of a severe accident with early large release, as well as in the case of plans for twenty kilometer and 50 kilometer evacuation zones around the Pickering NGS.

11. **Re shadow evacuation** issues
    - "Shadow evacuation" refers to the people who voluntarily leave the area following a nuclear incident or accident, beyond those who are asked by the authorities to do so. In the Fukushima accident, for example, there were considerable "shadow evacuation" populations, especially women and children.

    - The U.S. Nuclear Regulatory Commission requires its licensees to include a shadow evacuation of twenty percent of the public to a distance of 15 miles from the Nuclear Power Plant in its traffic estimates and planning. ("Criteria for Development of Evacuation Time Estimate Studies.") NUREG/CR-7002, November, 2011. The U.S. General Accounting Office has just released a report (March 2013) in which it reviewed, among other things, the extent to which the U.S. regulator, the NRC understands public awareness as to how to respond in case of a nuclear power plant emergency. It found that there had not been an evaluation of people's understanding beyond the established 10 mile emergency planning zone. See GAO-13-243, U.S. General Accounting Office, Report to Requestors, NRC Needs to Better Understand Likely Public Response to Radiological Incidents at Nuclear Power Plants. (March 2013) The General Accounting Office recommended that the U.S. NRC conduct an evaluation in the

area beyond the 10 mile zone, of people's likely responses in respect of evacuation, during a nuclear emergency, and determine how the rate of shadow evacuations would affect their evacuation time estimates and plans. While the NRC requires licensees to include factors for an additional shadow evacuation within 15 miles of another 20% of that population, the GAO is concerned that the NRC does not have a basis to determine if this requirement is sufficient or reasonable. (At 26).

- The TNERP, 2012 comments that shadow evacuations may occur and contribute to evacuation times. Specific areas next to the Primary Zone are identified in the Plan. (at 4.7.1) A similar comment is included in the DNERP, 2011 (at 4.8.2). The Toronto plan indicates that traffic control will be initiated when the emergency requires evacuation, or "when spontaneous evacuations begin to occur." (at 4.9) The 2008 OPG report on evacuation done for the Pickering refurbishment stated that it included a factor for "some portion" of shadow evacuations out to a 15 km radius from the plant. (at ES-2)

- It is not apparent that there is evidence that the CNSC or OPG or municipal emergency planning officials have tested the state of information and knowledge on the part of the public around the Pickering NGS beyond the 10 km zone. It can be expected that there could be considerable populations of people involved in shadow evacuations given the population numbers located adjacent to the 10 km Primary Zone. Another five kilometers into the City of Toronto extends even further into the former City of Scarborough, extends to approximately to Brimley Ave. and encompasses the neighbourhoods of Guildwood and Scarborough Junction. Five more km to a radius of 20 km west from the Pickering NGS extends to Toronto's Woodbine Ave. and the Don Valley Parkway north of that. It is also reasonable to assume that people will voluntarily evacuate even in greater distances throughout at least the eastern side of the City of Toronto in case of a general emergency at Pickering.

- **RECOMMENDATION:** CELA submits that a similar recommendation to the one made by the U.S. General Accounting Office to the U.S. Nuclear Regulatory Commission is relevant in this case: that the CNSC require the applicant to conduct a study as to the awareness of the Pickering Nuclear Plant of people beyond the Primary Zone at Pickering, and as to their likely response in the event that a general emergency is declared and the Primary Zone is evacuated. The CNSC should require the applicant to evaluate the impact of increased evacuation zones of twenty and fifty kilometers on evacuation time estimates, as well as any other needed adjustments to the emergency plans surrounding

Pickering such as locations of Emergency Workers Centres, numbers of emergency workers required for evacuation management, traffic routes, size of evacuation centres, and locations and capacity of Decontamination and Monitoring Units, and to report its findings to the CNSC and to the provincial EMO, the City of Toronto, and the Region of Durham.

12. Family reunification

- Family reunification would be one of the most significant issues that people are concerned with following an evacuation. This is recognized in the TNERP, 2012, but no provisions are included about how reunification will be accomplished other than that there will be a number of factors affecting reunification. (at 4.7.1 (d)) A similar treatment is included in the DNERP, 2011 (at 4.8.3).

- **RECOMMENDATION:** CELA recommends that CNSC direct the applicant to work with the municipalities to consult with the surrounding communities on specific plans for family reunification following evacuation in the event of a severe nuclear emergency.

13. Decontamination

- IAEA Guide GS-G-2.1 outlines some approaches to radioactive decontamination. Apart from people who have been heavily contaminated, such as potentially some of those on-site, it recommends that changing clothes, showering and washing exposed skin will reduce levels of contamination and prevent further spread of contamination in a nuclear emergency. (2.2.4)[36]
- The PNERP, 2009 includes decontamination, "removal of deposited radioactive material" on the list of specific protective measures available. In terms of personal monitoring and decontamination, the PNERP states that "evacuees **who are not likely to be contaminated** will be advised to evacuate...undertake self-decontamination." Self-decontamination is described consistently with the IAEA guide. The PNERP states that monitoring and decontamination units should be set up and the affected public directed to those centres if possible. (emphasis added) PNERP 2009, Para. 6.7.5
- The DRNERP considers the potential for contamination from loose particulate on people in the event of an ongoing emission; and also the possibility of

[36] See also ICRP Publication 109 at 66.

internal contamination. (At Para. 4.10). It states that "if evacuees cannot clear the affected area before an emission, they may be directed to proceed for monitoring and decontamination." If units for monitoring and decontamination are not yet set up, they will be advised to "go to a destination of their choice, shower and bag their clothes." Further details and direction will be provided through the PEOC; the priority is to ensure people leave the affected area as soon as possible. (At Para. 4.10.4)

- The TNERP, 2012 states that when evacuations are underway during an emission, the first priority is to "leave the affected area as quickly as possible." It states that evacuees will be advised "via an operational directive" to go to a facility for monitoring and decontamination or to self decontaminate, and that details will be provided through emergency bulletins along with advice as to where to go for follow-up "assurance monitoring". The TNERP, 2012 states that "given the population density, self-decontamination may be the primary means of decontamination, if required." (At 4.7.1 (b)). However, it does not contain the explanation about what self-decontamination means and how to carry it out.

- **RECOMMENDATION:** Explanations about what "self-decontamination" means; how to do so; and a statement as to its efficacy should be included in the Toronto Nuclear Emergency Response Plan and in outreach and education to the public about implementation of the plan.

14. **Monitoring**
    - OPG has now installed "Near Boundary Gamma Monitoring System" and indicated in its application for this licence that it expected it to be in full use in the last quarter of 2012 (July 4, 2012 Application for Renewal of the Pickering A and B Operating Licence P-CORR-00531-03719, Att. 3 p. 130).

    - The IRSS report noted that in some countries the governmental and licensee monitoring is automatically exchanged (page 58). Automatic boundary monitoring was recommended as well by the CNSC Fukushima Task Force (at 38). The availability of this data is extremely important during emergencies as well as during routine operations.
    - The Toronto NERP references "Assurance Monitoring" led by Ministry of Labour in the province in areas adjacent to a radioactive release where protective measures are not required, "aimed at assuring the public that air, food and water are safe." (at 4.10.5)

- **RECOMMENDATION:** The CNSC should confirm that the automatic gamma monitoring is in place at Pickering, and require the automatic exchange of its data with the regulator as suggested by the IRSS and Fukushima Task Force reports.

15. C**ontrol of agricultural products**
    - IAEA Safety Guide GS-G-2.1 outlines expectations for including arrangements to ensure that the public will be instructed not to eat or drink potentially contaminated food, milk and water in the event of a major release. It noted that radiation induced thyroid cancers following the Chernobyl accident occurred mainly **at distances more than 50 km** from the plant, and that "the most effective protective action to prevent or reduce these thyroid cancers would have been to restrict the consumption of potentially contaminated food and milk." (At V.24)

    - CELA notes that the 50 km secondary zone around the Pickering NGS, which is stated to be primarily for ingestion control, would not encompass this situation in which most of the impacts from ingestion following Chernobyl were actually beyond 50 km. Following the experience at Fukushima this is an appropriate response since there were hotspots located as far away as 50 and 80 km.

    - ICRP Publication 109 outlines the preventive agricultural actions that would reduce or prevent doses from ingestion: banning consumption of locally grown food; covering open wells; sheltering animals and animal feed; control of milk; avoiding drinking of milk from animals grazing on potentially contaminated pasture; not eating fresh vegetables, fruit or other food that may have been outside during the release; monitoring of drinking water particularly in case of run-off; and continuing restrictions until sampling shows return to established limits. (at 67)

    - The PNERP, 2009, includes Protection Action Levels (PALS) for ingestion control (food and water) at Annex E; and sets out the levels for foods for general consumption, milk, infant foods and drinking water at which items would be banned. It states that these effective dose PALS were "adopted by the Province in 1984 upon the recommendation of Provincial Working Group #3 and are

generally consistent with Health Canada Intervention levels (2003) and IAEA Safety Series No. 115 (2004).[37]

- The DNERP, 2011 has a brief reference to banning consumption of local water, milk, meat and produce in the section dealing with Partial Activation of the Plan, as a Precautionary Measure. It indicates that the PEOC would discuss with the Regional Emergency Operations Centre the implementation of precautionary measures and communicate them to the public by emergency bulletins issued by the PEOC. There is no mention of food and water bans in the Full Activation section of the DNERP, 2011. The TNERP, 2012 contains an outline under both the Partial Activation and Full sections of the plan, with a list of potential precautionary measures to be considered by the PEOC and does list "clearing the milk storage of dairy farms; banning consumption of any item of food or water that may have been exposed outdoors; banning consumption and export of locally-produced milk, meat, produce, milk-and-meat producing animals" among the precautionary measures that may be indicated. The TNERP indicates that these would be the subject of PEOC emergency bulletins and that the City of Toronto would follow the Province's operational directives regarding implementation. (TNERP, 2012 at 4.3 (e) and 4.5.4 (b))

- **RECOMMENDATION:** CELA recommends that the CNSC request that the Provincial Nuclear Emergency Plan expand its monitoring provisions and ingestion control zones to a distance of 100 km from the NGS, and that it undertake appropriate measures to ensure that monitoring can be done following an accident within that 100 km zone for agricultural produce, foodstuffs, milk and water.

- **RECOMMENDATION:** CELA recommends that the DNERP, 2011 should explicitly outline the measures in respect of controlling ingestion food and water that may be required in the case of a severe nuclear emergency of the type outlined in ICRP Publication 109.

[3737] The PNERP at Annex E, states that the IAEA document International Basic Safety Standards for Protection Against Ionizing Radiation and for Safety of Radiation Sources, IAEA, Safety Series No. 115, 2004 validates the provincial PALS for food and water consumption.

16. **Worker safety**

- The Emergency Worker Protection Plan and Procedures (Annex C to Part II of the DRNEP) states that "until notified otherwise, the Emergency Worker Centres shall enforce a maximum exposure limit of no more than 50 MSv." (At 3.1.1.) Emergency workers (other than police officers already issued personal protective equipment) must first report to the designated Emergency Worker Centres before entering an emergency response sector within the 10 km Primary Zone that is designated a colour representing above background levels of radiation. (Green is at or below background; Orange is background up to 5 mSv per hour; Red is over 5 mSv per hour.) Emergency workers include police, fire, works, transit, OPG and possibly others such as utilities. (Annex C) In sectors designated Orange, workers are to carry dosimeters, check them every hour, and leave the sector if a reading reaches 40 mSv or upon reaching four hours in the sector. In the Red zone, workers are to be accompanied by a knowledgeable escort; are to check dosimeters every 30 minutes, and shall leave after a maximum of one hour. (DNERP Annex C at 3.3.1) Workers report through the Emergency Worker Centres again on leaving the sector. There are default Sector Safety Status ratings for the outset of an emergency until data is available; safety status is to be updated hourly if there is an emission over land occurring in the Primary Zone. (Annex C at 3.2.3)

- Annex C to the Durham plan states that the maximum exposure limit "may only be exceeded in cases of extreme necessity (e.g. to save life or prevent serious injury) by **volunteers** who clearly understand the level of risk they will be facing. (Annex C at 3.1.3) It is not evident how volunteers will be obtained and how their understanding of the level of risk and consent to same is to be assured. Approval from the Regional Emergency Operations Centre must be obtained before emergency workers may be dispatched into a sector where the dose is likely above 50 mSv. (Annex C at 3.1.3)

- **RECOMMENDATION:** Risks of exceeding maximum exposure limits must be discussed with workers in advance of any accident. Methods to review risks and obtain consent to exceed those limits should be explicitly clarified in the Durham Plan. Similar provisions must be included in the Toronto Plan if it is intended that there may be emergency or other workers who volunteer to exceed maximum exposure limits.

- The IRSS report (page 58) referenced and encouraged implementation of the Fukushima Task Force report recommendation that there be additional dose limits established for workers both during and following emergencies in Canada. The Fukushima Task Force, 2011 also recommended (at 54) that the CNSC review the *Radiation Protection Regulations*, section 15 as to potential revisions to "ensure consistency with international guidance." Section 15 provides for the exceeding of applicable dose limits during control of emergencies, and these limits are far higher (ten times higher) than the limits otherwise applicable to workers as provided elsewhere in those *Regulations.* While this is not specific to the Pickering NGS, it is relevant to the context of emergency planning at any of the plants.

- **RECOMMENDATION:** The Fukushima Task Force / IRSS recommendations to establish additional dose limits for workers during and following nuclear emergencies in Canada should be addressed by the CNSC as soon as possible.

17. Frequency of practising emergency planning / drills

- The Ontario Solicitor General advised in its 1987 report to the Hare Commission that exercises were to be held yearly for each facility both onsite and offsite. It would appear from the evidence that this advice had been allowed to lapse at least as to offsite drills in the years since that statement. (See Hare 1988 Vol. 1 at page 227)

- OPG stated that it has conducted drills with offsite agencies in 2008, 2010 and 2012 (CMD 13-H2.1 at 64). However, the IAEA's IRSS Report to Canada (November – December 2011) recommended that Canada "conduct full scale emergency exercises on a periodic basis" (at pages 10 and 70.) The Fukushima Task Force Report, 2011, it noted that "the last full scale nuclear exercise in Ontario was in 2007." (at 46) It is evident then, that the drills OPG says it conducts with offsite agencies are not full scale nuclear exercises. The Task Force further stated that "federal and provincial nuclear emergency planning authorities are not making regularly scheduled full scale NPP exercises a priority." (At 52). This was echoed by the IRSS report which also called for full scale nuclear emergency planning drills to be conducted regularly. It indicated that this should include federal, provincial, municipal and licensee. (IRSS, Recommendation RF8)

- The CNSC's Fukushima Task Force Report, 2011, found that, "Emergency response organizations are capable of responding to single-unit, beyond-design-basis events. Evaluation and revision of emergency plans in regard to multi-unit accidents and severe external events, including an assessment of the minimum complement requirements, have not been performed. As a result, it has not been conclusively demonstrated that emergency response organizations will be capable of responding effectively in a severe event and/or multi-unit accident."(at 39) It also found that "the performance of the emergency response organization under severe event or multi-unit accident conditions has not been challenged by designing and conducting exercises that are based on such conditions." (at 40)

- The CNSC Staff CMD 13-H2.B referenced that a "Unified Response Exercise" is planned for May 2014 and stated that "work has begun on coordinating the interfaces" between the various agencies. (At 8). CELA notes that this exercise will be conducted two and a half years after the receipt of the 2011 Fukushima Task Force Report and three years after the Fukushima accident. CELA does not consider this time frame to be responsive to the Task Force criticism of insufficient prioritizing in Canada of such emergency planning exercises.

- **RECOMMENDATION:** CELA recommends that the CNSC should require annual conduct of exercises dealing with these types of full scale severe event or multi-unit accident scenarios for each plant along with conclusive demonstration of their effectiveness as a licence condition for Pickering in this application. Furthermore, the CNSC should require inclusion of members of the surrounding community and public interest organizations so as to increase input into and confidence in the results. CELA also recommends that their results should be made public, along with lessons learned, and improvements recommended as a result of the exercises; and that the CNSC should require reporting of implementation of those improvements on an annual basis as part of the oversight that it should undertake with respect to offsite emergency planning.

18. **Response time**
    - Capacity of operators and responders to respond and carry out all functions in a timely way for Beyond Design Basis accidents is a significant issue in terms of the effectiveness of emergency planning and preparedness. IAEA Safety Requirements GSR-R-2, "Preparedness and Response for a Nuclear or Radiological Emergency" states that "For facilities in threat category I or II

{which includes nuclear power plants} the threat assessment shall demonstrate for the range of postulated emergencies that identification, notification, activation and other initial response actions **can be performed in time** to achieve the practical goals (see para.2.3) of emergency response." (At Paragraph 4.26.) (Emphasis added). The practical goals in Para. 2.3 include among others, regaining control of the situation, preventing and mitigating consequences; and preventing health effects, both as to early injuries and as to long term effects such as cancers.

- In this respect, it should be noted in particular, that IAEA GSR-R-2 requires, in a section on mitigative action, that "Arrangements shall include emergency operating procedures and guidance for the operator on mitigatory actions for severe conditions, for the full range of postulated emergencies, **including accidents beyond the design basis**." (At paragraph 2.39.) (Emphasis added). However, there is no evidence that OPG has taken this approach, and as reviewed elsewhere in this report, has focussed its emergency planning on-site for design basis accidents.

- In particular, IAEA Guideline GS-G-2.1, "Arrangements for Preparedness for a Nuclear or Radiological Emergency" sets out Response Time Objectives (At Appendix VI, Table 12; pages 104-108). They are applicable for "selected critical response functions or tasks" for nuclear power plants and others. This IAEA Safety Standard states that they should be used as part of the performance objectives for a response capability and should be used as part of evaluation criteria for exercises.
- However, there is no evidence that these response time objectives have been established for the Pickering plant (or within the Durham NERP, the Toronto NERP or the provincial nuclear emergency response plan). Moreover there is no indication that they have been used or documented in emergency response evaluation; nor that the regulator, CNSC has required demonstration of response time objectives as part of its criteria in licensing the Pickering nuclear power plant.
- Some of the matters of particular concern to the surrounding community in the event of a severe, beyond design basis accident, as to capacity to respond in a timely manner, and which should therefore be demonstrated by the operator; and required by the regulator to be verified include, among others (from IAEA GS-G-2.1 Table 12):

- Classifying / declaring the emergency, within 15 minutes "from the time at which conditions indicating that emergency conditions exist are detected"
- Notifying local authorities in the Precautionary Action Zone and the Urgent Protective Action Planning Zone, within 15 minutes from the time of declaring the emergency
- Recommending urgent protective actions for the public on the basis of the emergency classification, within 30 minutes from the time of classifying / declaring the emergency.

- **RECOMMENDATION:** The response times required by these IAEA Safety Requirements and Guideline documents GS-R-2 and GS-G-2.1 should be included in the Provincial and municipal emergency plans for Pickering. In particular, the CNSC should require that these response times are met and demonstrated as part of its licensing decision for the Pickering NGS.

C. Safety –

There are a large number of extremely serious safety issues facing the NGS at Pickering. For these reasons, among others, CELA urges the CNSC not to grant the requested Licence to Operate to OPG. Rather CELA urges that the CNSC require OPG to provide a plan for an orderly closure and decommissioning of all of the units at Pickering. OPG is planning to operate the Pickering B reactor beyond the 210,000 "Equivalent Fuel Power Hours (EFPH) hours "assumed design life". (See E Docs 4057120 Submission of Technical Basis for Continued Operation of Pickering B Units 5-8 Pressure Tubes Dec. 14, 2012 OPG to M. Leblanc at p. 1). The plan to operate beyond the design life of the plant is of extremely serious safety significance. Some of the indications of the rapidly increasing safety risks include:

- Unexpected recent results include the discovery of slight bowing and a thicker black deposit than previously observed on fuel elements removed from the reactor (Dec 11 SCR report on Nov. 30 observations – Edocs 4052277)
- Ever more complex aging management requirements – for example see OPG Aging Management Process 2011 (E Docs 3832128) and OPG Integrated Aging Management (E Docs 3725316), Heat Transport System Aging Analysis with impacts on safety margins and increasing uncertainties along with need for additional

research and potential adjustments including to trip set points and operating constraints (E Docs 3588658).

- Adverse effects on the effectiveness of station shutdown systems as a result of aging (See CNSC submission March 2011 Regulatory Oversight Plan re Pickering B End of Life (E Docs 3669120, p. 11))
- Lack of two entirely independent shutdown systems at Pickering A (Pickering A 2010 Safety Report E Docs 3069405, p. 28)
- Shared Vacuum building and pressure relief duct between Pickering A and B stations in the context of an aging set of reactors (Pickering A 2010 Safety Report E Docs 3069405, p. 28)
- shared safety systems: emergency coolant injection and vacuum building (Pickering A Safety Report, p. 21)
- Probabilistic Safety assessments are inherently incomplete.[38]

D. Sufficiency of Information Base for Licensing

There are a number of areas where the information on critical issues is not complete, and is not necessarily expected to be available by the time of the Day Two Hearing. CELA submits that the Panel should not make a decision on extending the operation of the Pickering Plant beyond its design life without having this additional information.

- Examples of these deficiencies in the record include:
    - The not yet available update of the 2009 Pickering A PSA, particularly in respect of both internal and external events, including seismic, high winds, fires, floods and other hazards (See CMD 13-H2.B, CNSC Staff Supplementary Submission, at p. 5), now not expected until end of 2014 for certain elements rather than end of 2013.
    - The Pickering B updated PSA has been provided, but CNSC staff state they will not have completed a detail review of it until June, 2014; however CELA submits this staff review

[38] A list of reasons that Probability Risk Assessments cannot provide a complete assessment of accident risk was provided in the Working Group #8 Report: There are types of accidents that are often explicitly excluded such as those caused by earthquakes, fires, floods; there are types of initiating causes not considered because they are difficult to quantify e.g. deliberate hostile action; gross human error; there are combinations of events that escape consideration; there are many areas have no statistical or experimental data available and so reliance is placed on judgment; and there are calculated combinations of events put below a certain level of probability because they are considered "highly speculative" at those "low levels". (At 23.)

is essential information for the Panel prior to authorizing the extended operating life. (CMD 13-H2.B at p. 5)

- The Pickering B PSA results are not inclusive of all threats and hazards; for example they do not include in the quantitative results malfeasance or terrorism.
- OPG's supplementary submission (CMD 13-H2.1B at p. 11) states that a Nuclear Response Multi-Agency Reference Manual in respect of emergency planning to provide a "baseline of roles and responsibilities for external agencies" is in preparation and will be presented to the Commission at a meeting in August, 2013. This follows the scheduled completion of this hearing but CELA submits should be available prior to completion of this licence hearing as it is a matter of significant import for the relicensing.
- The lack of understanding the "black deposit" issue on discharged fuel bundles form Unit 1.
- The latest update of the Heat Transport System aging strategy (expected to be updated in 2015 for the period 2016-2020); CNSC staff reviews of preliminary assessments are not due until December 2013.
- The several units that lack Passive Autocatalytic Recombiners for hydrogen mitigation, (planned to be done in 2013 and 2014)
- Specific issues noted in the CNSC CMD13-H2 that must be satisfactory before proceeding: Steam Line Break (at p. 28); Channel Voiding during a Large Loss of Coolant Accident (at p. 28); review and acceptance of the results of the fuel-channel life cycle project that was due to be completed by March 2013 (at p. 87).
- Hazard Analysis, internal, external and malevolent including airplane crashes; completion of which is expected mid to end of 2013 (CMD13-H2 at p. 30).
- Hold points are planned in respect of regulatory oversight of aging of fuel channels (CMD 13-H2 at 42); specifically "four hold points for end of assumed design life of each of the Pickering B units." (at 87)
- The following selected Fukushima Action Items are outstanding as listed in OPG's CMD 13-H2.1B; they are of sufficient import that they should be resolved prior to issuance of the requested licence extension:
    - FAI 1.3.2 Where the existing means to protect Containment integrity and prevent uncontrolled releases

of radioactive products in beyond design basis accidents including severe accidents are found inadequate, a plan and schedule for design enhancements to control long term radiological releases and, to the extent practicable, unfiltered releases. December 2015.

- FAI 2.1.1 Re-evaluation, using modern calculations and state of the art methods, of the site specific magnitudes of each external event to which the plant may be susceptible. December 2013.

- FAI 3.1.2 For multi-unit stations, provide plans and schedules for the inclusion of multi-unit events in SAMGs. December 2013.

- FAI 3.2.1 An evaluation of the adequacy of existing modeling of severe accidents in multi-unit stations. The evaluation should provide a functional specification of any necessary improved models. December 2012.

- FAI 4.1.1 – An evaluation of the adequacy of existing

  Emergency plans and programs. December 2012.

E. Siting

- One of the key requirements of the IAEA Safety Requirements Site Evaluation for Nuclear Installations, NS-R-3 (2003), is to analyze "the characteristics of the population of the region and the capability of implementing emergency plans over the projected lifetime of the plant." (At 2). That document states that it is primarily concerned with low probability severe events. It states, "population growth and population distribution shall be monitored over the lifetime of the nuclear installation." (At 3.) It further states that, if after evaluation no measures can be taken to keep the "radiological risk to the population associated with accident conditions, including those that could lead to emergency measures being taken" acceptably low, then "the site shall be deemed unsuitable for the location of a nuclear installation of the type proposed." (Excerpts at 9.) The concern with the ability to implement an emergency plan is also emphasized in the new Draft IAEA Safety Standard "Safety Aspects in Siting for Nuclear Installations", DS433, October 10, 2011. (At 50)

- Given the existing population density in area of Pickering (as reviewed earlier in the discussion on evacuation), the Pickering NGS is no longer a suitable site for operation of a nuclear power plant; particularly for operation of a multi-unit station. As noted earlier, Durham Region's population as a whole as of 2009 was 614, 970; projected to grow to 949,100 by 2026, and within 40 km of the Pickering site were 3.2 million people back in 2001. These population numbers are too high to be located in close proximity to nuclear generating stations. [39] [40]

    - The Province of Ontario's Places to Grow process has continued to propose considerably increased population numbers for Durham over the coming year. The trends in population density show Durham region have increased and continuing to increase population density. As noted earlier, there are sectors around Pickering in which the estimates indicate that evacuation in certain conditions could take from 4 to 37 hours according to the DRNERP as reviewed above in the discussion with respect to evacuation.

    - Working Group # 8 in 1988 recommended that the province take appropriate action in "the advisability of restricting new housing construction near nuclear facilities." A similar recommendation was made by the Joint Review Panel in the Darlington New Build EA Report. It not now being possible to prevent this housing construction, and heavy population density having built up in the Pickering area, including both in the Cities of Pickering and Toronto (Scarborough), the CNSC should not authorize the further licensing of this plant beyond its design life and should not extend its operating license beyond 2014.

    - As outlined in the Pickering A and B Safety Reports, there is also a considerable workforce in the area. There are also major transportation routes of national importance that would be disrupted in the event of a

[39] Figure 2-3 in the Pickering B Safety Report, 2012 NK30-SR—1320-00001 Rev. 4 shows the population trends of Metro Toronto and Durham Region since the 1970s when the plant was originally cited. (P. 88 of 110)

[40] See also Page 89 of the Pickering A safety report – which provides a graph of demographic data in the broader circumference around the Pickering site.

severe accident at Pickering, including Highway 401, Highway 2 and the CN and CP Rail lines.

- In addition there are a large number of major airstrips and airports in the area.[41] The presence of this multiplicity of air traffic would both represent a major disruption of commercial aviation traffic in the event of a severe offsite accident at Pickering, and also poses an ongoing risk to the plant itself. IAEA Safety Guide NS-G-3.1 states that "the potential for aircraft crashes that may affect the plant site should be considered in the early stages of the site evaluation process and it should be assessed over the entire lifetime of the plant." (At 22).[42]

- The area is also the location of Canada's newest national (urban) park, as well as to a large number of recreational areas important to the GTA and especially the Scarborough and Pickering communities as listed in the Pickering A Safety Report.

- CELA submits that the Pickering site would never be authorized today for a new nuclear facility. For the same reasons, neither should it be granted a licence to operate beyond the design life of the Plant. CELA submits that the Pickering NGS no longer meets the safety expectations of the public nor of siting standards by its location in such a highly populated region as a result of which expeditious evacuation is not possible.

F. Re recommendations for community engagement

- In reviewing the materials relevant to emergency planning at the Pickering NGS and in Ontario generally, CELA noted that there is insufficient consultation with the public as to the choices made; and there is insufficient communication with the public as to the plans and their details once they are developed. It is a matter of significant concern as to the extent to which the public in both Durham Region and the City of Toronto is aware of, and engaged in providing input to the content of the nuclear emergency

[41] Pickering A Safety Report, Table 19

[42] IAEA Safety Guide NS-G-3.1, "External Human Induced Events in Site Evaluation for Nuclear Power Plants." (IAEA, 2002).

plans. This in itself increases the risks and potential consequences from a severe offsite accident at the Pickering nuclear plant.

- Many residents of Durham region are unaware of provisions in the Nuclear Emergency Response Plan that anticipate that they will find their own accommodation with friends and family in case of evacuation; that they may be asked to "self-decontaminate" in some scenarios, and what that means; that KI is effective only if taken before or immediately upon commencement of a release; they are unaware of the transportation plans that would be available if they do not have their own vehicles; and they are concerned about family reunification in the event of evacuation scenarios in which members of their family are evacuated separately from the family such as from schools and long term care institutions.

- IAEA Publication "Lessons Learned from the Response to Radiation Emergencies (1945 – 2010), (IAEA, August 2012) includes a comment in the chapter "providing information and issuing instructions and warnings to the public", about the importance of providing information to the public on protective actions to be taken in event of an emergency in **advance** of any emergency for threats such as Nuclear Power Plants. They stated that "This will engender confidence – the knowledge that the officials have their interest at heart – and, by doing so, improve compliance with protective action recommendations in the event of a real emergency. In addition, there will be a better understanding of the systems used to warn them of an emergency." (At 27) CELA agrees with this assessment but we do not see a sufficient level of advance communication with the public in the 10 km zone around the Pickering NGS, both within the Region of Durham and within the City of Toronto, to feel confident that people sufficiently understand the protective actions to be taken in the event of a Pickering NGS emergency. CELA recommends that the CNSC require extensive public engagement to be undertaken by OPG as a condition of any further operating licence of the Pickering NGS, to include specific explanation of the protective actions that may be required, why, and how they would be communicated and in what eventualities.

- This recommendation is reinforced by the comment in ICRP Publication 109[43] which recommends engagement with stakeholders and discussions of the plans, including with members of the public. The rationale is that "Otherwise, it will be difficult to implement the plan effectively during the response. The overall protection strategy and its

[43] International Commission on Radiological Protection, "Application of the Commission's Recommendations for the Protection of People in Emergency Exposure Situations", (ICRP Publication 109, 2008)

constituent individual protective measures should have been worked through with all those potentially exposed or affected, so that time and resources do not need to be expended during the emergency exposure situation itself in persuading people that this is the optimum response." (at 42)

G. REGULATORY OVERSIGHT: DECISION OF THE CNSC IN THIS APPLICATION

CELA urges the CNSC to exercise its role as regulator in respect of emergency planning in response to Nuclear Power Plant accident threats at the Pickering station. CELA urges the CNSC to exercise a stringent oversight role as to whether emergency planning and preparedness have been proven prior to exercising its discretion to provide a further operating licence to the Pickering NGS.

- The IAEA Standard, Preparedness and Response for a Nuclear or Radiological Emergency, Series No. GS-R-2, Safety Standards (Vienna: IAEA, 2002) sets out expectations as to the responsibility of the regulator. A more complete copy of this excerpt is provided as Appendix A to this submission. It is the regulator's responsibility, among other things, to do the following (excerpts from GS-R-2 paragraphs 3.8 to 3.12:
    - The regulatory body shall require that arrangements for preparedness and response be in place for the on-site area for any practice or source that could necessitate an emergency intervention.
    - The regulatory body shall ensure that such emergency arrangements are integrated with those of other response organizations.
    - The regulatory body shall ensure that such emergency arrangements provide a reasonable assurance of an effective response, in compliance with these requirements, in the case of a nuclear or radiological emergency.
    - The regulatory body shall require that the emergency arrangements "shall be tested in an exercise before the commencement of operation [of a new practice]. There shall thereafter at suitable intervals be exercises of the emergency [arrangements], some of which shall be witnessed by the regulatory body."
    - In fulfilling its statutory obligations, the regulatory body… shall establish, promote or adopt regulations and guides upon which its regulatory actions are based;… shall provide for issuing, amending, suspending or revoking authorizations, subject to any necessary conditions, that are clear and unambiguous and which shall specify (unless

elsewhere specified):… the requirements for incident reporting;…and emergency preparedness arrangements.
- In planning for, and in the event of [a nuclear or radiological emergency], the regulatory body shall act as an adviser to the government.
- The regulatory body shall ensure that the co-ordinated arrangements are implemented adequately by the operators.

- The Fukushima Task Force 2011 discussed the lack of specific regulatory requirements for operators for emergency planning and the lack of specific and detailed requirements as well as the lack of sufficient regulatory oversight given the gap in the regulatory framework. (CNSC Fukushima Task Force Report 2011 at 40). CELA concurs with this concern, as in reviewing G-225 "Emergency Planning at Class I Facilities and Uranium Mines and Mills" and RD-353, "Testing the Implementation of Emergency Measures", we observed that the requirements were too high-level and non-specific to provide useful measures against which the nuclear emergency plans applicable to an accident at Pickering could be compared and tested. The Fukushima Task Force reiterated this concern in its chapter reviewing the Canadian nuclear regulatory framework in view of lessons learned from the Fukushima accident. It again stated that the CNSC should require offsite emergency plans to be submitted along with applications to construct or operate nuclear power plants. (At 53).

- The Fukushima Task Force report stated that: ``Federal and provincial nuclear emergency planning could be strengthened through establishing a formal, transparent, national-level oversight process for offsite nuclear emergency plans, programs and performance, and through scheduling of regularly planned full-scale exercises.``[44] The IRSS report noted these Fukushima Task Force made recommendations that the CNSC should require the submission (to the CNSC) of the provincial nuclear emergency response plans. The IRSS report encouraged this to be done. (At 58) In the presentation by CNSC at the March, 2013 inter-jurisdictional emergency planning workshop, the responsibility of regulators to ensure emergency response capability and these Fukushima Task Force and IRSS recommendations were also noted.

- The IRSS report (conducted of CNSC from Nov 26 to Dec 2, 2011) also noted that there are a multiplicity of agencies and levels of government with responsibilities in nuclear emergency planning in Canada and recommended that the CNSC should "verify the requirements and

[44] (CNSC Fukushima Task Force Report, CNSC INFO-0824, October 2011 at iv, v)

standards described in the offsite emergency plans are met, through tests and assessments." (at page 59)

- **RECOMMENDATION:** CELA submits that the CNSC should not grant the licence to OPG beyond the current licence period without verifying "through tests and assessments" the adequacy of the emergency plans in place for the Pickering NGS, both on-site and off-site, to respond to severe nuclear emergencies.

- **RECOMMENDATION:** CELA submits that even without additional regulatory amendments recommended by the Fukushima Task Force and the IRSS, the CNSC already has jurisdiction to consider the adequacy of the emergency plans in place at Pickering in deciding whether to issue the licence requested, and/or whether to impose additional requirements by way of licence conditions to better protect health, safety and the environment. (Sections 3, 9, 24 of the *Nuclear Safety and Control Act*, S.C., 1997, c. 9)

- **RECOMMENDATION:** CELA urges that the Fukushima Task Force recommendations for CNSC oversight of the offsite nuclear emergency response plans be pursued forthwith by way of amendment of the CNSC regulations and requirements there-under. This particularly includes the recommendation for description of the regulatory requirements to address radioactive hazards during an emergency **in greater detail**. This also includes the recommendation of the Task Force to enhance regulatory oversight with periodic safety reviews and to increase requirements for "requirements and expectations for both design basis and beyond design basis accidents``. (Task Force at v).

H. Conclusion and Recommendations

- **RECOMMENDATION 1:** CELA submits that this licence should not be granted until all of the measures list by OPG in its application in Appendix 6, along with other recommendations made by the 2011 IRSS Report, the 2011 CNSC Fukushima Task Force and recommendations herein are actually in place and demonstrated to the regulator, with evidence, to be effective. CELA also submits that it is critical that this evidence be made public. Members of the surrounding communities must be able to understand what is in place; how effective it is; what has changed; and on what basis the regulator is judging the emergency plans to be in place.

- **RECOMMENDATION 2:** CNSC should require multi-unit severe accident planning to be demonstrated by OPG, along with the effectiveness of off-site emergency response in such a case. Similarly, CNSC should ensure, contrary to previous practice, that extreme natural hazard initiated events and "gross human error" are also examined in terms of presenting an emergency planning basis, and that the on-site and off-site emergency preparedness and planning are demonstrated to be sufficient and reliable to respond to all of these undesirable scenarios in the event that they lead to severe offsite releases.

- **RECOMMENDATION 3:** CELA recommends that this post-accident source term information be required by the CNSC as a condition of licensing and that the CNSC require OPG to upgrade their capacity to provide source term information and its basis, for multi-unit accidents, as a condition of the Pickering NGS licence. This should include reassessment of plume and dose modelling for multi-unit accidents at the Pickering NGS as recommended by the Fukushima Task Force.

- **RECOMMENDATION 4:** CELA recommends that the CNSC should require the licensees to demonstrate that there are, in place, properly resourced, sufficiently detailed emergency planning and preparedness plans that would address Chernobyl–size accidents or Fukushima–size accidents. The basis for this recommendation includes world-wide experience with these catastrophic accidents. This recommendation is independent of particular event sequences and rather takes account of the myriad ways that things that can go wrong resulting in an accident and resulting in a serious breach of containment, regardless of how caused. It also includes consideration of the fact that among the events that may initiate a catastrophe at a CANDU are those that are beyond the control of the operator such as hostile action or unforeseen external weather events or unforeseen combinations of failures including human error.

- **RECOMMENDATION 5:** The authority of Toronto Emergency Planning Officials to immediately initiate the Public Alerting System upon receipt of a notification from OPG for a general emergency with an imminent or ongoing emission should be clearly specified. If it is not intended that this authority be provided to Toronto's officials under the TNERP, this should be stated with a rationale for the discrepancy compared to the DRNERP.

- **RECOMMENDATION 6:** CELA recommends that the CNSC refuse further extension of Pickering's operating licence without the 3 km and 10 km alerting systems fully functional, both within the Region of Durham and within the City of Toronto, with robust evidence that they have been fully tested and are effective to meet the objectives specified in the PNERP, 2009.

- **RECOMMENDATION 7:** CELA also recommends that the emergency response plans time-frames be compressed so as to provide alerts to the public, and instructions to the public on protective actions required in as short a time frame as possible, preferably less than 30 minutes from the onset of the accident. Methods to compress this time frame should be considered and tested, and their efficacy should be one of the points of evaluation by the CNSC in the licence applications by the operators.

- **RECOMMENDATION 8:** CELA recommends that as an interim measure, the CNSC should require that OPG in conjunction with the City of Toronto, conduct outreach and notification to members of the public resident in Toronto (at a minimum within the Primary Zone), as to the availability of KI and provide advice as to where it may be obtained.

- **RECOMMENDATION 9:** The applicability of Durham's Annex D to the residents of Toronto in the Primary Zone must be clarified. Alternatively, the same provisions for KI distribution, consent and information letters for school age children, and other matters dealt with in Annex D must be specified in the TNERP.

- **RECOMMENDATION 10:** CELA recommends that the CNSC should require the operator to systematically evaluate and report back to the CNSC the percentage of households within the 10 km Primary Zone, both within the Region of Durham and the City of Toronto, who have obtained KI tablets in advance, as well as the percentage of institutions covered by the plan who have them on hand in sufficient quantities to cover all of their residents or students. Based on this evaluation, CELA recommends that the CNSC require the approach that was taken in France be taken in Canada for the 10 km zone around each operating nuclear generating station, to undertake and ensure 100% pre-distribution of KI tablets to the residents in the Primary Zone and that this requirement be included in the licensing conditions for the Pickering NGS.

- **RECOMMENDATION 11:** CELA recommends that the CNSC require OPG to include in its outreach material to the public, in conjunction with regional emergency response officials, explanations about the capability of sheltering and its limitations as described in the IAEA Guide GS-G-2.1 and to reinforce instructions as to steps to take for rapid and effective evacuation in the case of notification of a significant emergency.

- **RECOMMENDATION 12:** CELA recommends that the Pickering Operating licence should not be extended without the Provincial Radiation Health Response Plan and the municipal Radiation Health Response Plans in place.

- **RECOMMENDATION 13:** CELA recommends that in view of the experience at Chernobyl and Fukushima, the CNSC should request that the province immediately revisit the 50 km secondary ingestion zone with a recommendation to change it to 100 km. This should be done as part of detailed planning for severe offsite accidents so that appropriate monitoring of food, agricultural products, milk, and water is established and in place in the event of such an accident.

- **RECOMMENDATION 14:** CELA recommends that the CNSC require that the nuclear emergency planning zones be expanded. CELA submits that the 10 km Primary zone should be extended to 30 km and the 50 km Secondary zone should be extended to 100 km.

- **RECOMMENDATION 15:** CELA recommends that the CNSC should require OPG to work with the local municipalities to ensure the public clearly understands what plans are in place to assist them with evacuation from the Primary Zone if they do not have their own transportation. The details of those plans should be clearly specified in the Durham and Toronto Nuclear Emergency Plans, and widely communicated to the public in outreach and education.

- **RECOMMENDATION 16:** CELA recommends that the CNSC should require OPG to communicate to the public in annual outreach and education, the fact that the nuclear emergency response plans expect the public to make their own arrangements in the event of evacuation, and for those who cannot, what is expected to be provided by the municipalities. The appropriateness of this approach should further be discussed with the public in terms of future nuclear emergency planning.

- **RECOMMENDATION 17:** CNSC should require OPG to conduct studies and to work with offsite emergency responders, the municipalities and the Province to ensure that there are realistic evacuation plans in the case of a severe accident with early large release, as well as in the case of plans for twenty kilometer and 50 kilometer evacuation zones around the Pickering NGS.

- **RECOMMENDATION 18:** CELA recommends that the CNSC require the applicant to conduct a study as to the awareness of the Pickering Nuclear Plant of people beyond the Primary Zone at Pickering, and as to their likely response in the event that a general emergency is declared and the Primary Zone is evacuated. The CNSC should require the applicant to evaluate the impact of increased evacuation zones of twenty and fifty kilometers on evacuation time estimates, as well as any other needed adjustments that would result from larger evacuation zones to the emergency plans surrounding Pickering such as locations of Emergency Workers Centres, numbers of emergency workers required for evacuation management, traffic routes, size of evacuation centres, and locations and capacity of Decontamination and Monitoring Units, and to report its findings to the CNSC and to the provincial EMO, the City of Toronto, and the Region of Durham.

- **RECOMMENDATION 19:** CELA recommends that CNSC direct the applicant to work with the municipalities to consult with the surrounding communities on specific plans for family reunification following evacuation in the event of a severe nuclear emergency.

- **RECOMMENDATION 20:** Explanations about what "self-decontamination" means; how to do so; and a statement as to its efficacy should be included in the Toronto Nuclear Emergency Response Plan and in outreach and education to the public about implementation of the plan.

- **RECOMMENDATION 21:** The CNSC should confirm that OPG's automatic gamma monitoring is in place at Pickering, and require the automatic exchange of its data with the regulator as suggested by the IRSS and Fukushima Task Force reports.

- **RECOMMENDATION 22:** CELA recommends that the CNSC request that the Provincial Nuclear Emergency Plan expand its monitoring provisions and

ingestion control zones to a distance of 100 km from the NGS, and that the province undertake appropriate measures to ensure that monitoring can be done following an accident within that 100 km zone for agricultural produce, foodstuffs, milk and water.

- **RECOMMENDATION 23:** CELA recommends that the DNERP, 2011 should explicitly outline the measures in respect of controlling ingestion food and water that may be required in the case of a severe nuclear emergency of the type outlined in ICRP Publication 109.

- **RECOMMENDATION 24:** Risks of exceeding maximum exposure limits must be discussed with workers in advance of any accident. Methods to review risks and obtain consent to exceed those limits should be explicitly clarified in the Durham Plan. Similar provisions must be included in the Toronto Plan if it is intended that there may be emergency or other workers who volunteer to exceed maximum exposure limits during an emergency.

- **RECOMMENDATION 25:** The Fukushima Task Force / IRSS recommendations to establish additional dose limits for workers during and following nuclear emergencies in Canada should be addressed by the CNSC as soon as possible.

- **RECOMMENDATION 26:** CELA recommends that the CNSC should require annual conduct of exercises dealing with full scale severe event multi-unit accident scenarios along with conclusive demonstration of their effectiveness as a licence condition for the Pickering NGS. Furthermore, the CNSC should require inclusion of members of the surrounding community and public interest organizations so as to increase input into and confidence in the results. CELA also recommends that their results should be made public, along with lessons learned, and improvements recommended as a result of the exercises; and that the CNSC should require reporting of implementation of those improvements on an annual basis as part of the oversight that it should undertake with respect to offsite emergency planning.

- **RECOMMENDATION 27:** The response times required by these IAEA Safety Requirements and Guideline documents GS-R-2 and GS-G-2.1 should be included in the Provincial and municipal emergency plans for Pickering. In particular, the CNSC should require that these response times are met and demonstrated as part of its licensing decision for the Pickering NGS.

- **RECOMMENDATION 28:** CELA submits that the CNSC should not grant the licence to OPG beyond the current licence period without verifying "through tests and assessments" the adequacy of the emergency plans in place for the Pickering NGS, both on-site and off-site, to respond to severe nuclear emergencies.

- **RECOMMENDATION 29:** CELA submits that even without additional regulatory amendments recommended by the Fukushima Task Force and the IRSS, the CNSC already has jurisdiction to consider the adequacy of the emergency plans in place at Pickering in deciding whether to issue the licence requested, and/or whether to impose additional requirements by way of licence conditions to better protect health, safety and the environment. (Sections 3, 9, 24 of the *Nuclear Safety and Control Act*, S.C., 1997, c. 9)

- **RECOMMENDATION 30:** CELA urges that the Fukushima Task Force recommendations for CNSC oversight of the offsite nuclear emergency response plans be pursued forthwith by way of amendment of the CNSC regulations and requirements there-under. This particularly includes the recommendation for description of the regulatory requirements to address radioactive hazards during an emergency **in greater detail**. This also includes the recommendation of the Task Force to enhance regulatory oversight with periodic safety reviews and to increase requirements for "requirements and expectations for both design basis and beyond design basis accidents``.

I. Decision Requested:

CELA requests that the CNSC not issue the licence requested by OPG to operate the Pickering Units A and B for a further five years. Rather, CELA requests that the CNSC order OPG to prepare an application for the orderly closure and decommissioning of the Pickering Nuclear Generating Station.

All of which is respectfully submitted this 3rd day of May, 2013:



CANADIAN ENVIRONMENTAL LAW ASSOCIATION

Per

Theresa A. McClenaghan

Executive Director and Counsel

Appendix A – Excerpt from IAEA GS-R-2 "Preparedness and Response for a Nuclear or Radiological Emergency, Series no. GS-R-2, Safety Standards (Vienna: IAEA, 2002).

"3.8. **The regulatory body shall require** that arrangements for preparedness and response be in place for the on-site area for any practice or source that could necessitate an emergency intervention. For a facility in threat category I, II or III "Appropriate emergency [preparedness and response] arrangements shall be established from the time that nuclear fuel [or significant amounts of radioactive or fissile material] is brought to the site, and complete emergency preparedness as described here shall be ensured before the commencement of operation." (Ref. [12], Para. 2.36.) **The regulatory body shall ensure that such emergency arrangements are integrated with those of other response organizations as appropriate before the commencement of operation**. **The regulatory body shall ensure that such emergency arrangements provide a reasonable assurance of an effective response, in compliance with these requirements, in the case of a nuclear or radiological emergency. The regulatory body shall require that the emergency arrangements "shall be tested in an exercise before the commencement of operation [of a new practice]. There shall thereafter at suitable intervals be exercises of the emergency [arrangements], some of which shall be witnessed by the regulatory body."** (Ref. [12], para. 2.37.)
3.9. **"In fulfilling its statutory obligations, the regulatory body… shall establish, promote or adopt regulations and guides upon which its regulatory actions are based;… shall provide for issuing, amending, suspending or revoking authorizations, subject to any necessary conditions, that are clear and unambiguous and which shall specify (unless elsewhere specified):… the requirements for incident reporting;… and emergency preparedness arrangements**." (Ref. [10], para. 3.2.)
3.10. "In planning for, and in the event of [a nuclear or radiological emergency], the **regulatory body shall act as an adviser to the government** and [response organizations] in respect of nuclear safety and radiation protection." (Ref. [10], para. 6.6.)
3.11. The national co-ordinating authority and the response organizations shall ensure that the arrangements for response to a nuclear or radiological emergency are co-ordinated with the arrangements for response to conventional emergencies. The **regulatory body shall ensure that the co-ordinated arrangements are implemented adequately by the operators**.
3.12. In the event of a nuclear or radiological emergency the time available for decision making and for implementing an effective strategy for response may be short. It is therefore important that an appropriate management system be used. All organizations that may be involved in the response to a nuclear or radiological emergency shall ensure that appropriate management arrangements are adopted to meet the timescales for response throughout the emergency. Where appropriate, the management system shall be consistent with that used by other response organizations in order to ensure a timely, effective and co-ordinated response." **(Emphasis added)**

Risk Specific Plan

TORONTO NUCLEAR EMERGENCY RESPONSE PLAN (TNERP)

August 2020

Office of Emergency Management www.toronto.ca/oem

TORONTO

Toronto Nuclear Emergency Response Plan (TNERP)

Lead: Office of Emergency Management

Supporting City of Toronto Divisions, Agencies and Commissions (DACs):

Toronto Fire Services	Toronto Public Health	Toronto Police Service
Toronto Paramedic Services	Toronto Transportation	Toronto Transit Commission
Toronto Water	Toronto Occupational Health and Safety	Strategic Communications

Supporting External Agencies:

Centennial College	Canadian Red Cross	York University

Accronyms and Abbreviations

Table 1: Accronyms and Abbreviations

AAZ	Automatic Action Zone
BDBA	Beyond Design Basis Accident
CMOH	Chief Medical Officer of Health
CNSC	Canadian Nuclear Safety Commission
CPZ	Contingency Planning Zone
CRL	Chalk River Laboratories
DNGS	Darlington Nuclear Generating Station
DPZ	Detailed Planning Zone
EMCPA	Emergency Management and Civil Protection Act
EIC	Emergency Information Centre
EOC	Emergency Operations Centre
EPZ	Emergency Planning Zone
IPZ	Ingestion Planning Zone
ITB	Iodine Thyroid Blocking
KI	Potassium Iodide
km	Kilometre
LGIC	Lieutenant Governor in Council
MCSCS	Ministry of Community Safety and Correctional Services
MDU	Monitoring and Decontamination Unit
MOHLTC	Ministry of Health and Long-Term Care
MTO	Ministry of Transportation, Ontario
NEMCC	Nuclear Emergency Management Coordinating Committee
PEOC	Provincial Emergency Operations Centre
PNERP	Provincial Nuclear Emergency Response Plan
PNGS	Pickering Nuclear Generating Station
PPE	Personal Protective Equipment
RD	Radiological Device
UTCC	Unified Transportation Coordination Centre
UTMP	Unified Transportation Management Plan

Executive Summary

The City of Toronto is a Designated Municipality and within the affected area of Pickering Nuclear Generating Station. Municipalities designated pursuant to Section 3(4) of the Emergency Management and Civil Protection Act (EMCPA) as municipalities in nuclear Detailed Planning Zones (DPZs) have the following responsibilities:

- Preparedness
- Provision of Personnel
- Response
- Training & Exercises
- Infrastructure

Details of these responsibilities are described in Annex I Appendix 15 of the Provincial Nuclear Emergency Response Plan (PNERP) – Master Plan 2017

The Pickering Nuclear Generating Station (PNGS) Detailed Planning Zone is the area immediately surrounding the reactor facility extending out to an approximate radius of 10 kilometres which includes the eastern most limit of the City of Toronto.

The City of Toronto is also implicated as a designated host municipality for emergencies at the Darlington Nuclear Generating Station (DNGS). In coordination with the Provincial Nuclear Emergency Response Plan (PNERP) and the Implementing Plan for the Pickering Nuclear Generating Station, this Plan lays out the City of Toronto's response to a nuclear emergency focusing on Pickering's Nuclear Generating Station (PNGS) but also making provisions for an emergency at Darlington Nuclear Generating Station (DNGS).

The key strategies employed in the Toronto Nuclear Emergency Response Plan are evacuation, protective action, and public information. The activities the Toronto Emergency Operations Centre (EOC) will enact include coordination between the Provincial Emergency Operations Centre (PEOC) and the City of Toronto's Divisions, Agencies, and Corporations (DACs); establishment of Reception Centres and Emergency Worker Centres; and, public alerting and information in coordination with the Provincial Emergency Information Section.

Led by the Toronto Office of Emergency Management (OEM), the City of Toronto's Nuclear Emergency Planning Committee (TNEPC), consisting of key Divisions, Agencies, and Corporations (DACs) with leadership roles and major responsibilities in a nuclear emergency response operation is responsible for this Plan. Its membership is also responsible for coordinating their related operational plans with the overall intent and strategies of this one. This Plan is being continuously updated and expanded upon.

Appendices:

Appendix 1 - Pickering Nuclear Generating Station Detailed and Contingency Planning Zones
Appendix 2 - Pickering Nuclear Generating Station Ingestion Planning Zones
Appendix 3 - Population Data by Sector/Planning Zone
Appendix 4 - Toronto EOC Nuclear Emergency Notification Procedure
Appendix 5 - Emergency Information and Alerting
Appendix 6 - Toronto Nuclear Mass Evacuation/ Transportation Plan
Appendix 7 - Nuclear Emergency Reception Centres
Appendix 8 - Toronto Nuclear Emergency Local Traffic Control Plan
Appendix 9 - Emergency Workers Centre - Land
Appendix 10 - Emergency Workers Centre - Marine

Figures and Tables:

Figure 1: Nuclear and Radiological Emergency Response Planning Structure (2017 PNERP)..... **Error! Bookmark not defined.**
Figure 2: Initial Provincial Response to an On-Site Emergency Notification as outlined in the Implementating Plans for the PNGS and DNGS ..... **Error! Bookmark not defined.**
Figure 3: Protective and Precautionary Measures – (all references made in the above table can be found in the 2017 PNERP Master Plan)..... **Error! Bookmark not defined.**
Figure 4: Pickering Nuclear Generating Station Detailed and Contingency Planning Zones (extracted from the PNGS Implementing Plan) .... **Error! Bookmark not defined.**
Figure 5: Pickering Nuclear Generating Station Ingestion Planning Zones (extracted from the PNGS Implementing Plan). 43

Annexes:

TBD

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1.0 Scope and Authority

1.0.1 This document is the official City of Toronto Nuclear Emergency Response Plan (TNERP). It is raised in accordance with the Emergency Management and Civil Protection Act (EMCPA); the Provincial Nuclear Emergency Response Plan – Master Plan (PNERP); the Implementing Plan for the Pickering Nuclear Generating Station (PNGS IP); the City of Toronto Emergency Plan, the City of Toronto Emergency Support Functions (ESFs) and the City of Toronto Risk Specific Plans (RSPs). Toronto's Office of Emergency Management (OEM) under direction of the Toronto Emergency Management Program Committee (TEMPC) has oversight of this Plan.

1.0.2 The hierarchy of legislative and non-legislative authorities governing emergency response plans for the Pickering Nuclear Generating Station are depicted in the PNERP and replicated here:

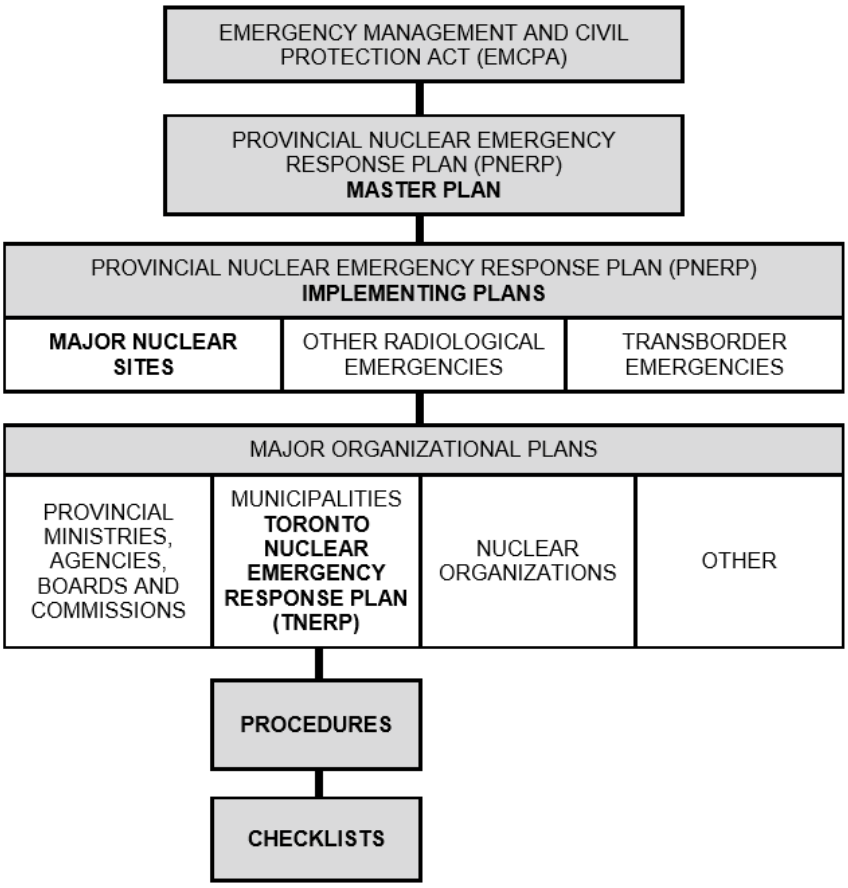


Figure 1: Nuclear and Radiological Emergency Response Planning Structure (2017 PNERP)

1.0.3 The TNERP outlines the roles and responsibilities of the City of Toronto, including its Divisions, Agencies and Corporations (DACs), with respect to provisions of the PNERP and PNGS IP. It must be read in conjunction with those plans. In case of any apparent discrepancies between the PNGS IP and the TNERP, the former shall take precedence.

1.0.4 Together, this set of plans describes how provincial decisions are implemented by the City of Toronto in response to a nuclear emergency.

1.1 Aim

1.1.1 The aim of the TNERP is to provide operational guidance for the City of Toronto's response to a nuclear emergency, setting out plans for deployment of resources and enabling communication and coordination amongst responsible partners and the City of Toronto's Office of Emergency Management (OEM).

1.2 Municipal Response Plans

1.2.1 The City of Toronto and the Regional Municipality of Durham are Designated Communities with respect to PNGS (PNERP Master Plan, Annex A). The City of Toronto is the Designated Host Community in emergency response operations relating to Darlington Nuclear Generating Station (DNGS) (PNERP Master Plan, Annex A).

1.2.2 In accordance with the PNERP, this Plan is developed to address associated responsibilities and activities including offsite emergency response arrangements; and, activities of designated municipalities, municipal divisions, boards, and police services.

1.2.3 Radiological and Designated Host Community plans are being conceptualized to amplify the TNERP in accordance with roles and responsibilities outlined in the PNERP, **Annex I – Appendix 16**.

1.3 Partners and Emergency Operations Centres

1.3.1 Federal, provincial, municipal, Ontario Power Generation, and other partners utilize emergency operations centres (EOCs) to manage and coordinate emergency response operations including nuclear emergencies. Partner EOCs relevant to this Plan include but are not limited to:

- The Government Operations Centre (Public Safety Canada)
- The Federal Coordination Centre (Public Safety Canada)
- The Regional Emergency Coordination Centre (Public Health Agency of Canada, Ontario Region)
- Ontario Power Generation Corporate Emergency Operations Facility
- The Provincial Emergency Operations Centre (PEOC)
- The Ontario Ministry of Health Ministry Emergency Operations Centre (MEOC)

- The Ministry of Transportation Ontario Unified Traffic Coordination Centre (UTCC)
- The Regional Municipality of Durham Emergency Operations Centre
- The Canadian Red Cross, Toronto Region Duty Officer; and
- Divisional Operations Centres (DOCs) and other similar organizations or functions within the City of Toronto's divisions, agencies and corporations

The Office of Emergency Management's operational partners include but are not limited to the following internal and external partners:

- Toronto Fire Services
- Toronto Police Service
- Toronto Paramedic Services
- Toronto Public Health (TPH)
- Toronto Transit Commission (TTC)
- Canadian Red Cross
- York University – Keele Campus
- Centennial College – Progress Campus
- The Marine Emergency Worker Centre and Reception Centre at Bluffers Park Complex
- Ontario Power Generation (OPG); and
- The Ontario Office of the Fire Marshal and Emergency Management (OFMEM) (includes the PEOC)

1.3.2 To ensure liaison and coordination between different elements of the emergency response system, the following arrangements and agreements shall be made in advance of an emergency:

- Provincial Liaisons to be deployed to the Toronto EOC
- PNGS Liaisons to be deployed to the Toronto EOC; and
- OPG support to Emergency Worker Centres including monitoring and decontamination capabilities, radiation monitoring team activities, and technical briefings

1.4 Tactical Response

1.4.1 The TNERP provides operational guidance. Where questions of tactics arise, the TNERP may allude or make reference to potential tactics but it does not prescribe them to first line response organizations or operators. Tactical plans are developed and maintained by participating partners and divisions within the City of Toronto.

2.0 Emergency Response: Overview

2.0.1 The TNERP's primary focus is on the Pickering Nuclear Generating Station which resides approximately 45 kilometres east of Toronto City Hall. The most easterly limit of City of Toronto border is situated approximately 5 kilometres west of the nuclear generating station.

2.0.2 The greatest hazard to people is potential exposure to and inhalation of airborne radionuclides, radioiodine and particulates that could be emitted from the nuclear generating station in times of emergency. Depending on the severity of damage and/or malfunction of the nuclear generating station, radioactive emissions to the surrounding environment could continue for weeks and may cover a relatively small or large area around the nuclear generating station. Levels of radioactivity emitted from the station may range from low to higher amounts.

2.0.3 Protective measures are available for minimizing the radiation hazard in a nuclear emergency. They include entry control (restricting the public from entering specific areas); sheltering (staying indoors); evacuation (leaving the area when directed); thyroid blocking (consumption of Potassium Iodide (KI pills) made available to members of the Pickering Detailed Planning Zone; and, the use of protective equipment and self-decontamination (cleaning oneself of any exposure to the "dust"). Each of these measures are defined in the Nuclear/Radiological Glossary, Appendix C, of the PNGS IP. The operational use of these measures is prescribed in appropriate sections of this Plan.

2.0.4 For the purposes of the PNERP, PNGS IP, and this Plan, four centrifugal planning zones around PNGS are considered:

a. Automatic Action Zone: The area immediately surrounding the PNGS out to an approximate radius of 3 kilometres. (See Appendix '1' of the TNERP).

b. Detailed Planning Zone: Inclusive of the Automatic Action Zone, it is the area around the PNGS within a 10 kilometre radius. Detailed planning and preparedness is carried out for measures against exposure to radioactive emission in this zone. It includes an area of Toronto from the Durham-Toronto boundary west to Morningside Avenue and extending to Finch and Steeles Avenues in the north. The Zone extends out into Lake Ontario to a radius of approximately 10 kilometres from PNGS. The exact boundaries of the zone are identified in (Appendix '1' of the PNERP), including parts of the Regional Municipality of Durham.

c. Contingency Planning Zone: The centrifugal area between 10 and 20 kilometres from the PNGS. Contingency planning and arrangements are made so that

during a nuclear emergency, protective actions can be extended beyond the Detailed Planning Zone to reduce potential for exposure; and

d. Ingestion Planning Zone: The Ingestion Planning Zone encompasses all areas of the City of Toronto, Regional Municipalities of Durham, York and Peel and City of Kawartha Lakes within a 50 kilometre radius of PNGS. The Ingestion Planning Zone includes all other zones

City of Toronto population data related to these zones is available in Appendix '3' of the TNERP.

2.0.5 Planning times for radioactive emissions resulting from an accident at PNGS depend on the condition and functioning of the station containment system, as well as the Station's ability to prevent escape of radioactive material. Planning assumptions are:

a. A minimum interval of 2 days between occurrence of the accident and the commencement of an emission when containment systems are functioning normally

b. Venting (controlled) could cause intermittent emissions lasting many weeks; and

c. Impaired containment could cause continuous emissions very soon after an accident

2.0.6 Emergency facilities could be established when a full nuclear emergency response is staged. Partnerships listed in para 1.3 of the TNERP could be utilized to establish:

- A Marine Emergency Worker Centre at the Scarborough Bluffs (Bluffers Park)
- An Evacuation/Reception Centre at York University; and
- An Emergency Worker Centre at Centennial College

2.0.7 The Toronto EOC is equipped with a dedicated landline which is linked with OPG's Corporate Emergency Operations Facility in Whitby, Ontario. In the event of a telecommunications failure, Toronto EOC will use two-way radio communications with Metronet radios that are pre-established and regularly tested through Toronto Police Service.

2.1 Concept of Operations

2.1.1 Response to a nuclear emergency at Pickering Nuclear Generating Station can be generally categorized by the type of emergency it responds to: a "Design Basis Accident" (DBA) or a "Beyond Design Basis Accident" (BDBA). In a DBA, station containment systems will likely be functional and will facilitate controlled release of decayed radiation, giving response organizations time to alert the public and implement

protective measures. The main hazard would be exposure to radionuclides and risk of environmental contamination and radioactivity would be lowered. In a BDBA, station containment systems may be impaired, potentially leading to early or uncontrolled release of radioactive emissions, risking high radiation doses and environmental contamination in the DPZ.

2.1.2 Radiological emergencies could also arise as a result of accidents at reactor facilities or during the transportation of radioactive material; employment of Radiological Devices, Radiological Dispersal Devices, or Radiological Exposure Devices (malicious human-caused events); satellite re-entry; nuclear weapon detonation; or, lost, stolen, or orphaned radiation sources. In such events, field monitoring will inform the delineation of planning or response zones surrounding the incident site and which exposure control and protective measures shall be employed.

2.1.3 The primary hazard the TNERP prepares for are accidents at the Pickering NGS; however, as a Designated Host Community for nuclear emergency response at Darlington NGS, elements of the TNERP may be enacted to manage consequences associated with an event at that location as well in support of the Regional Municipality of Durham.

2.1.4 If an emergency occurs at the PNGS, a notification process overviewed below will be immediately initiated. The PEOC shall immediately activate and assume incident command. In a nuclear emergency response operation, the Toronto EOC will activate to an emergency response level that parallels the PEOC and it will enact an approximately similar Incident Management System (IMS) structure. The Toronto EOC will notify all concerned partners and stakeholders within the City of Toronto as soon as possible.

2.1.5 The PNERP, Annex D, Section 5.0 outlines Ontario's notification categories and their associated response. They are:

a. Reportable Event: An event affecting the reactor facility which would be of concern to the off-site authorities responsible for public safety. Provincial and municipal duty staff should respond as per routine monitoring.

b. Abnormal Incident: An abnormal occurrence at the reactor facility which may have a significant cause, and/or may lead to more serious consequences. Response should include enhanced monitoring from respective emergency operations centres and staff checks.

c. On-Site Emergency: A serious malfunction which results or may result in atmospheric release of radioactive material. Partial or full activation of emergency operations centres shall occur and various off-site response centres shall be established; and

d. General emergency: An ongoing or imminent atmospheric release of radioactive material as a result of a more severe accident. Response plans, organizations, and emergency operations centres shall be fully activated and appropriate protective measures may be taken.

2.1.6 The combined City of Toronto concept of operations can be best summarized as:

a. Notification of a nuclear or radiological emergency through established contact procedures. (For the City of Toronto – Emergency Level Notifications ESF)

b. Actions by the owner/operator on site to respond to the emergency. Activation of emergency response organizations and their nuclear emergency response plans.

c. Determination of the type, potential scale, and potential impact of the emergency and the scale of response: partial or full activation

d. Official declaration of a Provincial emergency.

e. Determination and implementation of appropriate protective action response strategy

   i. Precautionary measures
   ii. Protective measures for exposure and/or ingestion control
   iii. Invoking of any required mutual aid agreements

f. Alerting and public communications (continuous)

g. Determination and implementation of emergency worker protection strategy

h. Determination of need for and implementation of appropriate evacuation strategy

   i. Emergency Worker Centres
      Emergency Reception Centres; and
   ii. Demobilization and return to normal state upon cessation of the emergency

2.2 Initial Notification of Nuclear Emergencies in Ontario

2.2.1 The PNERP and the PNGS IP establish standards for initial notification of nuclear emergencies. Reactor facilities are responsible for notifying designated provincial and municipal contacts of a nuclear emergency within 15 minutes of categorizing the event. This notification should include the notification category. The PEOC, in turn, is responsible for deciding on its initial response level and notifying the Designated Host Community and other stakeholders of its response within 15 minutes.

2.2.2 Paragraphs 2.1.4 and 2.1.5 of the TNERP outline the nuclear emergency notification categories and process to the PEOC, Toronto EOC, and Durham EOC.

2.2.3 If partial or full activation is required, the EOC shall be automatically activated to the required level and OEM's management team along with the City's Senior Leadership will be notified. The EOC will immediately notify its municipal, private, non-profit, and other partners of the emergency.

2.2.4 Just as the nuclear facility and the PEOC will establish operating and reporting periods, the Toronto EOC will also establish operating and reporting periods at that time.

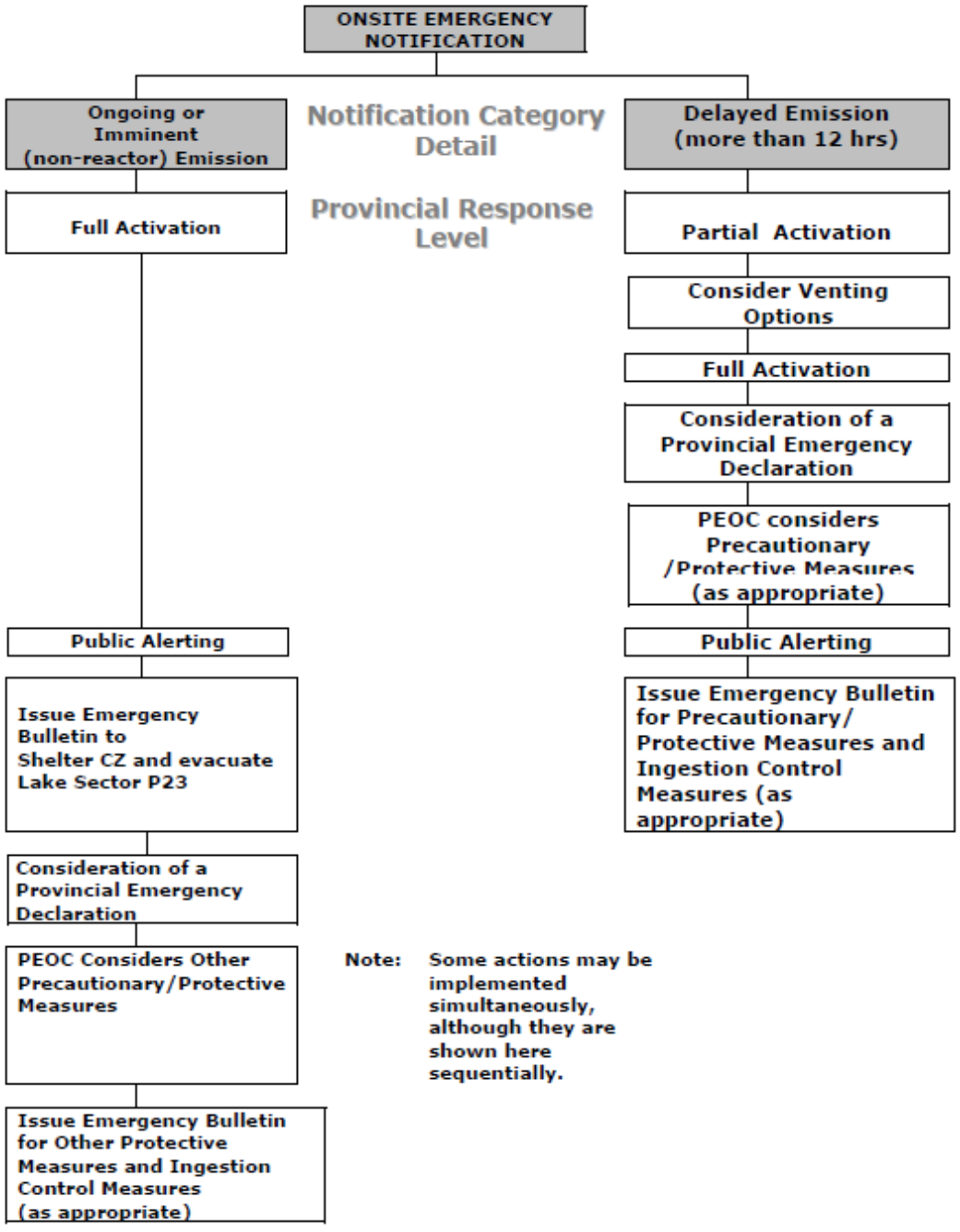


Figure 2: Initial Provincial Response to an On-Site Emergency Notification as outlined in the Implementating Plans for the PNGS and DNGS

2.3 Initial Notification of Radiological Emergencies in Ontario

2.3.1 The first indications of a radiological event may come from the Canadian Nuclear Safety Commission for routine matters or incidental release; other government agencies reporting incidents within their area of responsibility (i.e. Transport Canada reporting an accident and spill); a local emergency response organization; or a community.

2.3.2 In the event that notification is received, the PEOC shall make notifications and take action in accordance with the PNERP Implementing Plan for Other Radiological Emergencies. There may be implications for the City of Toronto that could require activation of components of this response Plan or other emergency response plans.

2.4 Activation and Deactivation of Emergency Plans

2.4.1 The TNERP will be immediately actioned as soon as notification of PNERP activation is received. The level of Plan activation and EOC activation will align with the PEOC unless specified otherwise.

2.4.2 The Toronto EOC will notify all City of Toronto partners that the EOC and TNERP have been activated, and they will also immediately activate their plans and organizations in parallel.

2.4.3 The following table outlines initial posturing after notification is received and emergency plans are activated.

Table 2: Initial Provincial and City of Toronto response and posture

INITIAL NOTIFICATION	INITIAL PROVINCIAL RESPONSE	INITIAL CITY OF TORONTO RESPONSE
Reportable Event	Routine Monitoring	Routine Monitoring
Abnormal Incident	Enhanced Monitoring	Enhanced Monitoring
On-site Emergency (No emission occurring)	Partial Activation	Partial EOC Activation
On-site Emergency (Emission ongoing or expected within 12 hours)	**Full Activation**	**Full EOC Activation**
General Emergency (Emission ongoing or expected within 12 hours)	**Full Activation**	**Full EOC Activation**

2.5 Operational Lead

2.5.1 Incident Command resides with the PEOC Commander. Whenever a nuclear emergency or a radiological emergency requiring activation of the PNERP occurs, the PEOC Commander is primarily responsible for leading the off-site response by supporting and coordinating the emergency response.

2.5.2 The PEOC Commander shall consult with the EOC Director for the municipality when planning to issue operational directives or communicate an emergency order for a protective measure within a municipal area.

2.5.3 In accordance with Chapter 59 of the Toronto Municipal Code, the Toronto Emergency Management Program Committee Control Group will assume Incident Command for the City of Toronto. The EOC Director will be primarily responsible for coordinating the off-site emergency response and implementing this plan.

2.6 Declaration and Termination of an Emergency

2.6.1 The authority for the declaration and termination of Provincial emergencies pursuant to the EMCPA is the Lieutenant Governor In Council (LGIC) or the Premier if the urgency of the situation requires that it be made immediately.

2.6.2 The authority for the declaration and termination of an emergency in the City of Toronto pursuant to Chapter 59 of the Toronto Municipal Code is the Mayor. They may declare an emergency, take action, and make orders as they consider necessary and not contrary to the law.

2.7 Emergency Phases

There are three phases of a nuclear emergency outlined in the PNERP and amplified in the PNGS IP: the Early Phase, the Intermediate Phase, and the Recovery Phase. These phases of response differ depending on whether the initial response activation is partial or full.

Transition between phases is not always clear. Recovery plans should define a transition process from the nuclear emergency response phase to the recovery phase, identify the organizations involved, assess the need for additional resources, and adjust protective actions as required. Basic recovery transition criteria include:

- Completion of the nuclear emergency and facility's return to safe operation
- Ability to safely and permanently return evacuees to their residences; and
- Discontinuation of all emergency response activities

2.7.1 Early Phase

The Early Phase of the emergency:

a. Begins with an initial notification before or during a radioactive release as described in parasgraphs 2.2 and 2.3 of this plan

b. Starts with the first warning of a significant radiological problem and could last from hours to days

c. May require use of protective measures. The PEOC Science Section's technical assessment of the situation shall prepare a preliminary assessment and updated assessments of the need for exposure control, ingestion control, and/or emergency worker protective measures.

2.7.2 Intermediate Phase

The Intermediate Phase:

a. Begins once the radioactive release or source is brought under control (though not necessarily contained) and reliable environmental radiation monitoring is available for use in protective action decision-making.

b. The PEOC Scientific Section shall undertake and continuously update assessments of:

- Off-site environmental radiation monitoring, producing a picture of the contamination situation
- Protective actions, such as exposure and ingestion control measures, which will inform the Protective Action Response Strategy directed by the PEOC to all stakeholders; and
- Sector safety status, resulting in recommendations for emergency workers operating in the area.

c. Psychosocial support measures shall also be implemented as necessary during the intermediate stage. Planning for the management of radioactive waste generated by the emergency should preferably begin during this phase.

2.7.3 Recovery Phase

The Recovery Phase:

a. Begins when short-term and long-term actions can be taken in order to restore, to an acceptable level, both the organizations involved and the communities affected by, the nuclear emergency and the associated response activities.

b. May include emergency management and response operations continuing (e.g., ingestion control protective measures, restoration activities, etc.).

c. May include activities described in a separate plan such as:

- Case for persons exposed and/or contaminated
- Psychosocial support
- Long-term relocation issues
- The resettlement of and return of individuals affected by the nuclear emergency
- Long-term support to the public living in contaminated areas
- Decontamination or reconstruction of property damaged as a result of the emergency and associated response activities; and
- Economic impact studies and studies on how to revive local business activity

3.0 Protective Action Response Strategy

3.0.1 During the response to a nuclear emergency, the PEOC shall implement a protective action response strategy based on the PEOC Scientific Section's analyses and recommendations to protect the public and responding emergency workers from the effects of a radioactive emission. The Toronto EOC shall adopt the PEOC's Protective Action Response Strategy and communicate and coordinate its implementation in the City of Toronto.

3.0.2 Protective action decision-making can be categorized according to response phase where the hazard and its location are known.

3.1 Guiding Principles for Protective Action Decision-Making

3.1.1 Protective actions include both precautionary and protective measures. They are complementary to each other and may be applied in combination. It may be necessary to justify and optimize the application of protective actions with respect to risks and costs (psychosocial and economic).

3.1.2 When a protective action is warranted at any boundary of a response sector in the Detailed Planning Zone, it should be applied to the whole response sector. If a protective measure is warranted in the Detailed Planning Zone, it should be applied to the entire ring of sectors in order to ensure protection when winds are shifting.

3.1.3 The PEOC Commander, as the operational lead for the off-site response, has the authority on behalf of the Province for protective action decision-making and shall direct the implementation of protective measures as appropriate. They may issue operational directives or emergency orders if an emergency is declared.

3.1.4 Protective actions include precautionary measures, exposure control protective measures, ingestion control protective measures and additional measure to protect the public.

3.1.5 Protective measures will be implemented through emergency bulletins communicating the PEOC Commander's direction to the public and stakeholders in the emergency response. If no emission is expected for 36 hours or more at the time of issue, the emergency bulletin should include the date and time of expected emission; sectors potentially affected by the emission; if or when precautionary measures or protective actions will be ordered and what they might be; public inquiry phone numbers; and, evacuation instructions.

3.1.6 Emergency bulletins issued within 36 hours of expected emission will be increasingly directive. Emergency bulletins for sheltering-in-place will be broadcast as soon as that need is identified. The timing to issue an operational directive for sheltering-in-place shall ultimately be determined by the PEOC. Alert Ready and other broadcast methods will be used. Alert Ready in Ontario is part of a national service designed to deliver critical and potentially life-saving emergency alert messages to Canadians. Emergency alerts are distributed on radio, TV and compatible wireless devices to help ensure that Ontarians have the critical information they need in emergencies to take necessary precautions to protect themselves and their families.

3.2 Precautionary Measures

3.2.1 The PEOC Commander shall direct precautionary measures as appropriate in the Detailed Planning Zone, the Contingency Planning Zone, or parts therefor. Timing will be a consideration in this direction.

3.2.2 The Toronto EOC will communicate and coordinate the dissemination of these emergency directives.

3.2.3 Protective measures may include:

a. Closing of beaches, recreation areas, etc.

b. Closing of workplaces and schools

c. Suspension of admissions of non-critical patients in hospitals

d. Entry control

e. Clearing the milk storage of dairy farms

f. Banning consumption of any item of food or water that may have been exposed outdoors

g. Banning consumption and export of locally produced milk, meat, produce, milk- and meat-producing animals; and

h. Removing milk and meat-producing animals from outside pasture and exposed water sources

3.3 Protective Measures for Exposure Control

3.3.1 Evacuation, Decontamination, and Temporary Relocation: The purpose of an evacuation is to prevent or minimize the exposure of members of the public to the effects of radiation. All residents in the affected area will be directed to evacuate, and those who require transportation to leave the Detailed Planning Zone will be assisted according to the Mass Evacuation Transportation Plan outlined in Appendix 6 of the TNERP). All routes will be utilized to evacuate the Detailed Planning Zone.

3.3.2 In the event of an ongoing or imminent emission, evacuees exposed to radioactive emissions can be expected to have varying levels of contamination. Where found, contamination will be in the form of loose particulate on people, their belongings, and vehicles. Internal contamination may be present in individuals exposed to radioactive emissions. Self-decontamination may be the primary means of decontamination; however, monitoring at decontamination facilities will be required for those evacuees who will not be able to self-decontaminate.

3.3.3 For the purpose of this plan, temporary relocation shall be considered synonymous with evacuation. Functionally, it will occur almost identically during an immediate nuclear emergency response.

3.3.4 Iodine Thyroid Blocking: The decision to direct thyroid blocking will be made by the Provincial Chief Medical Officer of Health (CMOH) in coordination with the PEOC. Potassium Iodine (KI) pills are pre-stocked at the Emergency Worker and Evacuation/Reception Centres in the City of Toronto. Once notified of the need for thyroid blocking, the City of Toronto will notify staff located in the Detailed Planning Zone.

3.3.5 If and when the CMOH issues direction to the public to ingest a dose of KI, the City will take actions to notify or confirm that staff working in the Pickering Detailed Planning Zone are directed to take this protective measure. The process is outlined in Section 4.5 of this plan.

3.3.6 Shelter-in-Place: In the case of an imminent emission, the operational directive to shelter-in-place shall be issued by the PEOC via an emergency bulletin at least 4 hours before the emission is expected to commence. Emergency bulletins will be issued by the PEOC Emergency Information authority, via Alert Ready and broadcast media. The Toronto EOC will further distribute the bulletin through Strategic Communications staff using its Emergency Information and Media Relations Emergency Support Function (ESF) and other means, as required.

3.3.7 In the case of an ongoing emission, all sectors adjacent to sectors requiring evacuation will be directed to shelter-in-place.

3.4 Protective Measures for Ingestion Control

3.4.1 Before an emission commences, appropriate ingestion control measures will be directed by the PEOC via emergency bulletin as a precaution within and, if necessary, adjacent to the Detailed Planning Zone. The Toronto EOC will amplify the PEOC's direction and the City will adopt directions immediately.

3.4.2 If general Province-wide monitoring indicates the need, appropriate ingestion control measures will be considered in areas known or suspected to be contaminated. Based on the data produced by ground monitoring, additional ingestion control measures will be considered, where necessary, while the original precautionary measures may be lifted by the PEOC where appropriate.

3.4.3 Protective measures for ingestion control most relevant to the City of Toronto may include:

a. Milk control

b. Water control

c. Foodstuff control

d. Land control; and

e. Environmental decontamination

3.5 Protective Action Decision-making for Radiological Emergencies

3.5.1 Protective measures may have been implemented by government agencies early in the event, before reliable radiological information was available. Once Environmental Monitoring Teams are activated and data is received and analyzed, these protective measures can be adjusted or new ones directed based on operational, technical, and public policy considerations.

3.6 Additional Measures to Protect the Public

3.6.1 The PEOC Commander may recommend other practical dose reduction measures to the public. Such measures may be implemented in combination with the measures described above or, may simply be recommended to provide an additional level of protection against possible radionuclides present. Such measures include:

a. Respiratory protection, including ad hoc protection;

b. Self-decontamination and decontamination of critical areas and objects; and

c. Staying indoors to the extent that it is practical.

3.6.2 Detailed advice regarding these measures shall be developed and implemented in both the preparedness stage through public awareness and education as well as for the emergency phase through the emergency bulletin process. Chapter 5 of the PNERP, Initiating An Emergency Response prescribes various measures that can be taken during each phase of a nuclear emergency. The following chart is extracted from the PNERP depicts those measures

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Early Phase (Section 5.9.1)		Intermediate Phase (Section 5.9.2)			Recovery Phase (Section 5.9.3)		
Precautionary Measures	Protective Measures (Implementation Criteria)	Precautionary Measures	Exposure Control Measures	Ingestion Control Measures (based on OILs)	Precautionary Measures	Exposure Control Measures	Ingestion Control Measures (based on OILs)
- Closing of beaches, recreation areas, etc. - Closing of workplaces and schools - Suspension of non-critical patient admissions in hospitals - Entry (access) control - Clearing milk storages of dairy farms - Banning consumption of exposed *foodstuff* or water	- *Sheltering-in-place* (Default measure, as appropriate; when projections available - *Generic Criteria* **Annex E, Appendix 1**) - *Iodine Thyroid Blocking* (Default measure, as appropriate; when projections available - *Generic Criteria*) - *Evacuation* (Default measure, as appropriate; when projections available - *Generic Criteria*) - Protective Clothing (as applicable) - Respiratory Protection (as applicable) - Self-*Decontamination* (as applicable) - Staying indoors (as far as practicable)	- Closing of beaches, recreation areas, etc. - Closing of workplaces and schools - Suspension of non-critical patient admissions in hospitals - *Entry control*	- *Sheltering-in-place* (OILs, **Annex E, Appendix 2**) - *Iodine Thyroid Blocking* (OILs) - *Evacuation* (OILs) - Relocation (OILs) - Protective Clothing (as applicable) - Respiratory Protection (as applicable) - Staying indoors (as far as practicable)	- *Milk control* - *Water control* - *Pasture control* - Produce and *crop control* - *Livestock control* - *Foodstuff* control	- Rescinded as appropriate	- Rescinded as appropriate	- *Milk control* - *Water control* - *Pasture control* - Produce and *crop control* - *Livestock control* - *Foodstuff* control - *Land control* - *Environmental decontamination*

Figure 3: Protective and Precautionary Measures – (all references made in the above table can be found in the 2017 PNERP Master Plan)

4.0 Operational Response

4.0.1 The operational response activities of the City of Toronto depend on the notification category received from the PEOC. The City of Toronto will respond accordingly based on the directions received from the PEOC or appropriate authority.

4.0.2 This response plan specifies strategies and operations that will be undertaken in response to an event at Pickering NGS which results in, or has the potential to result in, an emission of radioactive material into the atmosphere. It is intended to be flexible and scalable: some of the strategies or operations may be enacted in response to similar events at Darlington NGS or for radiological emergencies.

4.1 Guiding Principles for an Operational Response

4.1.1 In a nuclear or radiological emergency, the goals of an operational response are to:

a. Mitigate radiological and non-radiological consequences

b. Ensure that designated municipal and affected agencies are kept apprised of the situation and, where time permits without threatening public health and safety, are consulted prior to any decisions being made

c. Keep the public informed; and

d. Prepare for the resumption of normal social and economic activity

4.1.2 The initial notification of a nuclear emergency and corresponding actions are outlined in paragraph 2.4 of the TNERP and expanded upon below.

4.2 Recap of Response Overview

4.2.1 The initial response to a nuclear emergency varies based on the type of event or incident that is occurring. Generally, when an event or incident occurs at a nuclear facility, the operator shall report the incident to the PEOC and other implicated partners within 15 minutes of its becoming aware of the occurrence.

4.2.2 The PEOC, the Toronto EOC, and applicable partners will adopt an operational posture appropriate for the type of event or incident that is occurring.

4.2.3 Initial response actions for the PEOC and the Toronto EOC are outlined in Table 2, Initial Provincial and Municipal Response on the following page.

Table 3: Initial Provincial and City of Toronto Response (based on information extracted from the PNERP Annex D and the PNGS and DNGS Implementing Plans)

INITIAL NOTIFICATION	INITIAL PROVINCIAL RESPONSE	INITIAL CITY OF TORONTO RESPONSE
REPORTABLE EVENT	**ROUTINE MONITORING** **1.** Provincial Emergency Operations Centre (PEOC) shall notify the municipal contact point(s), Ontario Power Generation (OPG), and others as appropriate, and shall monitor the situation. **2.** Scientific Section staff is consulted, if appropriate. **3.** If and when appropriate, PEOC Emergency Information (EI) staff issues news release(s).	**ROUTINE MONITORING** **1.** Emergency Management Public Order (EMPO) of Toronto Police Service (TPS) shall be notified by PEOC. **2.** PSU shall notify Office of Emergency Management (OEM). **3**. Emergency response staff, (TPS and OEM) will remain in contact with the PEOC and monitor event.
ABNORMAL INCIDENT	**ENHANCED MONITORING** **1.** PEOC shall adopt Enhanced Monitoring, and shall so inform the municipal contact point(s), OPG, and any other organizations affected. **2.** External notifications to Michigan, New York, Ohio and Quebec are made. **3.** PEOC to set up a duty team consisting of operations staff, scientific staff, OPG representative(s), EI staff, and others as required. **4.** If and when appropriate, PEOC EI staff issue news release(s). **5.** Provincial staff are notified to remain available to report in for duty.	**ENHANCED MONITORING** **1.** Emergency Management Public Order (EMPO) of Toronto Police Service (TPS) shall be notified by PEOC. **2.** PSU shall notify Office of Emergency Management (OEM). **3.** Emergency response staff will monitor the event via the OEM. The OEM will activate the Emergency Operations Centre (EOC).

INITIAL NOTIFICATION	INITIAL PROVINCIAL RESPONSE	INITIAL CITY OF TORONTO RESPONSE
ONSITE EMERGENCY (No emission occurring)	**PARTIAL ACTIVATION** **1.** PEOC shall adopt Partial Activation response and shall initiate the appropriate internal and external notifications, including the municipal contact points and the host communities. **2.** PEOC shall be fully staffed. Consideration shall be given to issuing an Emergency Bulletin and/or news release. **3.** Ministry EOCs and Joint Traffic Control Centre (JTCC) to be established and appropriately staffed.	**PARTIAL ACTIVATION** **1.** OEM will issue notifications to place municipal emergency response organizations on standby. **2.** Toronto EOC will be fully activated. **3.** Emergency information function at Toronto EOC is operational. **4.** OEM will activate the Emergency Social Services ESF to activate emergency centres to become operational without undue delay.
ONSITE EMERGENCY (Emission ongoing or expected within 12 hours)	**FULL ACTIVATION** **1.** PEOC shall notify and require the municipal contacts to activate the public alerting system. **2.** PEOC shall adopt Full Activation, and shall initiate the appropriate internal and external notifications including the host community. **3.** PEOC shall issue the appropriate Emergency Bulletin. **4.** PEOC shall issue operational directives implementing the following operational measures, unless there are good reasons for modifying this response, for: **(a)** Sheltering-in-place in the Automatic Action Zone **(b)** Suspension of road and rail traffic through the Automatic Action Zone **(c)** The clearance of all boaters in Lake Sector P23 **5.** PEOC shall assess the situation for further action. **6.** PEOC shall issue further Emergency Bulletins, as appropriate.	**FULL ACTIVATION** **1.** Public Alerting will be initiated via Toronto EOC **2.** Toronto OEM will issue notifications to activate municipal emergency response organization. **3.** Toronto EOC, including Emergency Information and Media Relations function and other centres will be activated and fully staffed. **4.** Toronto EOC will implement operational directives, as issued by the PEOC. **5.** Toronto EOC will activate all three Emergency Response Centres, York University, Emergency Worker Centre at Centennial College and Emergency Worker and Reception Centre at Bluffers Park Complex.

INITIAL NOTIFICATION	INITIAL PROVINCIAL RESPONSE	INITIAL CITY OF TORONTO RESPONSE
	7. PEOC EI section shall issue news releases, as appropriate. **8.** JTCC and Ministry EOCs to be established.	
GENERAL EMERGENCY (Emission ongoing or expected within 12 hours)	**FULL ACTIVATION** **1.** PEOC shall notify and ensure that the municipal contacts have activated the public alerting system. **2.** PEOC shall issue the appropriate Emergency Bulletin. **3.** PEOC shall issue operational directives implementing the following operational measures for: (a) suspension of road, rail and air traffic throughout the Automatic Action Zone (b) the evacuation of the Automatic Action Zone and Lake Sectors P23 through P25 unless there are good reasons for modifying this response. **4.** If emission is ongoing or, if evacuations will not be completed prior to emission, issue operational directives implementing the operational measures for: (a) Evacuees to report for radiation monitoring or, if not possible, to evacuate to a destination beyond the PZ and to undertake self-decontamination. (b) The ingestion of KI pills in the Automatic Action Zone. (c) Sheltering-in-place in the rest of the Detailed Planning Zone. Otherwise, take this action 4 hours (or, at a time deemed appropriate) before the expected time of commencement of the emission. **5.** PEOC shall adopt Full Activation, and shall initiate the appropriate internal and external notifications, including the host community. **6.** PEOC shall assess the situation for further action.	**FULL ACTIVATION** **1.** Public alerting will be initiated via Toronto EOC **2.** Toronto OEM will issue notifications to activate municipal emergency response organization **3.** Toronto EOC, including emergency information and media relations function and other centres will be activated and fully staffed. **4.** Toronto EOC will implement operational directives, as issued by the PEOC. **5.** Toronto EOC will activate all three Emergency Response Centres, York University, Emergency Worker Centre at Centennial College and Emergency Worker and Reception Centre at Bluffers Park Complex.

INITIAL NOTIFICATION	INITIAL PROVINCIAL RESPONSE	INITIAL CITY OF TORONTO RESPONSE
	7. PEOC shall issue further emergency bulletins, as appropriate. **8.** PEOC EI section shall issue news releases, as appropriate. **9.** Ministry EOCs and JTCC to be established.	

4.2.3 Operational directives on protective measures and strategies may be sent via emergency bulletins at this point. Declaration of a provincial emergency may also follow immediately after notification.

4.2.4 The City of Toronto's response strategies and operations will differ based on the type of emergency and response plan activation level. In the event of an "Abnormal Incident", the Toronto EOC shall activate to **Level 3 – Major Emergency**.

4.2.5 The PEOC's response posture will be that of either partial or full activation, which the Toronto EOC will match. The PEOC may be partially activated but shall be fully staffed if a reactor emission is expected to occur in 36 hours or more, or if no emission is expected. It may be fully activated for an ongoing emission (or one imminently occurring). In both cases, the Toronto EOC shall activate to **Level 3 – Major Emergency.**

4.3 Partial or Full Activation

4.3.1 In this plan, some of the strategies employed by the City of Toronto and the Toronto EOC to respond to an emergency differ based on partial or full activation of the Plan, as noted above.

4.3.2 The initial sequence of actions for activation and response will be:

Table 4: Partial Activation and Full Activation

Partial Activation	**Full Activation**
• The Toronto EOC will activate to **Level 3 – Major Emergency** • Issue notification placing municipal emergency response organizations on stand-by according to the Emergency Level Notifications Emergency Support Function (ESF) • Establish the Emergency Information Centre according to the Emergency Information and Media Relations ESF • Receive and implement operational directives from the PEOC Commander regarding protective measures	• The Toronto EOC will activate to **Level 3 – Major Emergency** • Issue notification activating municipal emergency response organizations according to the Emergency Level Notifications ESF • Establish the Emergency Information Centre according to the Emergency Information and Media Relations ESF • Establish the following emergency centres to become operational as soon as required: o Marine Emergency Worker Centre o Reception/Evacuation Centre o Emergency Worker Centre

4.4 Public Alerting and Direction

4.4.1 Whenever the "Alert Ready" public alerting system is to be activated, the PEOC Commander shall concurrently issue an emergency bulletin to the broadcast media with instructions to the public.

4.4.2 In the case of a General Emergency notification from the PNGS, the City of Toronto should immediately activate its public alerting system. In all other cases, the PEOC Commander shall decide when to activate the public alerting system and issue the necessary instructions to the Designated Host Communities.

4.4.3 Communication shall report that a problem exists, the affected area, instructions to monitor media for more information, precautionary and protective measures being directed, and precautionary and protective measured being rescinded.

4.4.4 In a radiological emergency, the Province and the affected municipalities shall consult and decide on responsibilities for issuing emergency bulletins.

4.4.5 The City of Toronto's public alerting system used to implement the TNERP shall confirm to the following principles, per the PNERP and PNGS IP:

- Provisions shall be made to ensure that residents of the City of Toronto can be alerted to take immediate protective action within 15 minutes of initiation
- Alerting must be coordinated with the Regional Municipality of Durham, the City of Toronto, and the Province of Ontario, ensuring timely and accurate information is disseminated
- This Plan must describe and ensure that the public alerting system has the capability to issue an alert to the affected population in the Detailed Planning Zone, located both indoors and outdoors, within 15 minutes

The City of Toronto participates in the Alert Ready network and will submit emergency notifications to the PEOC for "broadcast immediate" release.

4.4.6 The City of Toronto will adopt and further transmit all directives and bulletins from the PEOC Commander. Public alerting and information is further expanded upon in Appendix '6' of this Plan.

4.5 Implementation of Protective Measures

4.5.1 Having assessed the need for protective measures and identified a strategy for implementation, the PEOC will upgrade to a Full Activation prior to directing the City of Toronto to implement protective measures and/or to evacuate at least 36 hours prior to the emission, if possible.

4.5.2 As outlined in paragraph 3.0 'Protective Action Response Strategy' of this Plan, the main strategies for protective measures are precautionary measures, evacuation, iodine thyroid blocking, and shelter-in-place. Implementation directives for protective measures shall be communicated as outlined in the following sub-sections:

Table 5: Quick Reference

Quick Reference: Outline of communicating Protective Action implementation directions in the TNERP		
Protection Action	**Communication**	**Additional instructions**
Precautionary Measures	Paragraph 4.5.3	-
Evacuation	Paragraph 4.5.3	Paragraph 4.9
Iodine Thyroid Blocking	Paragraph 4.5.3	Paragraph 4.5.4
Shelter-in-Place	Paragraph 4.5.3	-

4.5.3 Once all relevant stakeholders have been informed and implementation of the necessary actions may begin, the PEOC shall issue an Emergency Bulletin informing the affected public of the timing and extent of the expected emission. The Bulletin will also include protective actions. The bulletin will include the following information:

- Date and time of expected emission
- Sectors which may be affected
- When precautionary and protective measures will be ordered and any variations by sector
- Public inquiry phone numbers; and
- Evacuation instructions if applicable

4.5.4 Internal notification for City staff to follow Ontario Ministry of Health direction to ingest KI will occur as follows:

- The Toronto EOC will notify the following divisions/agencies of the CMOH direction to ingest KI:
    - Parks, Forestry & Recreation
    - Transportation Services
    - Toronto Water
    - Toronto Zoo
    - Toronto Library
    - Toronto Police Service
    - Toronto Paramedic Services
    - Toronto Fire Services
    - Toronto Transit Commission
    - Toronto Hydro
    - Toronto Public Health
- Each of the divisions/agencies will enact pre-established procedures to forward these instructions onward to their staff/facilities within the Detailed Planning Zone.
- Each of the above divisions / agencies with 24/7 operations must ensure that the Toronto EOC/Office of Emergency Management has appropriate contact information for notifications, and that internal processes are in place.

4.5.5 Termination of protective measures will occur either when the specified timeline in Provincial direction elapses or when termination instructions from the Province are received.

4.6 Entry Control

4.6.1 Management of the main traffic routes shall be coordinated by the PEOC. While marine, air, road, and rail traffic are managed through the appropriate coordinating ministries and agencies via the PEOC, the City of Toronto will provide similar coordination over City road and marine traffic in the Detailed Planning Zone. Marine traffic will be managed by the Toronto Police Marine Unit.

4.6.2 In the event of an ongoing emission or one that is imminent, the PEOC may consider the following entry control measures and notify the proper authorities for implementation as appropriate. The City of Toronto will support the implementation of these controls within its jurisdictional and functional limits:

- Suspension of through traffic on main road and rail routes going through the Detailed Planning Zone (Highway 401, Highway 2, major rail corridors)
- Suspension of marine traffic in the Detailed Planning Zone portion of Lake Ontario
- Aircraft should be kept clear of the Detailed Planning Zone

4.6.3 If it is likely that a radioactive emission will take place, operational directives or Provincial Orders will be issued to clear Response Sectors P23 through P25 of any marine craft. Entry control will be imposed via the Canadian Coast Guard, Toronto Police Marine Unit and the Durham Regional Police Service Marine Unit.

4.6.4 Full entry control should be implemented for sectors that have been evacuated; however, access will be allowed to emergency workers who have duties to perform in these sectors. This entry control shall be the responsibility of the police service of jurisdiction in accordance with the Provincial Unified Transportation Management Plan (UTMP) and the TNERP Appendix '10' Toronto Nuclear Local Traffic Control Plan.

4.6.5 Entry control will be directed and implemented in sectors undergoing sheltering-in-place.

4.7 Evacuation

4.7.1 This section of the Plan further details the evacuation in a nuclear emergency. The Toronto Nuclear Mass Evacuation Plan can be found in Appendix '7'

4.7.2 The first priority shall be to leave the affected area as efficiently as possible. Evacuees will be advised via bulletin to go to a facility for monitoring and decontamination or to self-decontaminate. All available routes will be utilized to evacuate the public and evacuation time estimates should be used to inform decision-making regarding implementation of evacuation strategies.

4.7.2 Transportation during a nuclear emergency will be complicated by significantly increased traffic on major arterial roads and highways. Integrated transportation management through the Unified Traffic Control Centre (UTCC) is required to ensure that evacuations can proceed as smoothly as possible.

4.7.3 In the event of a delayed radiological emission, evacuees are not expected to be contaminated; however, in the event of an ongoing or imminent emission, evacuees can be expected to have varying levels of contamination. It would be in the form of loose particulate on people, their belongings, and vehicles; alternately, it may be internal in those who have been exposed to ingesting the radioactive emission.

4.7.4 Decontamination facilities may be required for those who are not able to self-decontaminate as instructed by emergency bulletins.

4.7.5 Arrangements for mass evacuation transportation and medical transfers, reception, sheltering-in-place, and other associated needs are a responsibility of the City of Toronto. Many evacuees will make their own arrangements for independent care and lodging. Decontamination verification will be required and led by Ontario Power Generation.

4.7.6 Temporary relocation is the displacement of people from their homes for a period beyond one week and up to one year to avoid chronic exposure to radiation, usually from ground contamination. It can be directed post-emission, during the intermediate response phase, or subsequent to evacuation or sheltering-in-place.

4.7.7 Families may naturally seek to reunite and evacuate together. The ability for families to reunite may depend on time of day at the onset of the emergency and the urgency of evacuations. Reunification is a variable that could complicate evacuation directions and effectiveness.

4.7.8 The Toronto Nuclear Mass Evacuation/Transportation Plan (see Appendix '6') details the strategies, operational actions, and resources that will be employed to affect an evacuation. It is based on the principles and assumptions of this section.

4.8 Transportation Management

4.8.1 A Unified Transportation Management Plan (UTMP) shall be developed by the Province for the Detailed Planning Zone as well as the arterial roads that provide access to this zone. During an emergency evacuation, the Provincial Unified Transportation Coordination Centre (UTCC) shall be responsible for implementing the UTMP.

4.8.2 The UTCC shall operate in coordination with the Municipal Emergency Operations Centres, including the Toronto EOC, and the PEOC. In addition, the UTCC may communicate with municipal Traffic Operations Centres.

4.8.3 The UTMP is executed in three incremental stages consistent with the agreed upon evacuation time estimate data. Stages are:

- Stage 1: Traffic flows smoothly on the main evacuation routes, and the routes remain open
- Stage 2: Traffic is prevented from entering the Detailed Planning Zone, except for emergency workers. Traffic that is flowing smoothly along evacuation routes that intersects with the prohibited area is diverted around it
- Stage 3: If necessary, this stage is initiated when it appears that particular sectors are likely to be evacuated. Additional resources should be deployed to ensure that evacuation proceeds smoothly

4.8.4 The Toronto Nuclear Local Traffic Control Plan shall be implemented to assist with the City of Toronto's portion of the UTMP. The Plan (see Appendix '8') is strategic guidance that gives flexibility in command and tactics to both the UTCC and implicated City divisions, agencies, and corporations.

4.9 Radiation Health Response Plan

4.9.1 The Provincial Radiation Health Response Plan (RHRP) establishes health sector roles and responsibilities during planning, response, and recovery phases of nuclear or radiological emergencies. It describes operational concepts and principles, coordination, and implementation of precautionary and protective measures that guides Local Health Integration Networks (LHINs), paramedic services, hospitals, and cancer centres.

4.9.2 If it is estimated that the radiation dose in any sector is likely to be significant, as determined by the PEOC's Scientific Section, the appropriate provisions of the RHRP shall be implemented.

4.9.3 Where Toronto Paramedic Services are involved in this Plan or the City of Toronto is implicated in planning or response with LHINs, hospitals, or cancer centres,

the Toronto EOC will be required to generate situational awareness and coordinate response activities.

4.10 Personal Monitoring and Decontamination

4.10.1 Where evacuations are being undertaken during an emission, the first priority shall be to leave the affected area as quickly as possible. Evacuees will be advised (via an operational directive) to go to a facility for monitoring or to self-decontaminate.

4.10.2 Details for decontamination shall be provided through Emergency Bulletins as will the location of facilities where evacuees may go for follow-up assurance monitoring.

4.10.3 OPG will activate five Monitoring and Decontamination Units (MDUs) as follows;

- Three MDUs will be located at fixed sites; and
- Two MDUs will be mobile facilities, stored in trailers at an OPG facility and transportable, when required, to locations which have been pre-designated

4.10.4 Multiple sites which can host the mobile MDUs will be pre-designated to ensure the availability of infrastructure and amenities to support their operation. Fixed sites as well as the pre-designated sites for mobile units will be selected so as to provide, as far as possible, monitoring and decontamination options for all directives impacting the Detailed Planning Zone.

4.10.5 Fixed and mobile MDUs will provide assurance monitoring for those who have undertaken self-decontamination, as well as monitoring and decontamination for those evacuees who either require or desire it upon evacuating the Detailed Planning Zone. Mobile MDUs can also be deployed to support fixed MDUs if additional capacity is required at those locations.

4.10.6 The Ministry of Health and Long Term Care will develop arrangements, in coordination with OPG, hospitals, designated municipalities, and their public health units, to track evacuees for the purposes of internal and external contamination assessments and to provide follow-up for those affected.

4.11 Emergency Worker Protective Action Strategy

4.11.1 At the commencement of an emergency resulting in the activation of this plan, the Response Sectors in the Detailed Planning Zone will be assumed to carry the following safety status in accordance with the PNERP, based on the category of the notification initiated by PNGS:

Table 6: Emergency Worker Protective Action Strategy

Notification	Sectors in Green Safety Status	Sectors in Orange Safety Status	Sectors in Red Safety Status
Onsite Emergency with Ongoing Emission	All Remaining	P1, P2, P23	-
General Emergency with Ongoing Emission	All Remaining	P3-P14, P24	P1, P2, P23
All other emergencies	All	-	-

4.11.2 As soon as relevant data is available, the PEOC will re-assign safety status to all the sectors and will update them periodically. During the course of an emission over the land areas of the Detailed Planning Zone this updating will be done on an hourly basis. The safety status of sectors should be promptly communicated by the PEOC to all concerned.

4.11.3 It is the responsibility of each organization with emergency workers operating or required to operate in the Detailed Planning zone to ensure that they are kept apprised of the current safety status of response sectors.

4.11.4 This plan provides for the setting up of Emergency Worker Centres (EWCs) (see Appendix '9' & '10' of this plan). It expands on strategies for implementation of land and marine EWCs.

4.11.5 Emergency workers who need to enter a sector shall first report to a EWC, where they will be provided with personal monitoring devices and briefed on the health risks and precautions they should observe, as well as any maximum time limit on their stay in the sector.

4.11.6 If an emission is ongoing, emergency services who are required to operate in the Automatic Action Zone before an EWRC is functioning should carry and use the following equipment:

- Personal Protective Equipment (PPE)
- Dosimetry
- Stable iodine tablets; and
- A card listing the default safety status of sectors

4.11.7 OPG is responsible for the monitoring and decontamination aspect of EWCs, the relevant details of which will be provided in their plans/procedures.

4.12 Venting of Containment

4.12.1 During a Design Basis Accident (DBA), the holdup within the station containment structure (e.g. vacuum building) of any radioactive material released from damaged fuel would create the possibility of venting such contained radioactivity in a controlled manner and in a safe direction.

4.12.2 During a Beyond Design Basis Accident (BDBA), the holdup period of any radioactive material may be significantly reduced and radioactive material may be released in an uncontrolled manner.

4.12.3 PNGS shall include, in each hourly report to the PEOC, an estimate of the time at which the vacuum building pressure would reach the minimum level at which the filtered air discharge system can be operated.

4.12.4 The time interval between the occurrence and the accident and containment pressure reaching this minimum level will depend on the condition and behavior of the containment system. With no impairment to containment, this time interval is expected to be approximately 48 hours (an impaired containment could significantly reduce that time).

4.12.5 The PEOC should consider, in consultation with OPG, the Canadian Nuclear Safety Commission (CNSC), the City of Toronto, and the Region of Durham, whether venting would be feasible or advisable.

4.12.6 The Toronto EOC and the City of Toronto must be prepared to report on its emergency situation to support this decision. To assist with venting decisions, the City of Toronto will collect, collate, evaluate, and develop situational awareness of outstanding issues and consequences.

4.13 Protection and Care of Animals

4.13.1 In accordance with the EMCPA, paragraph 7.0.2 (4) and the PNGS IP, paragraph 5.3.1 (h), provisions must be made in this plan for the protection and care of all animals, including those left behind during an evacuation.

4.13.2 The COT Animal Care and Relief ESF shall be enacted as soon as it is clear evacuation is taking place. Additional assistance will be sought as necessary from the Ontario Society for the Prevention of Cruelty to Animals for the care of all animals; the Ontario Ministry of Agriculture, Food, and Rural Affairs (OMAFRA) for assistance for farm animals; and, the Ontario Ministry of Natural Resources and Forestry (MNRF), for issues pertaining to wildlife.

4.13.3 Provisions for animals brought to emergency reception centres – whether authorized or not – are made in the Toronto Nuclear Mass Evacuation/ Transportation Plan (see Appendix '6').

4.14 Liquid Emission Response

4.14.1 The main radiation exposure pathway for a liquid emission from PNGS is through contamination of a water supply source, with the resulting hazard being the subsequent ingestion of contaminated water.

4.14.2 If a liquid emission has occurred at PNGS in conjunction with an event that meets the notification category system as detailed in this plan and the PNGS IP, it shall be managed by this plan.

4.14.3 A liquid emission at PNGS that does not meet the notification category system shall be managed in accordance with the operator's response plan; however, it may escalate to a magnitude that is encapsulated within this plan. Accordingly, vigilance with reportable events is advised.

Appendix '1'

Pickering Nuclear Generating Station Detailed and Contingency Planning Zones

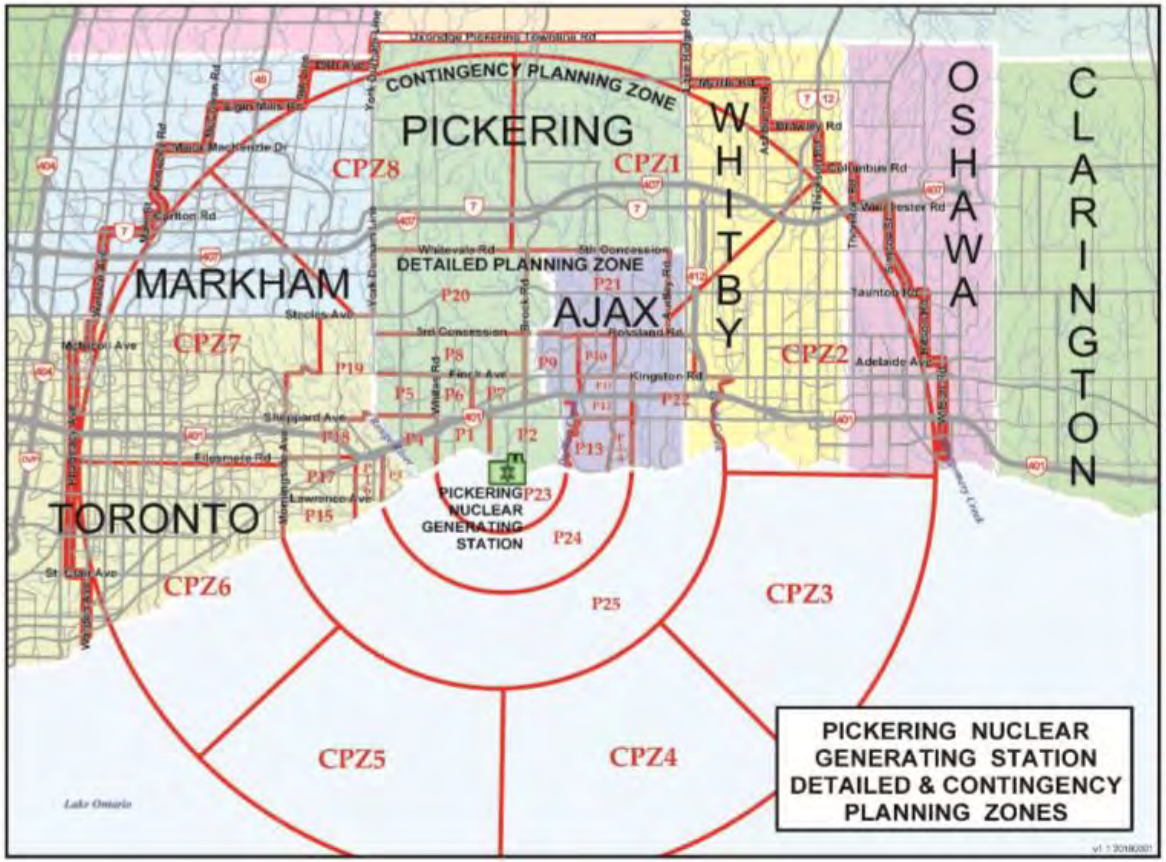


Figure 4: Initial Provincial and City of Toronto Response (based on information extracted from the PNERP Annex D and the PNGS and DNGS Implementing Plans)

Appendix '2'

Pickering Nuclear Generating Station Ingestion Planning Zones

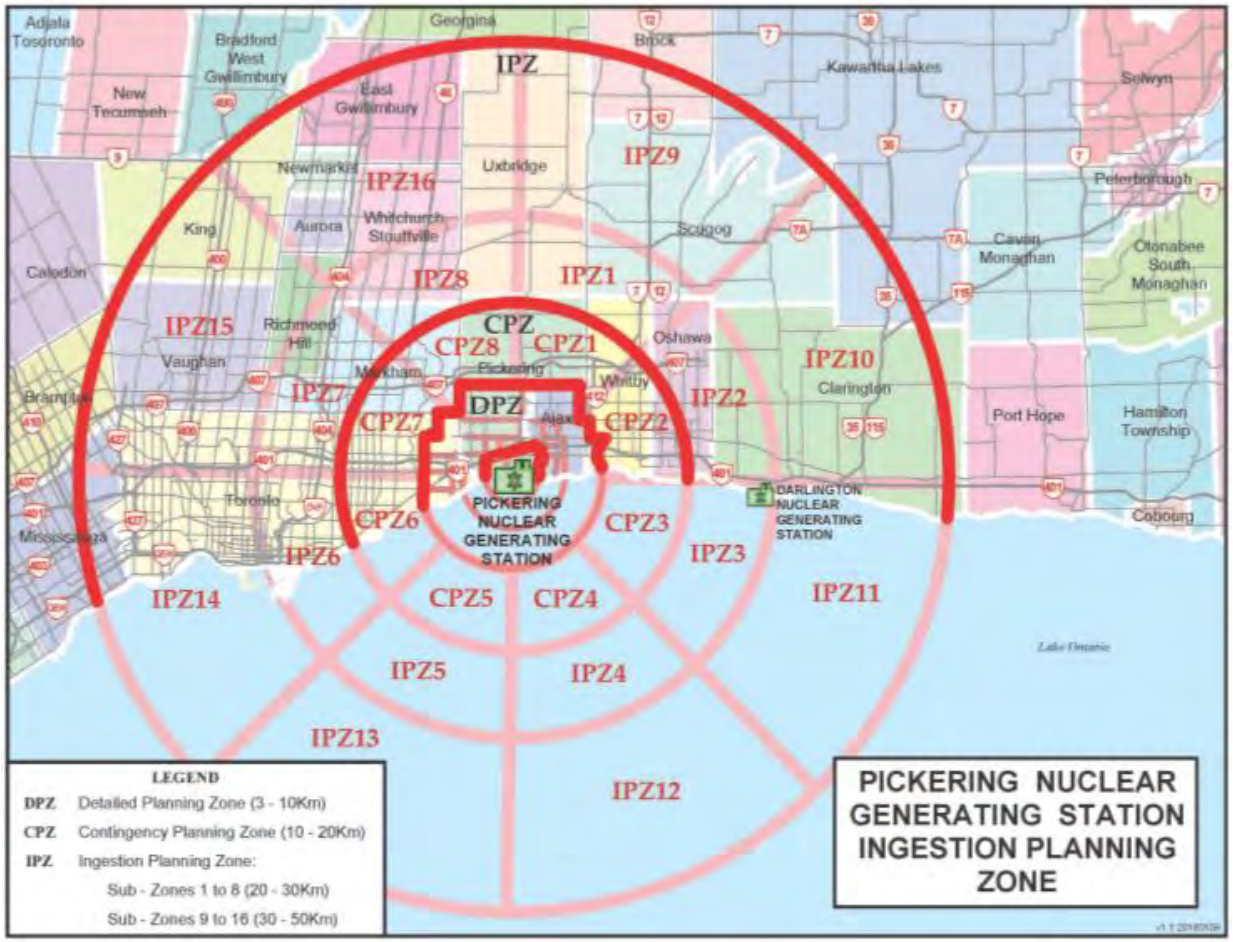


Figure 5: Pickering Nuclear Generating Station Ingestion Planning Zones (extracted from the PNGS Implementing Plan).

Appendix '3'

Population Data by Sector/Planning Zone

Population: P Zone areas highlighted in yellow refer to Toronto. Population estimates include resident data based on the 2006 Canada Census and estimates of employees who commute into the PZ (2006 Transportation Tomorrow Survey (TTS)).

Table 7: Population Data by Sector/Planning Zone

Sector	Population
P1	9,313
P2	12,761
P3	4,656
P4	8,605
P5	14,109
P6	11,353
P7	16,224
P8	17,098
P9	18,702
P10	15,374
P11	8,576
P12	3,309
P13	12,144
P14	8,857
P15	10,703
P16	8,419
P17	14,260
P18	22,376
P19	8,025
P20	288
P21	12,911
P22	18,388
PNGS Staff	4,500
Total with PNGS Staff	260,861
Total without PNGS Staff	256,361

Appendix '4'

Toronto Emergency Operations Centre

Nuclear Emergency Notification Procedure

Using OEM's Master Contact List, the following points of contact shall be notified of activation of the TNERP in the order they are presented:

- All City of Toronto Divisions
- COT Senior Leadership Team / Control Group
- [List all local utilities following this bullet]
- Toronto District School Board: [name, number, and email as applicable]
- Toronto Catholic District School Board: [name, number, and email as applicable]
- [List all applicable branches of voluntary organizations following this bullet]

Appendix '5'

Emergency Information and Alerting

1.0 – Background

1.1 The responsibility for activating the Alert Ready notification system and issuing emergency bulletins rests with the PEOC Commander. The aim of public direction is to communicate, directly to the affected public through emergency bulletins, the direction and guidance regarding protective actions they should take in order to ensure their safety and welfare.

1.2 Every effort shall be made to consult with emergency response organizations as to the content of the bulletin, preferring pre-scripted messages where possible, and to release them in a timely manner.

1.3 Emergency bulletins issued during a partial activation response level, before an emission is expected to occur, should be informative and permissive, whereas those issued once a full activation response has been adopted should be increasingly directive.

2.0 – Standards

2.1 In a partial activation response, emergency bulletins shall include the following information, as applicable:

- Date and time of expected emission
- Sectors (with geographical description) which may be affected
- Applicable precautionary and protective measures for the affected sectors or area and applicable timings; and
- Public inquiry phone number(s) and websites

2.2 In a full activation response and when an emission is expected in 36 hours or less, emergency bulletins should ensure that they include directions regarding:

- Date and time of expected emission
- Precautionary measures directed in specific zones
- Protective measures directed in specific sectors or zones
- Reception Centre information which can receive evacuees who are without accommodations
- KI pill availability and ingestion direction; and
- Public inquiry phone number(s) and websites

2.3 The Toronto Police Marine Unit is responsible for assisting in notifying and evacuating marine craft that do not have radios on board. Provisions must be made as part of their operational response.

3.0 – Emergency Information Centre

3.1 The City of Toronto will establish an Emergency Information Centre (EIC) for all activation levels and will follow procedures outlined in the Emergency Information and Media Relations ESF.

3.2 The EIC is responsible for the collection, dissemination, and monitoring of local emergency information and for coordination with the PEOC Emergency Information Section (EIS).

3.3 The EIC shall be coordinated by the Toronto EOC's Emergency Information Officer (EIO) and includes the corporate Strategic Communications team. OPG, neighbouring municipalities, and federal and provincial liaisons may participate in the operations of the EIC if desired.

3.4 The functions of the EIC include:

- In coordination with the Provincial EIS, preparing and issuing news releases and other public information documents for the local media and residents, describing the emergency and response measures
- Keeping the Provincial EIS apprised of communications environmental awareness, such as local public perceptions, rumours, and reactions
- Assisting local media covering the emergency in coordination with the Provincial EIS
- Monitoring local media to ensure that local news is being correctly transmitted to the public by the media and confirming this with the Provincial EIS; and
- In coordination with the Provincial EIS, arranging media briefings to communicate "key messages" to the public

3.5 The preferred channel for public inquiry is 3-1-1 Toronto.

Appendix '6'

Toronto Nuclear Mass Evacuation/ Transportation Plan

This Appendix shall constitute the Toronto Nuclear Mass Evacuation Plan. This Plan needs to be developed amongst a working group of partners and will be inserted into the TNERP when completed.

The following points will be incorporated the plan;

Concept of Operations

- Evacuations will be directed by Response Sector or groups of sectors, detailing the boundaries of the evacuation area by readily identifiable roads/landmarks
- Evacuees who may have been exposed to an emission will be directed either to proceed to a Monitoring and Decontamination Unit (MDU) or to self-decontaminate upon reaching their destination. Information on locations for monitoring shall be provided by the PEOC at the time of the emergency
- Evacuees who are not at risk of being contaminated will be instructed by to leave the Detailed Planning Zone and will not be directed to an MDU or to self-decontaminate
- Evacuees will be permitted to evacuate in the direction and to the destination of their choosing, subject to restrictions (due to weather, traffic conditions etc.) announced by the PEOC through the Emergency Bulletins
- The smooth and expeditious movement of evacuee traffic is the responsibility of the traffic control organization set up under the Joint Traffic Control Plan and Toronto Nuclear Local Traffic Control Plan
- The Joint Traffic Control Centre will monitor the evacuating traffic and inform the PEOC of any issues impacting the evacuation
- Evacuations will be directed by Response Sector or groups of sectors, detailing the boundaries of the evacuation area by readily identifiable roads/landmarks
- Evacuees who may have been exposed to an emission will be directed either to proceed to a Monitoring and Decontamination Unit (MDU) or to self-decontaminate upon reaching their destination. Information on locations for monitoring shall be provided by the PEOC at the time of the emergency
- Evacuees who are not at risk of being contaminated will be instructed by to leave the Detailed Planning Zone and will not be directed to an MDU or to self-decontaminate
- Evacuees will be permitted to evacuate in the direction and to the destination of their choosing, subject to restrictions (due to weather, traffic conditions etc.) announced by the PEOC through the Emergency Bulletins
- The smooth and expeditious movement of evacuee traffic is the responsibility of the traffic control organization set up under the Unified Traffic Control Plan and Toronto Nuclear Local Traffic Control Plan

- The Unified Traffic Control Centre will monitor the evacuating traffic and inform the PEOC of any issues impacting the evacuation

Logistics

- Municipal nuclear emergency plans need to identify the location of the following emergency facilities and shall include provisions for their selection, staffing, and resourcing:
    - Reception Centres
    - Evacuation Centres
    - Monitoring and decontamination for evacuees either in a Reception Centre or a separate facility
    - Emergency Worker Centres; and
    - An Emergency Information Centre
- Municipal nuclear emergency plans shall also identify the location of alternate municipal facilities outside the Contingency Planning Zone
- All stakeholder emergency plans shall describe how their emergency centres and facilities are linked via primary and backup communication systems which enable email and transfer of emergency information

Appendix '7'

Nuclear Emergency Reception Centres

To be completed as a separate plan and included in the TNERP as an a stand-alone Annex.

Appendix '8'

Toronto Nuclear Emergency Local Traffic Control Plan

A local traffic control plan needs to be developed to outline how City partners will coordinate with the Provincial Traffic Management Plan.

1.0 – Background

1.1 During an emergency, the Unified Traffic Control Centre (UTCC) shall be responsible for implementing the Unified Traffic Control Plan.

1.2 The Unified Traffic Management Plan (UTMP) is executed in three incremental stages consistent with the agreed upon evacuation time estimate data. Stages are:

- Stage 1: Traffic flows smoothly on the main evacuation routes, and the routes remain open
- Stage 2: Traffic is prevented from entering the Detailed Planning Zone, except for emergency workers. Traffic that is flowing smoothly along evacuation routes that intersects with the prohibited area is diverted around it
- Stage 3: If necessary, this stage is initiated when it appears that particular sectors are likely to be evacuated. Additional resources should be deployed to ensure that evacuation proceeds smoothly

Appendix '9'

Emergency Worker Centre

'Land'

1.0 – Background

1.1 The purpose of an Emergency Worker Centre (EWC) is to provide a staging area, decontamination facilities, respite, and single window access point for emergency workers with duties in the Detailed Planning Zone during a nuclear emergency.

1.2 Municipal plans shall detail how emergency services obtain equipment, appropriately store them, and maintain such equipment so that it is readily available, when required.

1.3 This appendix overviews plans for the EWC and the Marine EWC (MEWC) as required by PNGS IP.

2.0 – Emergency Worker Centres

2.1 The PNGS IP requires the nuclear facility to monitor and decontaminate emergency workers during a nuclear emergency. The activation of a EWC will be based on direction from the PEOC, in consultation with the Toronto EOC. The designated location of the EWC is Centennial College, Progress Campus at 941 Progress Avenue (at Markham Road).

An additional Emergency Worker Centre is located at the Bluffers Park Complex and is co-located with a Reception Centre for impacted boaters from Lake Ontario. Details of this Emergency Worker Centre and Reception Centre are outlined in Section 1 of this Appendix.

2.2 The purpose of the EWC is to provide safeguards to protect the health and safety of workers who may be required to provide emergency assistance in sectors with or that potentially may have higher than normal levels of radioactivity.

2.3 The EWC is intended to address health and safety issues related to emergency workers who are required to be deployed into the Detailed Planning Zone from:

- Toronto Fire Services
- Toronto Paramedic Services
- Toronto Police Service
- Toronto Transit Commission (TTC)

- Any City of Toronto division
- Other agencies and corporations of the City of Toronto; and
- Provincial, adjacent municipalities, and non-governmental organizations

This facility does not offer evacuee services or support for members of the general public.

2.4 The EWC will provide the means to:

- Instruct workers on use of Personal Protective Equipment and basic Radiation Safety
- Provide exposure control for workers to safely complete their assignments
- Decontaminate workers, their vehicles and equipment
- Track the deployment of workers; and
- Communicate the safety status of sectors from workers deployed into the Detailed Planning Zone to the Toronto EOC

2.5 The Emergency Worker Centre is only activated during a nuclear emergency that originates at the Pickering Nuclear Generating Station. It is not required for a nuclear emergency at the Darlington Nuclear Generating Station.

3.0 – Concept of Operations

3.1 Activation:

- The decision to activate the EWC by the PEOC based on consultations with Toronto EOC
- The timing and urgency of activation will be determined by the PEOC and communicated by the Toronto EOC to the designated contacts for the EWC at Toronto Fire Services, Toronto Police Service, Toronto Paramedic Services, Toronto Transit Commission and Centennial College

3.2 Reporting and Registration:

- Before being deployed into the Detailed Planning Zone, staff must report to the EWC to obtain instructions on basic radiation safety, dosimetry and reporting procedures for entry and exit from the Detailed Planning Zone
- Personal protective equipment (PPE) will be provided as required
- Each of the following agencies will staff a Registration desk to receive and record the names and deployment status of staff that are sent into the Detailed Planning Zone:
    - Toronto Police Service
    - Toronto Fire Services
    - Toronto Paramedic Services

- Toronto Transit Commission
- Ontario Power Generation; and
- Other agencies, as required

3.3 Vehicle and Pedestrian Traffic Flow: refer to OPG's approved procedure for Campus Flow Map and Traffic Flow Plan.

3.4 Signage:

- OPG will provide signage to direct vehicular and pedestrian traffic to maintain separation between clean and (potentially) contaminated pathways
- The signs will be stored in the OPG bunker at Centennial College and deployed by OPG staff during the activation of the EWC

3.5 Protective Measures:

- The EWC will use the safety limits prescribed in the PNERP - Master Plan to manage the duration of potential exposure and time spent by workers in the Detailed Planning Zone
- Potassium Iodide (KI) will be made available by OPG at the EWC for staff who are deployed into the Detailed Planning Zone
- The administration of KI shall be as directed by the Province
- KI is not required by staff working at the EWC as it is located outside the Detailed Planning Zone

3.6 Dosimetry:

- OPG will issue dosimetry and instructions to workers at the Exposure Control Desk. The dosimetry will alert the worker of a high dose rate and the radiation exposure level
- Baseline readings will be recorded by OPG for each worker before they dispatched into the Detailed Planning Zone
- Subsequent readings will be similarly maintained
- Copies of exposure records maintained by OPG will be made available to agency staff, as requested

3.7 Vehicle Monitoring and Decontamination:

- OPG will provide staff and equipment to monitor vehicle interiors and exteriors for radioactive contamination
- OPG will position their staff at the designated parking lots to monitor vehicles and occupants
- If contaminated, the vehicle will be identified and directed for decontamination at assigned parking lots

- If the vehicle is not contaminated, it will be directed to parking lots allocated for clean vehicles
- Toronto Fire Services will set up and provide vehicle decontamination in the designated parking lot
- Placement of the decontamination equipment should be determined in consultation with the TTC, if possible, to ensure sufficient room for maneuvering large vehicles such as TTC buses
- Toronto Fire Services staff will assist drivers through the decontamination process with instructions and offer guidance on the placement of their vehicle
- After decontamination, the exterior of the vehicle will be re-monitored by OPG
- If deemed clean, the interior of the vehicle will be monitored and decontaminated if required
- The emergency worker/driver will be directed to Personal Monitoring

3.8 Personal Monitoring and Decontamination:

- OPG will set up and operate a Personal Monitoring area according to approved OPG procedures
- Workers who are deemed clean will be sent to the Exposure Control Desk
- Workers requiring decontamination will be directed to Personal Decontamination
- Following personal decontamination, workers may be asked to provide a urine sample to determine if radioactive contaminants have been ingested or inhaled

3.9 Equipment Decontamination Procedures:

- OPG will provide guidance on radiation safety for the decontamination of equipment and accessories of emergency workers
- The Toronto Police Service will provide staff and equipment to handle and decontaminate firearms, with guidance from OPG on radiation safety

3.10 Registration and Re-deployment:

- Emergency workers who are deemed clean will inform their respective agencies of their availability for re-deployment
- OPG will advise individual workers if they have reached their exposure limits
- If they have not reached exposure limits, they will inform their agencies they are available for re-deployment inside the Detailed Planning Zone and wait at staging areas for further direction from their agencies
- If workers have reached their exposure limits, they should notify their agencies of their status and request further direction for assignments outside the Detailed Planning Zone

3.11 Media Relations and Emergency Information:

- The Province and Toronto Emergency Operations Centre through the Strategic Communications Emergency Information Officer will issue emergency information to the media for general and local issues respectively

3.12 Cessation of Operations:

- This Centre will be demobilized when advised by Toronto Emergency Operations Centre to cease operations
- Documentation collected (under Incident Management System), evacuee registration lists and dose records of evacuees and emergency responders should be collected and forwarded to the Toronto Office of Emergency Management

4.0 – Notifications

4.1 The Toronto Emergency Operations Centre will notify the Manager of Safety and Security, Centennial College to evacuate Progress Campus of students, faculty and non-essential staff. The College will ensure that designated areas of the campus are made accessible to Toronto Fire Services and Ontario Power Generation

4.2 Each agency represented at the Toronto EOC will inform their respective staff of the activation of the EWC and when it is scheduled to be operational. Agency staff at the EOC will also provide periodic reminders to their respective organizations of the purpose of the EWC and to direct their workers to report to the EWC before they are deployed into the Detailed Planning Zone

4.3 The City's Shelter, Support and Housing Administration division should notify their agency partners to report to the EWC before they are deployed into the Detailed Planning Zone e.g. Local Health Integration Network (LHIN), non-government organizations and other agencies involved in the care of vulnerable individuals

4.4 Lead and support agencies named in this document will be contacted by their respective organizations based on notifications made by the Office of Emergency Management at the onset of the nuclear emergency

5.0 – Responsibilities

5.1 Lead Agency – Toronto Fire Services:

- Appoint Incident Commander in Unified Command structure with Incident Management System
- Set up and operate exterior vehicle decontamination apparatus with OPG
- Organize operations

- Implement plans and procedures
- Liaise with Toronto Emergency Operations Centre
- Liaise with Toronto Police Major Incident Command Centre (MICC) and/or TPS Command Post
- Update PNERP Sector status maps

5.2 Ontario Power Generation:

- Issue dosimetry to emergency workers
- Maintain dose records of workers deployed into Detailed Planning Zone
- Instruct workers on the use of dosimetry and reporting requirements
- Assist Incident Commander to update PNERP Sector status maps
- Monitor and decontaminate EWC premises as required
- Monitor and decontaminate workers, vehicles, equipment and accessories
- Set-up facility according to approved OPG procedures
- Restore the EWC to normal condition at the conclusion of the emergency

5.3 Toronto Police Service:

- Appoint Police Incident Commander for policing operations
- Organize policing operations
- Register policing staff
- Implement plans and procedures
- Participate in Unified Command at EWC
- Liaise with Major Incident Command Centre
- Control entry to the Campus and traffic flow within Campus

5.4 Centennial College:

- Evacuate campus of students, faculty and non-essential staff
- Enable agency access to EWC gymnasium, designated areas for EWC Operations Centre, cafeteria and parking lots
- Provide desks, chairs, rooms/space, telephones, fax machines, photocopiers and other amenities as required to the agencies
- Maintain building operations, cleaning, sanitation, campus security, lighting, access to offices and rooms and contracted services
- Track expenses at EWC

5.5 Toronto's Office of Emergency Management (OEM) leads and facilitates all City activities related to the City's ability to mitigate, prepare for, respond to, and recover from major emergencies. The Office coordinates the activities of divisional and intergovernmental teams to plan and deliver emergency management objectives, and ensure an effective balance of compliance, administrative governance and delegation of responsibility throughout the organization.

The OEM maintains the City's Emergency Operations Centre (EOC), which can be activated in response to an emergency. Trained staff from across City divisions and related agencies are deployed to the EOC to ensure a coordinated response to an incident. The EOC is activated based on the response needed as outlined the table below. When there is no emergency it is maintained in a state of readiness.

The OEM is curator of the City of Toronto's Emergency Plan as well as this Nuclear Emergency Response Plan.

Appendix '10'

Emergency Worker Centre

'Marine'

1.0 – Background

1.1 In the event of a nuclear emergency at PNGS, it may be necessary to evacuate the Lake Ontario Sectors. To facilitate marine evacuations safely, a Marine Emergency Worker Centre (MEWC) will be established at the Bluffers Park Complex, at the bottom of Brimley Road in Toronto. This Plan is not applicable to the lake sectors of the Darlington Nuclear Generating Station.

1.2 The purpose of the Marine Emergency Worker Centre (MEWC) is provide protective measures to enable marine emergency responders to work safely when they evacuate the lake sectors of the Pickering Detailed Planning Zone. The MEWC hosts Monitoring & Decontamination Units (MDU) operated by OPG.

1.3 The scope and objectives of the Marine Emergency Worker Centre are:

- Coordinate the activities of marine emergency responders to evacuate the lake sectors of the Pickering Detailed Planning Zone
- Equip emergency responders to enter the Detailed Planning Zone with personal dosimetry, personal protective equipment and provide instructions on their use
- Update information on the status of the lake sectors, wind direction, weather forecasts, status of emissions from nuclear station
- Monitor and decontaminate emergency responders and their vessels according to approved OPG procedures
- Monitor and decontaminate marine evacuees from the Pickering Detailed Planning Zone
- Liaise with Toronto Police Major Incident Command Centre (MICC), Toronto Emergency Operations Centre (EOC) and Durham Regional Police Service (marine unit) for overall direction and situational awareness

2.0 – Concept of Operations

2.1 Marine evacuations will be required as directed by the Province in the event of imminent or ongoing emissions from the Pickering Nuclear Station. The Canadian Coast Guard and Toronto Police Marine Unit will be asked to clear lake sectors with continual marine broadcasts warning the boating public to avoid or leave the lake sectors of the Pickering Detailed Planning Zone.

2.2 Marine Evacuations:

As stated in the PNERP-Implementing Plan of the Pickering Nuclear Generating Station, boaters will be notified by the Canadian Coast Guard via marine radio to leave the area around the Pickering Nuclear Station. Many boats are equipped with the Global Maritime Distress and Safety System (GMDSS) which will automatically alert them of an emergency message.

A direct way of notifying these boaters may be required especially when an emission is about to occur (within 12 hours) or is already in progress.

It should not be automatically assumed that boaters are equipped with GMDSS or monitoring marine broadcasts at the time of the emergency.

Boaters should be strongly advised to leave the lake sectors and go beyond 10 km of the nuclear station

The Durham Regional Police Service helicopter may be requested to assist to determine if there are boaters in the lake sectors .

The Toronto Police Marine Unit and other agencies may be dispatched to evacuate boaters from the lake sectors. Boaters will be directed to either the Marine EWC at Bluffers Park or Iroquois Park (Whitby Harbour) for monitoring and decontamination.

2.3 Lead and Support agencies named in this document will be contacted by their respective organizations based on notifications made by the Office of Emergency Management at the onset of the nuclear emergency.

2.4 Monitoring and decontamination of boaters from lake sectors:

It is only necessary to monitor and decontaminate boaters after emissions have started. Monitoring and decontamination details are described in approved OPG procedures

2.5 Assistance after Monitoring & Decontamination:

Boaters may leave the Bluffers Park after they have been monitored and cleared of contamination. They may go to a destination of their choice but should be advised to listen to Provincial direction for protective measures especially if they are residents of the Pickering Detailed Planning Zone.

If evacuated boaters are residents of the Pickering Detailed Planning Zone, the Emergency Social Services Emergency Support Function may be activated to may offer assistance for temporary accommodations, if the Province has ordered evacuations.

If the boaters are able to live aboard their vessels until the evacuation order is lifted, they may choose to do so at a marina or yacht club that can host them.

Reception Centre staff will register boaters who are temporarily moored at the Bluffers Park Complex and other locations. This will enable families to be re-united, if needed. They may direct boaters who prefer temporary housing to accommodations being used for land-based evacuees.

If required, the Toronto Transit Commission may be requested to send buses to Bluffer Park to take evacuees to other destinations, depending on individual circumstances.

2.6 Media Relations and Emergency Information:

The Province and Toronto Emergency Operations Centre will issue emergency information to the media for general and local issues respectively. The boating community at the Bluffers Park Complex may also need emergency directions that are specific to their circumstances.

Public inquiries from the Bluffers Park Complex community should be answered by a designated spokesperson from the Command Post if they relate to specific issues about operations at Bluffers Park e.g. what remains open or has been shut down, access to yacht clubs or public marina, road access etc.

2.7 Mutual arrangements with Durham Regional Police Service and other neighbouring police services:

The evacuation of the lake sectors is a responsibility that is shared between the Toronto Police Service and Durham Regional Police Service.

Arrangements to evacuate, monitor and decontaminate boaters are twinned at the Bluffers Park Complex and at Iroquois Park, Port Whitby Harbour. While both locations would be set up to receive boaters, the Centre that should be used may depend on the wind direction at the time of the emergency.

2.8 Cessation of Operations:

This Centre will be demobilized when advised by Toronto Emergency Operations Centre to cease operations.

Boaters and the Bluffers Park Complex community should be advised of the status and/or termination of the emergency. Boaters within the Detailed Planning Zone should be told if they may return to the Detailed Planning Zone. OPG staff will monitor the site for contamination and decontaminate it if necessary.

Documentation collected (under Incident Management System), evacuee registration lists and dose records of evacuees and emergency responders should be collected and sent to the Toronto Office of Emergency Management.

3.0 – Responsibilities

3.1 Lead agency – Toronto Police Service (Marine Unit):

- Appoint Police Incident Commander for policing operations
- Organize policing operations
- Register policing staff
- Implement plans and procedures
- Participate in Unified Command at EWC
- Liaise with Major Incident Command Centre
- Update PNERP Sector status maps

3.2 Ontario Power Generation:

- Issue dosimetry to emergency workers
- Maintain dose records of workers deployed into Detailed Planning Zone
- Instruct workers on the use of dosimetry and reporting requirements
- Assist Incident Commander to update PNERP Sector status maps
- Monitor and decontaminate EWC premises as required
- Monitor and decontaminate workers, vehicles, equipment and accessories
- Set-up facility according to approved OPG procedures
- Restore the EWC to its normal condition at the conclusion of the nuclear emergency

3.3 The City of Toronto's Office of Emergency Management:

- Maintain the City of Toronto's Emergency Plan and Toronto Nuclear Emergency Response Plan
- Operates the Emergency Operations Centre
- Arrange for meals and temporary accommodation, if required by evacuees
- Organize mass transportation to enable evacuees to leave area, if required







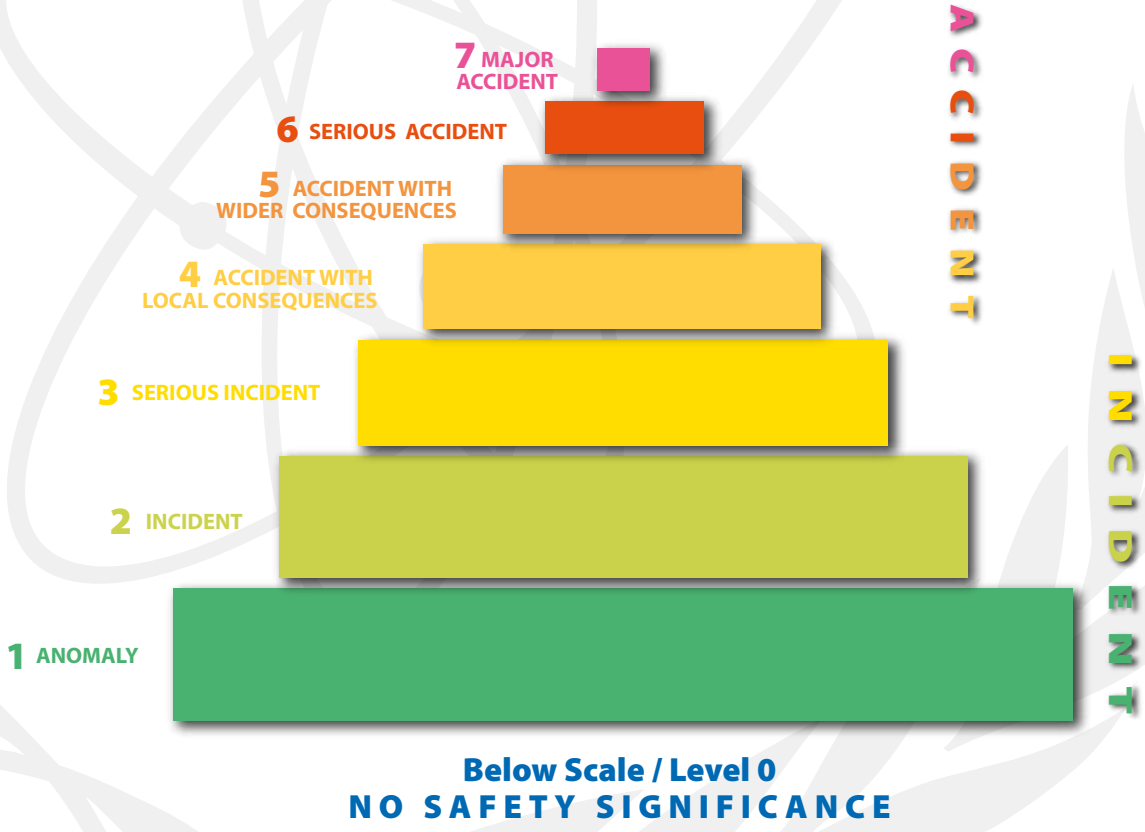
INES

THE INTERNATIONAL NUCLEAR AND RADIOLOGICAL EVENT SCALE

The INES Scale is a worldwide tool for communicating to the public in a consistent way the safety significance of nuclear and radiological events.

Just like information on earthquakes or temperature would be difficult to understand without the Richter or Celsius scales, the INES Scale explains the significance of events from a range of activities, including industrial and medical use of radiation sources, operations at nuclear facilities and transport of radioactive material.

Events are classified on the scale at seven levels: Levels 1–3 are called "incidents" and Levels 4–7 "accidents". The scale is designed so that the severity of an event is about ten times greater for each increase in level on the scale. Events without safety significance are called “deviations” and are classified Below Scale / Level 0.



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INES classifies nuclear and radiological accidents and incidents by considering three areas of impact:

People and the Environment considers the radiation doses to people close to the location of the event and the widespread, unplanned release of radioactive material from an installation.

Radiological Barriers and Control covers events without any direct impact on people or the environment and only applies inside major facilities. It covers unplanned high radiation levels and spread of significant quantities of radioactive materials confined within the installation.

Defence-in-Depth also covers events without any direct impact on people or the environment, but for which the range of measures put in place to prevent accidents did not function as intended.

Communicating Events

Nuclear and radiological events are promptly communicated by the INES Member States, otherwise a confused understanding of the event may occur from media or from public speculation. In some situations, where not all the details of the event are known early on, a provisional rating may be issued. Later, a final rating is determined and any differences explained.

To facilitate international communications for events attracting wider interest, the IAEA maintains a web-based communications network that allows details of the event to immediately be made publicly available.

The two tables that follow show selected examples of historic events rated using the INES scale, ranging from a Level 1 anomaly to a Level 7 major accident; a much wider range of examples showing the rating methodology is provided in the INES Manual.

Scope of the Scale

INES applies to any event associated with the transport, storage and use of radioactive material and radiation sources, whether or not the event occurs at a facility. It covers a wide spectrum of practices, including industrial use

EXAMPLES OF EVENTS AT NUCLEAR FACILITIES

	People and Environment	Radiological Barriers and Control	Defence-in-Depth
7	*Chernobyl, 1986* — Widespread health and environmental effects. External release of a significant fraction of reactor core inventory.		
6	*Kyshtym, Russia, 1957* — Significant release of radioactive material to the environment from explosion of a high activity waste tank.		
5	*Windscale Pile, UK, 1957* — Release of radioactive material to the environment following a fire in a reactor core.	*Three Mile Island, USA, 1979* — Severe damage to the reactor core.	
4	*Tokaimura, Japan, 1999* — Fatal overexposures of workers following a criticality event at a nuclear facility.	*Saint Laurent des Eaux, France, 1980* — Melting of one channel of fuel in the reactor with no release outside the site.	
3	*No example available*	*Sellafield, UK, 2005* — Release of large quantity of radioactive material, contained within the installation.	*Vandellos, Spain, 1989* — Near accident caused by fire resulting in loss of safety systems at the nuclear power station.
2	*Atucha, Argentina, 2005* — Overexposure of a worker at a power reactor exceeding the annual limit.	*Cadarache, France, 1993* — Spread of contamination to an area not expected by design.	*Forsmark, Sweden, 2006* — Degraded safety functions for common cause failure in the emergency power supply system at nuclear power plant.
1			Breach of operating limits at a nuclear facility.

EXAMPLES OF EVENTS INVOLVING RADIATION SOURCES AND TRANSPORT

	People and Environment	Defence-in-Depth
7		
6		
5	*Goiânia, Brazil, 1987* — Four people died and six received doses of a few Gy from an abandoned and ruptured highly radioactive Cs-137 source.	
4	*Fleurus, Belgium, 2006* — Severe health effects for a worker at a commercial irradiation facility as a result of high doses of radiation.	
3	*Yanango, Peru, 1999* — Incident with radiography source resulting in severe radiation burns.	*Ikitelli, Turkey, 1999* — Loss of a highly radioactive Co-60 source.
2	*USA, 2005* — Overexposure of a radiographer exceeding the annual limit for radiation workers.	*France, 1995* — Failure of access control systems at accelerator facility.
1		Theft of a moisture-density gauge.

such as radiography, use of radiation sources in hospitals, activity at nuclear facilities, and transport of radioactive material.

It also includes the loss or theft of radioactive sources or packages and the discovery of orphan sources, such as sources inadvertently transferred into the scrap metal trade.

When a device is used for medical purposes (e.g., radiodiagnosis or radiotherapy), INES is used for the rating of events resulting in actual exposure of workers and the public, or involving degradation of the device or deficiencies in the safety provisions. Currently, the scale does not cover the actual or potential consequences for patients exposed as part of a medical procedure.

The scale is only intended for use in civil (non-military) applications and only relates to the safety aspects of an event. INES is not intended for use in rating security-related events or malicious acts to deliberately expose people to radiation.

What the Scale is Not For

It is not appropriate to use INES to compare safety performance between facilities, organizations or countries. The statistically small numbers of events at Level 2 and above and the differences between countries for reporting more minor events to the public make it inappropriate to draw international comparisons.

History

Since 1990 the scale has been applied to classify events at nuclear power plants, then extended to enable it to be applied to all installations associated with the civil nuclear industry. By 2006, it had been adapted to meet the growing need for communication of the significance of all events associated with the transport, storage and use of radioactive material and radiation sources.

The IAEA has coordinated its development in cooperation with the OECD/NEA and with the support of more than 60 Member States through their officially designated INES National Officers.

The current version of the INES manual was adopted 1 July 2008. With this new edition, it is anticipated that INES will be widely used by the Member States and become the world-wide scale for putting into the proper perspective the safety significance of nuclear and radiation events.

INES

THE INTERNATIONAL NUCLEAR AND RADIOLOGICAL EVENT SCALE

INES

THE INTERNATIONAL NUCLEAR AND RADIOLOGICAL EVENT SCALE

GENERAL DESCRIPTION OF INES LEVELS

INES Level	People and Environment	Radiological Barriers and Control	Defence-in-Depth
Major Accident Level 7	• Major release of radioactive material with widespread health and environmental effects requiring implementation of planned and extended countermeasures.		
Serious Accident Level 6	• Significant release of radioactive material likely to require implementation of planned countermeasures.		
Accident with Wider Consequences Level 5	• Limited release of radioactive material likely to require implementation of some planned countermeasures. • Several deaths from radiation.	• Severe damage to reactor core. • Release of large quantities of radioactive material within an installation with a high probability of significant public exposure. This could arise from a major criticality accident or fire.	
Accident with Local Consequences Level 4	• Minor release of radioactive material unlikely to result in implementation of planned countermeasures other than local food controls. • At least one death from radiation.	• Fuel melt or damage to fuel resulting in more than 0.1% release of core inventory. • Release of significant quantities of radioactive material within an installation with a high probability of significant public exposure.	
Serious Incident Level 3	• Exposure in excess of ten times the statutory annual limit for workers. • Non-lethal deterministic health effect (e.g., burns) from radiation.	• Exposure rates of more than 1 Sv/h in an operating area. • Severe contamination in an area not expected by design, with a low probability of significant public exposure.	• Near accident at a nuclear power plant with no safety provisions remaining. • Lost or stolen highly radioactive sealed source. • Misdelivered highly radioactive sealed source without adequate procedures in place to handle it.
Incident Level 2	• Exposure of a member of the public in excess of 10 mSv. • Exposure of a worker in excess of the statutory annual limits.	• Radiation levels in an operating area of more than 50 mSv/h. • Significant contamination within the facility into an area not expected by design.	• Significant failures in safety provisions but with no actual consequences. • Found highly radioactive sealed orphan source, device or transport package with safety provisions intact. • Inadequate packaging of a highly radioactive sealed source.
Anomaly Level 1			• Overexposure of a member of the public in excess of statutory annual limits. • Minor problems with safety components with significant defence-in-depth remaining. • Low activity lost or stolen radioactive source, device or transport package.

NO SAFETY SIGNIFICANCE *(Below Scale/Level 0)*

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Canadian Environmental Law Association
EQUITY. JUSTICE. HEALTH.

June 8, 2018

Louise Levert, Senior Tribunal Officer
Canadian Nuclear Safety Commission
280 Slater Street, PO Box 1046
Ottawa, ON K1P 5S9

Delivered via email cnsc.interventions.ccsn@canada.ca

Dear Ms. Levert:

Re: Supplemental Submission from the Canadian Environmental Law Association Re: PNERP Implementing Plan for Pickering NGS (Hearing Ref No. 2018-H-03)

The Canadian Environmental Law Association (CELA) has undertaken a detailed review of the Implementing Plan for the Pickering Nuclear Generating Station ("Implementing Plan") and provides the following comments to the Canadian Nuclear Safety Commission (Commission). These comments are in addition to, and not a substitute for the findings and recommendations contained in our primary submission dated May 7, 2018.[1]

As the Implementing Plan was publicly available for only one week prior to the intervention deadline, we appreciate having this opportunity to provide comments to the Commission. For the reasons summarized below, we reiterate our request to the Commission that Ontario Power Generation's (OPG) request for a 10-year licence be denied:

- Emergency plans are not yet complete nor aligned
- Emergency planning zones are insufficient in size to safeguard human health
- Evacuation time estimate studies need to be updated prior to relicensing
- The availability of protective equipment for first responders must be confirmed
- Offsite monitoring during an accident requires review
- Transition to the recovery phrase requires greater detail and guidance
- Meteorological data and modelling is deficient

[1] Canadian Environmental Law Association, "Evaluating Environmental Protection and Emergency Preparedness at the Pickering Nuclear Generating Station" (7 May 2018), online: http://www.cela.ca/pickering-licence-renewal **[CELA Pickering NGS Submission]**

1. Emergency plans are not yet complete nor aligned

Currently, the only emergency planning documents which are updated and publicly available are the 2017 Provincial Nuclear Emergency Response Plan (PNERP 2017) and Pickering NGS's Implementing Plan. As these plans were released in December 2017 and April 2018, respectively, Durham Region's nuclear emergency response plan and evacuation plan have not been updated nor aligned with new provincial standards. Furthermore, the province of Ontario is conducting additional technical work which will inform the adequacy of the current planning zones and response measures. Some of the recommendations in this submission are informed by CELA's review of the current plan that was conducted during the provincial consultation in the summer of 2017, as these specific issues remain outstanding pending the province's additional technical review.[2] Where relevant, these points are reiterated in this submission even though they were raised during another licensee's recent licence hearing in Kincardine for the Bruce Nuclear Power Plant.

As Durham Region details in its intervention to the Commission, the evacuation plan maintained by the Durham Regional Police Service requires review to ensure alignment with PNERP 2017. Durham Region also notes that their emergency response expectations since the release of PNERP 2017 "should not be underestimated" and they will need sufficient emergency staff "over and above the current complement" to extend their response capability.[3] CELA submits that until Durham Region has completed necessary reviews and updates, the Pickering NGS should not be licensed for further operation. We also request the Commission inquire into the status of the municipal planning updates and potential timelines for completion.

Further planning required by Durham Region as a designated municipality is also outstanding. As s. 2.6.2 of the Implementing Plan states, designated municipalities "shall detail the planning data necessary to undertake an effective nuclear emergency response," referencing population estimates, institutional data and critical infrastructure. Because the Implementing Plan was released on April 30, 2018, there has not been sufficient time for this planning to occur. Furthermore, the Implementing Plan does not detail who provides guidance to municipalities in accomplishing this objective. We therefore ask the Commission query whether the Durham Region has been provided guidance in its review of "institutional data," and "critical infrastructure," and whether it requires assistance in this regard.

Lastly, the Office of the Fire Marshall and Emergency Management's (OFMEM) has noted that its technical study of PNERP 2017 – which reviews the size of emergency planning zones and

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[2] CELA, "Discussion on Planning Basis Review and Recommendations and List of Proposed Changes to the PNERP 2009" (28 July 2017) online: http://www.cela.ca/sites/cela.ca/files/EmergencyPlg.pdf

[3] http://www.nuclearsafety.gc.ca/eng/the-commission/hearings/cmd/pdf/cmd18-h6/CMD18-H6-67.pdf, p 10 **[CELA Discussion on PNERP]**

evacuation plans - is ongoing and completion not expected until the end of 2018.[4] CELA submits that the adequacy of emergency measures currently in place must be reviewed as soon as possible, following the release of better technical information. Upon release of the technical study, the Commission should publicly review its effects on emergency planning arrangements. Any further technical studies should be publicly reviewed by the Commission on an ongoing, annual basis.

2. Emergency planning zones are insufficient in size to safeguard human health

For the reasons highlighted below, CELA reiterates its recommendation to the Commission that protective actions within the Detailed Planning Zone (DPZ) be expanded from 10 km to 20 km, and monitoring and response efforts in the Ingestion Planning Zone (IPZ) expanded from 50 km to 100 km.

2.1 Beyond Design Basis Accidents

Section 2.2.4(d) of the Implementing Plan notes that in order to mitigate severe, off-site effects of Beyond Design Basis Accidents, protective actions may be necessary into the Contingency Planning Zone (CPZ). Unfortunately, the Implementing Plan also states "the CPZ does not require the same level or type of detailed arrangements as the automatic action zone or detailed planning zone." In the event of a radioactive hazard, it cannot be assumed that default protective measures – such as ingesting KI and safely evacuating - can be as effective as response measures which are pre-planned and tested. These deficiencies must be remedied as a condition of licensing.

We reiterate the Commission should not accept the province's continued reliance on improvisation and adaptation as its main strategy for responding to large off-site accidents that require evacuation and other measures beyond the DPZ. To analyze if the nuclear power plant is acceptably safe for continued operation, CELA recommends the Commission undertake a detailed review of the measures currently in place to mitigate severe off-site effects beyond the DPZ with specific reference to (1) their achievability and sufficiency, (2) the distances to which they are effective, and (3) the timing and resourcing required for their implementation.

2.2 Automatic Action Zone

CELA requests the Commission review whether vulnerable communities within this zone (ie. people with disabilities, babies, children, pregnant women, people residing in retirement homes or hospital patients who may require evacuation) have been identified and whether they have been specifically considered in emergency plans. All information pertaining to default protective

[4] CELA Pickering NGS Submission, *supra* note 1, p 49

actions, evacuation routes and emergency procedures must also be in the public domain to ensure the protection of the those residing or working in the AAZ.

2.3 Contingency Planning Zone

As CELA submitted in its primary submission, the detailed planning required in the DPZ should be expanded into the 20 km CPZ. Currently, the emergency plans before the Commission do not align with international guidance (see Table 1, below) nor ensure protective measures can be successfully implemented for all residents and evacuees in this area.

CELA recommends the Commission conduct a comparative analysis of the protective measures in place for the DPZ and CPZ and ensure licence conditions provide for (1) the health and safety of persons and the environment in the event of a large, offsite radioactive release and (2) are congruent with international guidance (see Table 1).

2.4 Ingestion Planning Zone

CELA recommends the Commission ascertain the information which has been communicated to residents, farmers, and other businesses who may be affected by the restrictions in the IPZ. We ask that examples of the information already disseminated be provided to confirm the existence of this communication, per section 2.4.3 of the Implementing Plan. We also request the Commission inquire into the level of advance planning that has occurred to ensure that in the event of a radioactive release, the food chain is protected.

2.5 International Guidance

CELA provides the following update to a table reviewing emergency planning zones and measures, in accordance with IAEA guidance, as provided in our primary submission.[5]

Table 1 Emergency Planning Zones and Accompanying Response Measures per IAEA Guidance

Zone	Size	Description	Response Measures
Precautionary Action Zone	3 – 5 km	Area within which arrangements should be made to implement precautionary urgent protective actions before or shortly after a major release with the aim of preventing or reducing the occurrence of severe deterministic effects[6]	Urgent protective actions include: isolation of a contaminated area or radioactive source; prevention of inadvertent ingestion; evacuation; Sheltering; respiratory protection and protection of skin and eyes; decontamination of individuals;

[5] CELA Pickering NGS Submission, *supra* note 1, p 48

[6] IAEA Safety Standards, "General Safety Requirements Part 7 - Preparedness and response for a Nuclear Radiological Emergency" (2015), p 76 **[GSR-7]**

Urgent Protective Action Planning Zone	5 – 30 km	Area where preparations are made to promptly shelter in place, to perform environmental monitoring and to implement urgent protective actions on the basis of the results of monitoring within a few hours following a release.[8]	prophylaxis with stable iodine; protection of the food supply and prevention of the consumption of significantly contaminated foodstuffs and water; management of the medical response; and, protection of international trade [7]
Extended Planning Distance	100 km	Distance around a nuclear power plant where arrangements are made to conduct early monitoring of deposition to locate hotspots with dose rates warranting (1) evacuation within a day following a release or (2) relocation within a week to a month following a release	Relocation, decontamination, replacement of food, milk and water [9]
Ingestion and Commodities Planning Distance	300 km	The distance around a nuclear power plant for the area within which arrangements are made, within hours of being notified by the nuclear power plant of the declaration of a General Emergency	Place grazing animals on covered feed; protect drinking water supplies that directly use rainwater (e.g. to disconnect rainwater collection pipes); restrict consumption and distribution of non-essential local produce, wildgrown products (e.g. mushrooms and game), milk from grazing animals, rainwater, animal feed; and, restrict distribution of commodities until further assessments are performed [10]

3. Evacuation time estimate studies need to be updated prior to relicensing

Section 2.6.3 of the Implementing Plan requires that evacuation time estimate studies "be prepared and regularly updated to facilitate transportation planning and the management of transportation during a response." CELA reiterates that this study should be updated as a prerequisite to licensing in order to align PNERP 2017 with existing plans. CELA also recommends that given growth projections in Durham Region, evacuation estimates be updated annually as a condition of licensing and be reviewed annually at the Commission's nuclear power plant oversight meeting.

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[8] GSR-7, *supra* note 6, p 77

[7] International Atomic Energy Agency, "Arrangements for Preparedness for a Nuclear or Radiological Emergency No. GS-G-2.1" (2007) online: http://www-pub.iaea.org/MTCD/publications/PDF/Pub1265web.pdf,p 32 **[IAEA GS-G-2.1]**, p 32

[9] IAEA, "Actions to protect the public in an emergency due to severe conditions at a light water reactor" (2013), online: https://www-pub.iaea.org/MTCD/Publications/PDF/EPR-NPP_PPA_web.pdf, p 102 **[IAEA Actions to protect the public]**

[10] *Ibid,* p 103

4. The availability of protective equipment for first responders must be confirmed

Section 6.8.9 of the Implementing Plan lists the equipment emergency services should carry (ie. respiratory protection, gloves, dosimetry). First, CELA recommends the Commission inquire as to the availability of this equipment for *all* first responders and the immediacy of its availability in the event of an emergency. Secondly, we ask the Commission to determine levels of supplies and whether their quantity and the number of emergency service personnel is updated routinely. Third, we submit the Commission should query the availability of this equipment beyond the 10 km and 20 km zones.

5. Offsite monitoring during an accident requires review

Section 4.6.5 of the Implementing Plan explains that prior to or during a radioactive emission, the Provincial Emergency Operations Centre (PEOC) Science Section "shall undertake technical assessments" which "shall serve as input into the PEOC Planning Section recommendations for Command decision-making." Response capacity in the event of a radioactive release is crucial and therefore CELA requests the Commission confirm the number, qualification and length of tenure for Science Section members. CELA submits that the depth of expertise and availability of the Science Section must be permanently available.

6. Transition to the recovery phrase requires greater detail and guidance

Section 4.8.4 of the Implementing Plan provides that stakeholder recovery plans should be prepared in advance and conform to the provincial recovery plan. The Implementing Plan does not, however, detail who must develop this plan which according to section 4.8.3 should address the care for persons exposed or contaminated, long-term relocation and care, and resettlement. Recovery plans are not new to PNERP 2017 and indeed, the CNSC's DIS-17-01 *Framework for Recovery in the Event of a Nuclear or Radiological Emergency* commenting on PNERP 2009 states:

> At a suitable stage, the PEOC will consult with the major organizations involved in the emergency response regarding their transition to the recovery phase, and what lead time they would need to make a smooth transition. Based on these consultations, the PEOC will set a time for ending the response phase and inform all stakeholders involved in advance.[11]

Accordingly, CELA requests the Commission require an update on the drafting of recovery and stakeholder plans and require a timeline for their completion and public review.[12]

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[11] CNSC, "DIS-17-01, Framework for Recovery in the Event of a Nuclear or Radiological Emergency" (2017) online: http://nuclearsafety.gc.ca/eng/acts-and-regulations/consultation/comment/d-17-01.cfm

[12] CELA was unable to located either of these plans in the public domain.

7. Meteorological data and modelling is deficient

Section 2.2.3 of the Implementing Plan reviews the "typical progression" of a design basis accident scenario, noting:

> Suitable meteorological conditions may make it possible to vent some of this contained radioactivity through filters in a direction away from populated areas. It may be possible to do this several times.

CELA asks the Commission to verify the "direction" referenced in the above noted provision. Additionally, we ask that the Commission verify the modelling of weather and meteorological contingencies to date, and whether further planning is necessary to ensure the health and safety of the public and the environment. The weather models relied upon in the PNERP do not incorporate 365 days-per-year of weather data and thus we recommend such monitoring data be a required as an input to emergency planning.[13]

Conclusion

The mandate of the Commission per s. 9 of the NSCA requires that it "prevent unreasonable risk to the environment and to the health and safety of persons." Determining whether the threshold of unreasonable risk has been met must be determined on a case-by-case basis. This is a subjective, value-based evaluation, albeit supported by technical information and analysis. With respect to interpreting "unreasonable risk," the Commission must be satisfied that even the most serious of accidents can be mitigated to the extent that the resulting harm is reasonable to both people and the environment.

For the foregoing reasons, CELA submits the Commission does not have the requisite information upon which to make this finding. The evidence before the Commission in this regard is limited and therefore, the Commission cannot fulfill its statutory mandate and establish that unreasonable risk to the health and safety of persons and the environment can be prevented.

CELA respectfully reiterates our request, as stated in our primary submission, that OPG's request for a 10-year licence be denied.

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[13] As CELA noted in submission to the OFMEM during the consultation on PNERP 2017, four years of weather data and five years of precipitation data was utilized and modelled in the "Independent Study of Technical Issues Relating to Offsite Consequences Resulting from a Release of Radioactivity at Chalk River Laboratories (International Safety Research Inc. (ISR), March 2004). We consequently recommended that four to five years of 365-days per year weather data be used as an input to emergency planning (see CELA Discussion on PNERP, *supra* note 3)

Thank you for your continued consideration of these matters.

All of which is respectfully submitted this 8th day of June 2018.

CANADIAN ENVIRONMENTAL LAW ASSOCIATION

Per



Kerrie Blaise

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Canada's Nuclear Regulator

CNSC Fukushima Task Force Report

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Commission canadienne de sûreté nucléaire

Canada

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CNSC Fukushima Task Force Report

INFO-0824

October 2011

Preface

The CNSC Fukushima Task Force was established under the authority of the Executive Vice-President and Chief Regulatory Operations Officer, Ramzi Jammal, to evaluate operational, technical and regulatory implications on Canadian nuclear power plants (NPPs) from the 2011 nuclear event in Fukushima, Japan.

The work of the Task Force was led by Dr. Greg Rzentkowski, Director General of the Directorate of Power Reactor Regulation, who is responsible for implementing regulatory actions, including policy decisions, regulatory requirements and recommendations for safety upgrades at Canadian NPPs.

Acknowledgements

The CNSC Fukushima Task Force was made up of the following members, supported by many other CNSC staff in a wide range of disciplines.

Chair:

Greg Rzentkowski	Director General, Directorate of Power Reactor Regulation

Vice-Chair:

Gerry Frappier	Director General, Directorate of Assessment and Analysis

Technical Leads:

Tom Schaubel	Director, Directorate of Power Reactor Regulation
Phil Webster	Director, Directorate of Power Reactor Regulation
Pat Hawley	Director, Directorate of Assessment and Analysis

Scientific Secretary:

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Project Management:

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David Newland	Director, Directorate of Regulatory Improvement and Major Projects (requirements for new builds)
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Chris Harwood	Technical Specialist, Directorate of Assessment and Analysis (deterministic safety analysis)
Luc Sigouin	Director, Directorate of Security and Safeguards (emergency response)

The CNSC Task Force wishes to thank the numerous CNSC staff members who provided expert advice and timely assistance to the Task Force members.

Executive Summary

On March 11, 2011, a magnitude 9.0 earthquake, followed by a devastating tsunami, struck Japan. It left an estimated 25,000 people dead or missing, about half a million homes destroyed or damaged, and 560 square kilometres inundated.

The combined impact of the earthquake and tsunami on the Fukushima Daiichi nuclear power plant (NPP) caused one of the world's worst-ever nuclear accidents. In the hours and days that followed, three of the plant's six reactors overheated and suffered damage. Workers battled extraordinary conditions to prevent or delay radioactive releases over the surrounding region and into the sea. It is a tribute to their efforts that releases were delayed sufficiently to enable the nearby population to be evacuated despite widespread damage to the local infrastructure.

As the accident unfolded, the evacuation zone was expanded and people in a wider area were asked to shelter indoors. Widespread radiation monitoring and control of food production and distribution were implemented. The Japanese government has indicated that some areas may remain uninhabitable for many years. Similarly, monitoring and control of food and water supplies will need to be maintained, perhaps for many years. The emergency response measures currently in place have prevented fatalities from radioactive releases and should ensure that any long-term health effects for the Japanese public are negligible.

Immediate actions taken by the Canadian Nuclear Safety Commission

While major accidents such as this happen very infrequently, it is vitally important that all nuclear facility designers and operators, nuclear regulators, and emergency response organizations learn every possible lesson. The Canadian Nuclear Safety Commission (CNSC) has always endeavoured to continuously improve both itself and the safety performance of the nuclear industry that it regulates. It is in this spirit that the CNSC responded immediately to the accident at Fukushima Daiichi with the following actions:

- activated its Emergency Operations Centre in Ottawa and staffed it 24/7 to monitor the emergency, assess early reports and provide timely, accurate information to Canadians and to other Canadian government departments and agencies
- requested licensees of Canadian Class I nuclear facilities[1], under section 12(2) of the *General Nuclear Safety and Control Regulations*, to review the lessons learned from the Fukushima Daiichi accident
- performed inspections of all NPPs and other nuclear facilities in Canada to assess the readiness of mitigating systems – these inspections covered seismic preparedness, firefighting capability, backup power sources, hydrogen mitigation and irradiated fuel bay cooling
- established a Task Force to evaluate the operational, technical and regulatory implications of the accident and the adequacy of emergency preparedness for NPPs

The CNSC Fukushima Task Force was created with the objective of reviewing the capability of NPPs in Canada to withstand conditions similar to those that triggered the Fukushima accident. Specifically, the CNSC Task Force examined the response of NPPs to external events of higher magnitude than have previously been considered. It also examined the licensees' capability to respond to such events. The focus was on the need to "anticipate the unexpected": events such as earthquakes, tornadoes or hurricanes that may cause a prolonged loss of electrical power, resulting in operators not being able to continue cooling the reactors. The focus was also on the need for an integrated response capability.

[1] Class I nuclear facilities are defined in the *Class I Nuclear Facilities Regulations* and include nuclear power plants, research reactors and fuel fabrication facilities.

Safety review criteria

The scope of the review, documented in *Nuclear Power Plant Safety Review Criteria,* was consistent with the defence-in-depth approach underlying the NPP design, namely:

- identification and magnitudes of external events
- adequacy of design-basis-accident analysis
- consideration of beyond-design-basis accidents
- implementation of severe accident management
- licensees' emergency response plans
- nuclear emergency management in Canada
- CNSC regulatory framework and processes

The defence-in-depth strategy assures prevention and control of events and accidents at several engineering and procedural levels in order to ensure the effectiveness of the protection of physical barriers against the release of radioactive materials. In principle, if a failure were to occur, it would be detected and compensated for, or corrected, by appropriate measures to maintain protection of the public.

The *Nuclear Power Plant Safety Review Criteria* generally exceed the requirements and expectations of the current CNSC regulatory framework. The CNSC Task Force review findings relate exclusively to the lessons learned from the Fukushima accident.

In the process of formulating the safety review criteria, the CNSC Task Force considered all the applicable lessons learned to date from the Fukushima accident and reviewed selected international reports to ensure that all aspects relevant to Canada were addressed. Effectively, the CNSC Task Force has subjected the Canadian NPPs, the existing emergency response measures, and the regulatory framework and supporting processes to a systematic and comprehensive "stress test" to evaluate means to further protect the health and safety of Canadians and the environment. The post-Fukushima review has examined events more severe than those that have historically been regarded as credible and their impact on the NPPs. The CNSC Task Force has proposed changes to designs or procedures, wherever gaps were found, in order to minimize or eliminate their impact.

Strengthening reactor defence in depth

Based on the post-Fukushima review, the CNSC Task Force confirms that the Canadian NPPs are robust and have a strong design relying on multiple layers of defence. The design ensures that there will be no impact on the public from external events that are regarded as credible. The design also offers protection against more severe external events that are much less likely to occur.

Nevertheless, the CNSC Task Force has a number of recommendations for strengthening each layer of defence built into the Canadian NPP design and licensing philosophy. In particular, the CNSC Task Force recommends that certain design enhancements for severe accident management – such as containment performance to prevent unfiltered releases of radioactive products, control capabilities for hydrogen and other combustible gases, and adequacy and survivability of equipment and instrumentation – should be evaluated and implemented wherever practicable. Some of these enhancements have already been implemented and others should be implemented as rapidly as practicable.

Enhancing emergency response

The CNSC Task Force also confirms that the current status of emergency preparedness and response measures in Canada, specifically the onsite and offsite preparedness and response, is adequate. The CNSC Task Force has verified that there are no significant gaps in emergency planning at Canadian NPPs. The licensees maintain and operate comprehensive and well-documented emergency plans which are regularly tested through self-audited drills and exercises. The CNSC Task Force has also verified that there are no

significant gaps in nuclear emergency planning at provincial and federal levels. The existing provincial and federal emergency plans are well documented and effectively integrated with onsite emergency preparedness and response measures.

Notwithstanding these measures, their effectiveness can be further improved through upgrading onsite emergency facilities and equipment, in particular through formalizing all arrangements and agreements for external support and installing automated real-time station boundary radiation monitoring systems with appropriate backup power. Federal and provincial nuclear emergency planning could be strengthened through establishing a formal, transparent, national-level oversight process for offsite nuclear emergency plans, programs and performance, and through scheduling of regularly planned full-scale exercises.

Improving regulatory framework and licensing

The CNSC Task Force has performed a detailed review of the CNSC regulatory framework and processes, and concludes that the *Nuclear Safety and Control Act* does not need revision and that there is no need to revisit the structure of the regulatory framework as a result of the lessons learned from the Fukushima Daiichi accident. The Canadian regulatory framework is strong and comprehensive and is effectively applied for the whole range of plant conditions, including severe accidents. In particular, the CNSC Task Force notes that the Act authorizes the Commission to establish classes of licences and that the CNSC has the authority and flexibility to rapidly amend licences to impose additional requirements in order to continuously improve the safety performance of the nuclear industry. This is regarded as a strength of the Canadian system.

Nevertheless, to widen the range of instruments allowing for an effective application of the Act, the CNSC Task Force recommends that the *Class I Nuclear Facilities Regulations* be amended to require licensees to submit offsite emergency plans. It also recommends that the *Radiation Protection Regulations* be amended to be more consistent with international guidance and to describe the regulatory requirements needed to address radiological hazards during the phases of an emergency in greater detail. Furthermore, the CNSC Task Force recommends enhancing the oversight of NPPs by implementing a periodic safety review process.

The regulatory document framework should be enhanced by updating selected requirements and expectations for design-basis and beyond-design-basis accidents. These updates will ensure that lessons learned are built into the regulatory oversight program for existing reactors and new builds.

Overall conclusion

The CNSC Task Force concludes that Canadian NPPs are safe and that the risk posed to the health and safety of Canadians or to the environment is small. The CNSC staff have also verified that all Canadian NPPs are located far from tectonic plate boundaries and that the threat of a major earthquake at a Canadian NPP is negligible. The CNSC Task Force is confident that the improvements recommended in this report will further enhance the safety of nuclear power in Canada and will reduce the associated risk to as low as reasonably practicable.

Under the oversight of the CNSC and its staff, Canadian NPPs have been operating safely for over 40 years. As has always been the case, they will only be licensed if the CNSC is satisfied that they will continue to be operated safely.

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1 Background

On March 11, a magnitude 9.0 earthquake[2] struck off the northeast coast of Japan's main island. A devastating tsunami followed. The earthquake and tsunami left an estimated 25,000 people dead or missing, about half a million homes destroyed or damaged and 560 square kilometres of land inundated.

The combined impact of the earthquake and tsunami on the Fukushima Daiichi nuclear power plant (NPP) caused one of the worst-ever nuclear accidents. In the hours and days that followed, the cores of three of the six reactors at the site melted down and released radioactive material over the surrounding region and to the sea.

The Japanese authorities initially rated the nuclear accident at level 4 on the INES[3] scale (International Scale of Nuclear Incidents). They subsequently increased the level to 7, the highest on the scale. A final assessment of the severity and causes of the incident will come only after the conclusion of full investigations, expected to take several years. Nevertheless, enough information is available to begin the lessons-learned process.

One of several actions that the Canadian Nuclear Safety Commission (CNSC) took in response to the accident was to set up a Task Force to investigate the lessons learned from the Fukushima Daiichi accident and their implications for Canada. This report documents the findings and recommendations of the CNSC Fukushima Task Force.

The report provides relevant background information in the following areas:

- a summary of the accident (section 2)
- Canadian and international actions in response to the accident (sections 3 and 4)
- a comparison of Japanese seismic and flooding hazards to Canadian hazards (section 5)

The report summarizes the detailed CNSC Task Force reviews in three main areas:

- capability of Canadian NPPs to withstand extreme external events, including a review of licensees' responses to the CNSC's request for information concerning lessons learned (section 6)
- adequacy of Canada's measures to respond to a major nuclear emergency (section 7)
- adequacy of the Canadian regulatory framework and processes, including findings involving changes to regulatory requirements (section 8)

The implications of the CNSC Task Force findings on potential new reactors in Canada are discussed in section 9. The conclusions and recommendations arising from the review are given in section 10.

Appendix A provides an overview of CANDU (Canadian Deuterium-Uranium) reactors with an emphasis on features important to accidents with loss of electrical power.

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[2] Earthquake magnitudes are measured on the moment magnitude scale (values are very similar to the earlier Richter scale). The scale is based on energy released by the earthquake. An increase in 1 on the scale represents a 32 times increase in energy released.

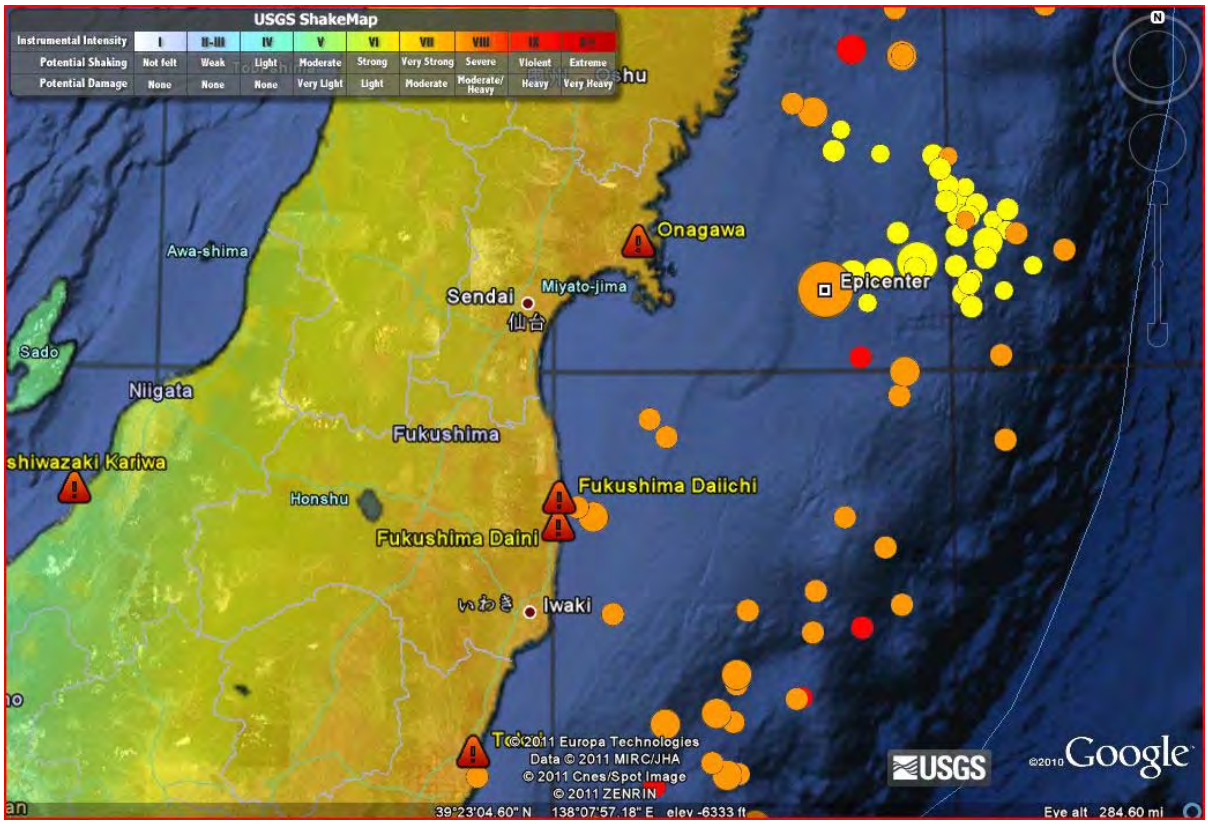
[3] The INES was developed by the International Atomic Energy Agency. More information is available at iaea.org/Publications/Factsheets/English/ines.pdf.

2 Summary of the Accident

On March 11, 2011, at 2:46 p.m. local time, a magnitude 9.0 earthquake struck off the northeastern coast of Japan approximately 175 km from the Fukushima Daiichi plant. This was one of the largest earthquakes in recorded history, moving parts of Japan 3 m east and slightly changing the speed of rotation of the earth. The maximum ground acceleration[4] at Fukushima Daiichi was 0.56 g, recorded in unit 2, about 25 percent greater than the plant design basis (meaning 25 percent greater than the ground acceleration that the plant was designed to withstand). Figure 2.1 shows the locations of the earthquake epicentre and the NPPs. The Tokyo Electric Power Company (TEPCO) operates the Fukushima Daiichi plant.

Although other reactors on the east coast of Japan were affected by the earthquake and tsunami, only Fukushima Daiichi units 1 to 4 suffered serious damage. This report considers only those units, since sufficient cooling was maintained at all other units.

Figure 2.1 Earthquake Shakemap Showing Nuclear Power Plant Locations



Units 1, 2 and 3 were operating at full power, and units 4, 5 and 6 were already shut down in scheduled maintenance outages. The operating units shut down automatically, as designed, at the time of the earthquake. At the same time, all offsite power was lost; however, emergency diesel generators started automatically as designed and supplied essential electrical equipment.

[4] Ground acceleration is a measure of the strength of ground motion in an earthquake and is important in understanding the effects on building structures. It is normally given in multiples of the acceleration due to gravity, g. The ground acceleration at a location depends on the magnitude of the earthquake and the distance from the epicentre.

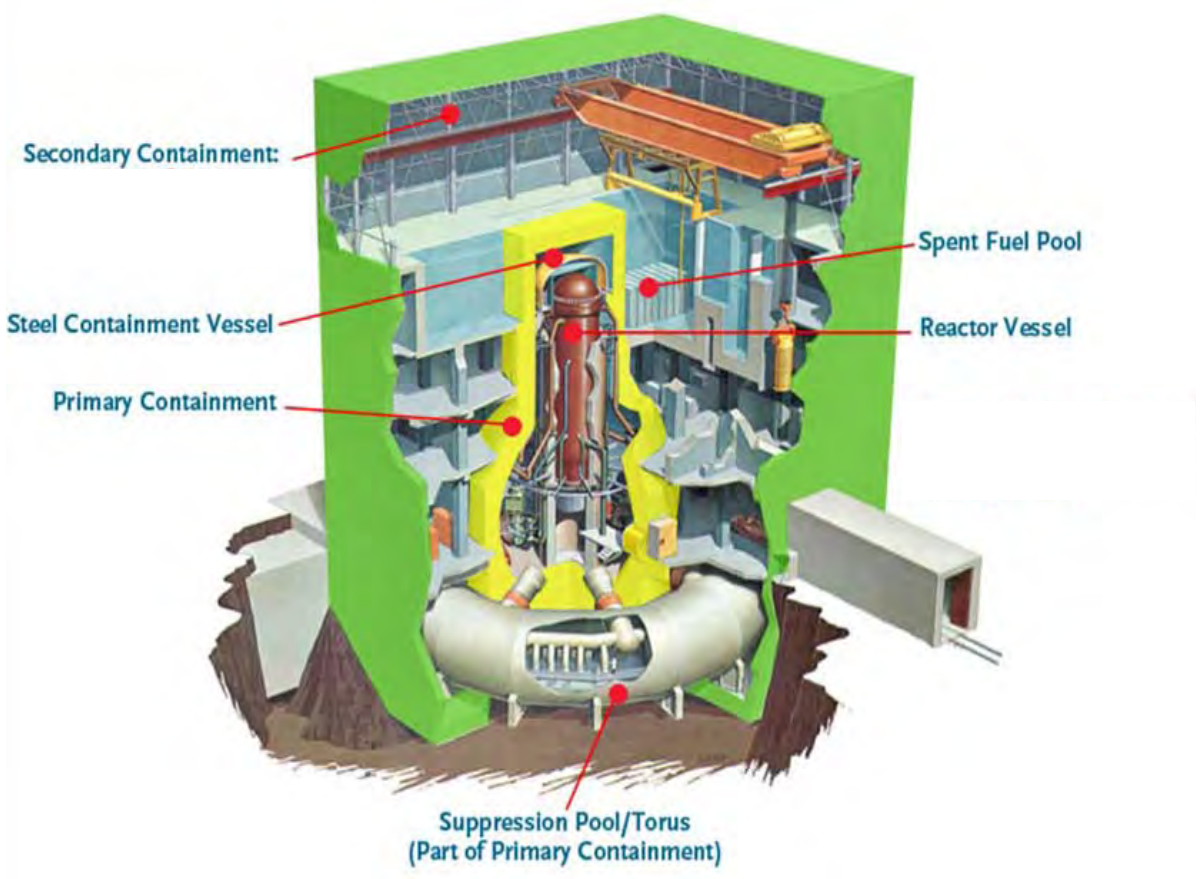
Beginning 41 minutes after the earthquake, a series of tsunami waves hit the station. The tsunami was much higher than had been considered in the plant design and it overwhelmed much of the low-lying equipment. The original station design assumed a maximum tsunami height of 3.1 m, later upgraded to 5.6 m. The highest of the tsunami waves that struck the Fukushima stations was estimated at 14 to 15 m on land. It is important to distinguish between the wave height at sea and the wave height due to run-up on land. The run-up height can be significantly higher than the wave height at sea and is a function of land topography.

Within 54 minutes after the earthquake, the tsunami had stopped all the emergency diesel generators and flooded the electrical switchgear. Units 1 to 4 had two air-cooled emergency diesel generators that escaped the flooding. It is not known if they were operable, but they could not have been used anyway because the electrical switchgear had been flooded. As a result, units 1 to 4 were left with only battery power.

2.1 Operating units

Figure 2.2 shows the general arrangement of a boiling-water reactor of the type used at Fukushima Daiichi.

Figure 2.2 Cutaway View of Boiling-water Reactor Type 1 Containment



Each unit contains one reactor. The reactor fuel elements are made up of uranium dioxide pellets in a zircaloy tube, about 4 m in length. The fuel elements are arranged in 8×8 bundles and positioned vertically in the reactor core. The reactor core is located low down in the reactor pressure vessel. The

reactor pressure vessel[5] is inside the steel primary containment which comprises a drywell (inside the yellow boundary shown on the figure) and a suppression pool or wetwell. The wetwell is partly filled with cold water and is used to condense steam from the reactor when it can no longer be sent to the turbine (e.g., after an accident).

Spent fuel from the reactor is stored in the spent fuel pool located at a high elevation inside the secondary containment. The secondary containment does not have pressure retaining capability.

The following description applies generically to each of units 1, 2 and 3 which were operating at the time of the earthquake. The timing of events varied from unit to unit, but the broad progression of events was similar.

After the loss of alternating current (AC) electrical power, pumps driven by steam turbines were used in units 2 and 3 to maintain cooling. These pumps use steam from the reactor as a power source and reject heat to the suppression pool. Continuous cooling of a reactor core must be maintained even after shutdown because the fuel continues to generate heat, known as decay heat[6]. After several hours the batteries were exhausted (or cooling pumps had failed) and all reactor cooling was lost. Unit 1 was a slightly older design and did not have steam-driven pumps. Unit 1 lost cooling almost immediately after the tsunami.

Without adequate cooling, pressure began to rise in each reactor and the reactor pressure vessel relief valves opened to vent[7] excess steam into the suppression pool located in the containment wetwell. Because steam was being removed from the reactor pressure vessel and not replaced, the reactor began to boil dry.

At some point, the core began to uncover and fuel began to rapidly overheat. As fuel temperatures rose, fuel failures began, first releasing gaseous fission products and progressively the less volatile fission products. When fuel sheath temperatures exceeded 1,200°C, the zircaloy sheath material reaction with steam accelerated significantly to produce zirconium oxide and hydrogen and a large amount of heat. The core began to lose structural strength and melt down[8].

The atmosphere in the reactor pressure vessel was a mixture of steam, hydrogen and fission products. This mixture was vented to the suppression pool and from there to the primary containment. Because the primary containment was, by design, filled with nitrogen, the hydrogen could not ignite or explode due to lack of oxygen.

The cold water in the suppression pool absorbed the energy of the steam being discharged from the reactor and kept primary containment pressure under control during the initial hours of the accident. But, with no heat removal from primary containment, the suppression pool heated up, becoming progressively less effective. Pressure in the primary containment began to rise. Due to the pressure buildup, the primary containment was at risk of failing and causing an uncontrolled release of radioactive substances. To avoid containment failure, the operator opened valves to vent the primary containment. Hydrogen in the vented gases mixed with air in the secondary containment to form an

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[5] The reactor pressure vessel is a large steel vessel containing the reactor core and filled with reactor coolant.
[6] Decay heat is produced by the decay of radioactive material in the fuel. For a typical reactor, decay heat falls from about 7 percent immediately after shutdown of the fission reaction to 1 percent after about 5 hours and 0.5 percent after a day.
[7] Venting is the process of removing unwanted or excess gas from a closed system, either automatically through relief valves or manually through vent valves opened by the operator.
[8] Zircaloy fuel sheaths melt at about 1,760°C. Fuel pellets melt at about 2,760°C.

explosive mixture, leading to explosions that damaged the secondary containment buildings and possibly other equipment.

Approximate timings of the significant parts of the accident sequence are given in table 2.1.

Table 2.1 Approximate Event Timings (hours)

Event	Unit 1	Unit 2	Unit 3	Notes
Earthquake	0.0	0.0	0.0	Reactors all shut down and stable
Tsunami and loss of AC power	0.9	0.9	0.9	Diesel generators incapacitated by tsunami
Loss of core cooling/make-up	~1.9	70.7	36.0	Units 1 and 3, loss of batteries Unit 2, pump failure
Increase in radiation reading	3.1			Possible start of core overheating
Top of core uncovered	~2.5	~75	~40	From calculations after accident
Fuel melt	~4.5	~77	~42	From calculations after accident
Reactor pressure vessel failure	~10	~109	~66	From calculations after accident
Start of containment venting	~20.0	~44.2	41.9	Data uncertain – conflicting reports
Injection of water begun	24.1	73.8	42.7	Fresh and/or seawater injected to reactor pressure vessels to restore lost inventory
Hydrogen explosion	24.8	87.4	68.3	Units 1 and 3 at reactor service floor Unit 2 inside secondary containment

The above data is based on information from the *Report of the Japanese Government to the IAEA Ministerial Conference on Nuclear Safety* [1] and augmented by other sources. Timings are given in hours from the time of the earthquake. Timings of some events are uncertain; however, this sequence of events is thought to be broadly correct.

The time of the start of core damage is quite uncertain. However, the large-scale production of hydrogen clearly indicates that core dryout and subsequent damage on unit 1 occurred within 24 hours of the earthquake. The start of core damage for units 2 and 3 appears to have been considerably later. Efforts to restore cooling with seawater likely were partially successful in delaying and reducing the extent of core damage and reactor pressure vessel failure.

Approximately 48 hours after the earthquake, high radiation readings forced the operating staff to evacuate from the main control room. Thereafter, they were able to enter the control room for only short periods.

After the initial days of the accident, in which the damage escalated and the utility struggled to regain control, a long period of gradual recovery followed. Electrical and water supplies were slowly restored. However, high radiation levels and widespread damage impeded work. Venting of gases continued periodically to prevent containment from overpressurizing. Highly radioactive water accumulated in low-lying rooms and leaked, or was discharged into the Pacific Ocean.

The damaged reactors are now being cooled by injections of water recovered from the containment or building basements. The water is cooled and passed through cleanup equipment which is gradually removing radioactive materials and salt. This recovery work will continue for many months according to the TEPCO recovery plan [2].

2.2 Spent fuel storage

Spent fuel discharged from a Fukushima-type reactor is initially stored in the spent fuel pool associated with that unit. The spent fuel pool is at the top of the secondary containment and is outside the primary containment (see figure 2.2). Spent fuel is cooled in the spent fuel pool for at least 18 months and can then be moved to the common spent fuel storage pool.

The common spent fuel storage pool held 6,375 fuel assemblies at the time of the accident. Although the central fuel storage pool was without active cooling for 13 days, the temperature rose only a few degrees and did not give rise to any safety concerns. Normal cooling was then resumed.

After at least five years in the central fuel storage pool, the assemblies can be transferred to dry storage. At the site, 408 assemblies were in dry cask storage and were unaffected by the earthquake and tsunami.

Table 2.2 shows the inventory of fuel assemblies in the spent fuel pools in units 1 to 4.

Table 2.2 Spent Fuel Pool Inventories (fuel assemblies)

Unit	Fuel in reactor	Spent fuel in pool	New fuel in pool
#1	400	292	100
#2	548	587	28
#3	548	514	52
#4	0	1,331	204

Fuel in the individual reactor spent fuel pools was a concern after the accident as active cooling was lost. However, in the absence of leakage, there was sufficient water to maintain fuel cooling for a few days. The heat load in unit 4 was high because the entire core had been unloaded into it recently. After the explosion in unit 4 on March 15, Japanese authorities were concerned that the pool could be leaking, leading to the fuel uncovering, overheating and generating hydrogen. However, they now believe that the explosion was caused by hydrogen leaking through the containment vent lines from unit 3. The presence of fission products in the unit 4 spent fuel pool indicates that some fuel failures may have occurred but the majority of fuel assemblies are undamaged.

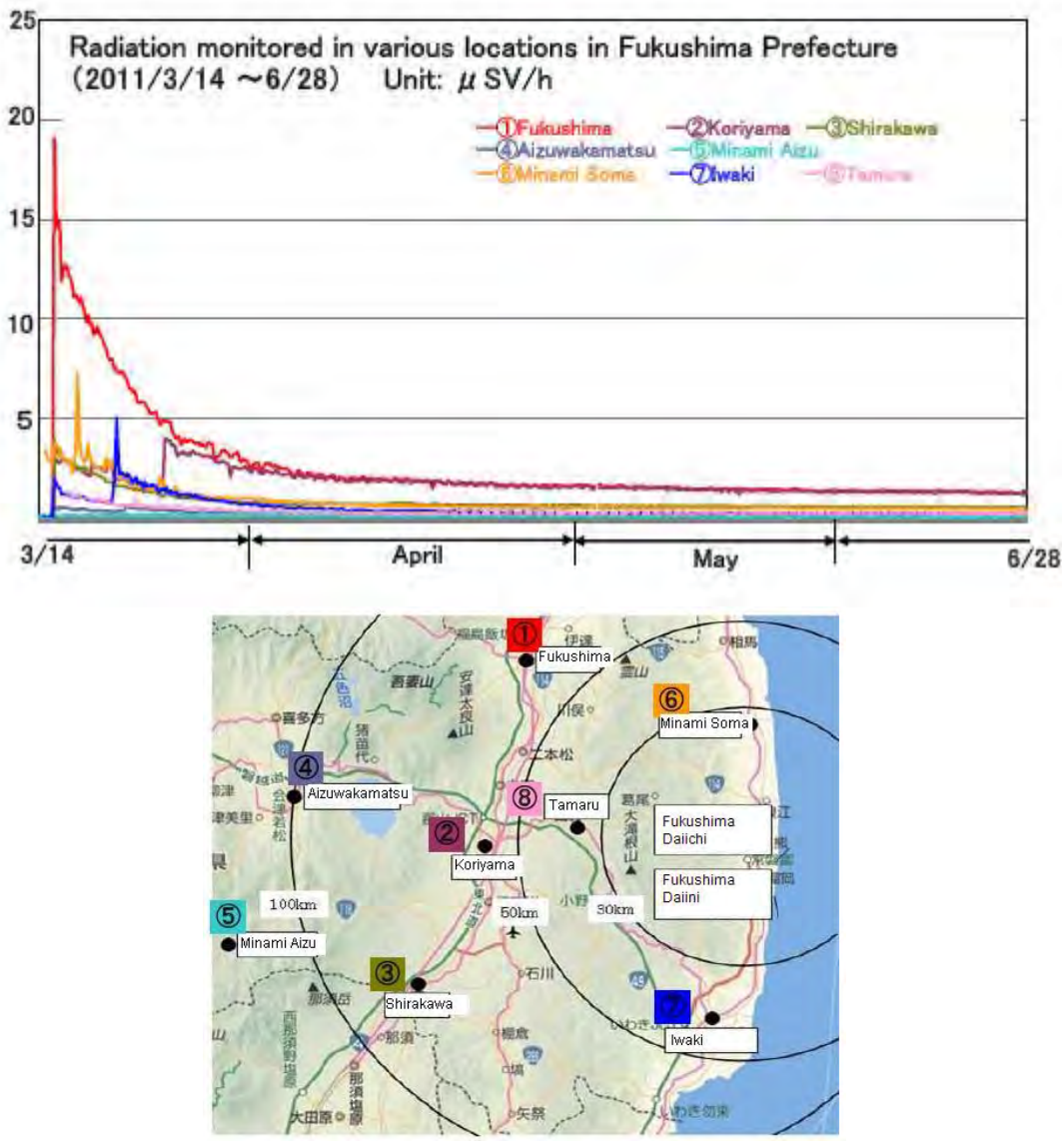
In May, the Japanese authorities became concerned that the earthquake, repeated aftershocks and the explosion in unit 4 may have weakened the concrete structure of the building supporting the spent fuel pool. To address this concern, a steel and concrete support structure was built below the unit 4 spent fuel pool.

2.3 Offsite consequences

Significant releases of radioactive material to the atmosphere began when the reactor containments were vented, beginning at about 20 hours after the earthquake for unit 1 and over 40 hours after the

earthquake for units 2 and 3. Major releases began on March 15 (4 days after the earthquake). An evacuation zone of 20 km had already been established. Figure 2.3 shows radiation readings taken at various locations within Fukushima Prefecture. For comparison, the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) [3] states that natural background radiation around the world typically ranges between 1 and 13 mSv/year (0.1 to 1.5 µSv/hr.), with an average of 2.4 mSv/year (about 0.3 µSv/hr.). The figure shows that the radiation levels are falling back towards normal background levels, although they are still higher than before the accident.

Figure 2.3 Radiation Readings in Fukushima Prefecture

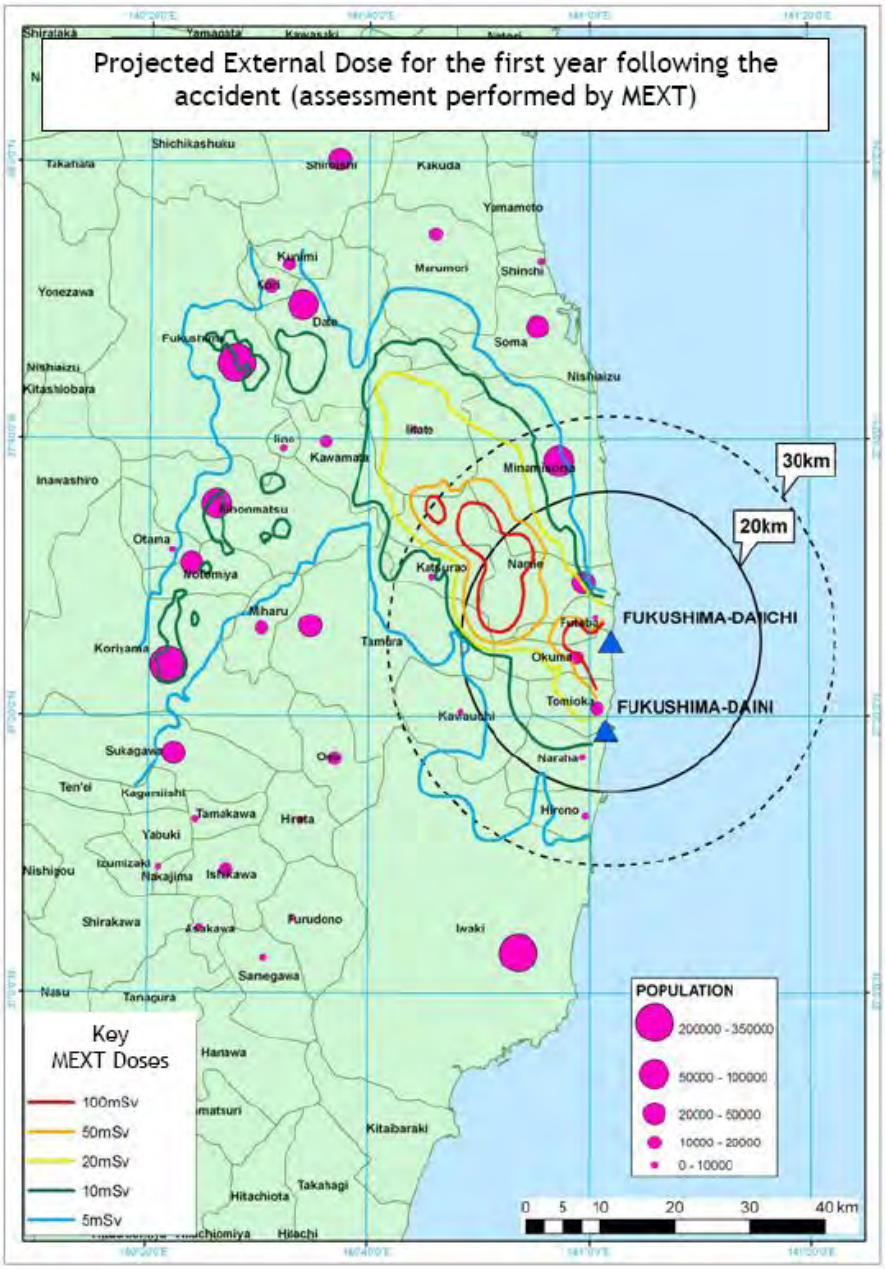


The Japanese authorities expanded the protective measures around Fukushima Daiichi as the accident progressed and the releases of radioactive materials increased. In the first few days and weeks after an accident, the most significant risk is from radioactive iodine-131 (half-life of 8 days). On March 11 (day 1), at 9:23 p.m. local time (6.6 hours after the earthquake), the authorities established an evacuation area with a radius of 3 km and a sheltering area with a radius of 10 km. The following

day, they extended the evacuation zone to 20 km and on March 15 (day 5) to 30 km. Preparations for distributing stable iodine[9] tablets began on March 12 (day 2).

Figure 2.4 shows the estimated external doses that would be received in the first year in the absence of evacuation.

Figure 2.4 Estimated First-year Doses



[9] Stable iodine in the form of potassium iodide (KI) is used to saturate the body with non-radioactive iodine so that radioactive isotopes of iodine are not taken up by the body. Iodine-131 is a particular hazard in the early days of an accident. Iodine concentrates in the thyroid gland and iodine-131 exposure can lead to increased risk of thyroid cancer later in life.

Figure 2.4 was developed by the French Institut de Radioprotection et de Sûreté Nucléaire (IRSN) [4] using data published by the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) and shows only external doses. Additional doses due to internal exposures, such as through inhaling contaminated air, ingesting contaminated foodstuffs and drinking water, would be in excess of this. The long-term external dose is dominated by the isotopes cesium-137 (half-life of 30 years) and cesium-134 (half-life of 2 years) which were deposited following releases from the damaged reactors.

Health Canada's *Canadian Guidelines for Intervention During a Nuclear Emergency* [5] recommend evacuation of the population if the projected whole-body dose[10] exceeds 50 mSv in 7 days. The International Commission on Radiological Protection (ICRP) publications 103 [6] and 109 [7] recommend protective measures (such as evacuation) if the projected dose is between 20 and 100 mSv/year, with the responsible authority establishing the desired level of protection. Although for radiation protection purposes we assume that all radiation exposures present a health risk, in practice, no adverse health effects have been observed at doses below about 100 mSv.

On April 22, an irregular evacuation zone was established to move people from the northwest area where higher activity had been measured. Some areas may remain uninhabitable for many years.

With the evacuation zones in place, it seems unlikely that members of the public will be exposed to external doses greater than 20 mSv/year. Monitoring and control of food and water supplies have been established over a wide area. These controls will need to be maintained, perhaps for many years.

3 Initial CNSC Response

Immediately after the incident, the CNSC took the following actions:

- activated the CNSC Emergency Operations Centre (EOC) and staffed it 24/7 to monitor the emergency, assess early reports and provide timely, accurate information to Canadians
- requested Canadian licensees of Class I nuclear facilities, uranium mines and mills to review the lessons learned
- performed inspections and walkdowns at nuclear facilities to assess system readiness of mitigating systems
- convened a Task Force to evaluate the operational, technical and regulatory implications of the accident for NPPs

These actions are discussed in the subsections below.

3.1 Activation of the CNSC Emergency Operations Centre

Following notification of the Fukushima Daiichi accident, by midday, March 11, the CNSC EOC was activated at its headquarters, in accordance with the *CNSC Emergency Response Plan CAN – 2.1* [8]. Staff from the CNSC Nuclear Emergency Organization (NEO) assembled in the EOC to assess the situation in Japan and develop the strategy for the Canadian response. For 23 days, CNSC NEO staff worked in the EOC on a 24/7 basis to monitor and assess the situation in Japan. CNSC specialists provided expertise in the fields of reactor technology, accident progression and radiation protection.

[10] Projected dose is the dose that would be received in the absence of protective measures.

The CNSC NEO monitored the situation in Japan in close collaboration with other Government of Canada departments and agencies, nuclear regulators from the United States, United Kingdom and France, as well as with the International Atomic Energy Agency (IAEA). The CNSC NEO supported the Department of Foreign Affairs and International Trade Japan Crisis Team on a daily basis by providing timely and accurate information and advice to Canadians in Japan and in particular to the Canadian ambassador and his staff in Japan. Information was posted on the CNSC Web site to provide a consistent, objective and credible source of information for the Canadian public, CNSC staff and other government departments.

Following the deactivation of the EOC on April 4, 2011, CNSC staff undertook a formal lessons-learned process to capture the important operational experience. An after-action report and an improvement plan were approved by the CNSC Management Committee. These reports are summarized in Appendix C.

3.2 Regulatory request to licensees

Subsection 12(2) of the *General Nuclear Safety and Control Regulations* [9] places an obligation on licensees to respond to a request from the Commission, or a person who is authorized by the Commission, to "conduct a test, analysis, inventory or inspection in respect of the licensed activity or to review or to modify a design, to modify equipment, to modify procedures, or to install a new system or new equipment". In accordance with this provision, the CNSC Executive Vice-President and Chief Regulatory Operations Officer wrote to all Class I nuclear facilities on March 17 requesting that licensees:

- "review initial lessons learned from the earthquake in Japan and re-examine the safety cases of nuclear power plants, in particular the underlying defence-in-depth concept, with focus on:
  - external hazards such as seismic, flooding, fire and extreme weather events;
  - measures for the prevention and mitigation of severe accidents;
  - emergency preparedness; and
- report on implementation plans for short-term and long-term measures to address any significant gaps."

Letters similar to the "12(2) letters" described above were sent to the operators of uranium mines and mills licensed by the CNSC. The Fukushima accident has the greatest relevance to NPPs and the CNSC has addressed it first through the work of the CNSC Task Force reported here. CNSC staff will use the results of the Task Force investigations of NPPs to drive continuous improvement at other facilities.

3.3 CNSC inspections of Canadian nuclear power plants

Immediately after the Fukushima event, CNSC site staff performed walkdowns at Canadian NPPs to verify the licensees' emergency preparedness for external hazards and severe accidents so that the CNSC could reassure the Commission and Canadian public that certain aspects that had contributed to the events in Japan had been specifically verified. These aspects included:

- seismic:
  - readiness of secondary control room and seismic route
  - availability of manuals and procedures

- fire:
  - confirmation of minimum shift complement[11] monitoring
  - arrangements for offsite support
- backup power availability and condition
- hydrogen igniters:
  - routine testing to confirm availability
- irradiated fuel bays (IFBs):
  - readiness of components and equipment
  - provision/availability of make-up water and heat sinks[12]
  - verification of alarms on flow, temperature, and stack release

This information was reported to the Commission on March 30, 2011, in CMD 11-M15, *CNSC Staff Presentation on Fukushima Event* [10]. There were no significant findings and no actions were placed on the licensees as a result of these inspections.

CNSC staff also verified the following activities taken by the licensees:

- capability of installed equipment and associated procedures to mitigate conditions that result from beyond-design-basis accidents
- capability of provisions to mitigate station blackout[13] conditions, including robustness of backup power and the emergency power supply systems
- capability to mitigate consequences of external events that may lead to beyond-design-basis accidents
- identification of important equipment needed to mitigate consequences of external events
- identification of any potential scenarios that could compromise the equipment's function during seismic events
- ability of units to rapidly reduce reactor power to match the station power demand following a loss of offsite power, the duration of battery backup, and fuel supply to emergency generators

As reported to the Commission on June 8, 2011, in CMD 11-M30, *Status Report on Power Reactors* [11], CNSC staff are satisfied with short-term actions taken by licensees.

3.4 The CNSC Task Force

The CNSC Fukushima Task Force [12] was set up to evaluate operational, technical and regulatory implications of the 2011 Fukushima Daiichi accident on Canadian NPPs. It was also tasked with reviewing NPP licensees' responses to the 12(2) letters. The Task Force Chair was tasked with reporting the results of the Task Force review to the Executive Vice-President and Chief Regulatory Operations Officer of the CNSC.

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[11] The minimum shift complement is the minimum number of qualified staff required to be present to ensure that the licensed activity can be carried out safely.
[12] A heat sink is a place to reject excess heat. It includes the equipment and fluids needed to transport the heat from the source (e.g., nuclear fuel) to the sink (e.g., the atmosphere or a large body of water).
[13] Station blackout formally refers to the loss of normal and backup AC power but not loss of emergency power. In this report, loss of emergency power is also considered. Normal AC power is supplied from the electrical grid and from the station's own main turbine generators. Backup power is supplied by multiple standby generators. Emergency power is supplied by independent generators.

The mandate of the CNSC Task Force was to:

- review submissions from licensees who had been directed under 12(2) letters to re-examine the safety cases of their respective NPPs; underlying defence in depth against external hazards; severe accidents; and emergency preparedness
- assess available technical and operational information from the events at the Fukushima Daiichi NPP and identify a high-level set of lessons learned
- develop recommendations for short-term and long-term measures to address any shortcomings at CANDU reactors, and recommend whether design or operational modifications, including supporting research, are needed
- determine priorities for implementation of corrective actions from lessons learned and the need for further examination
- develop recommendations, as appropriate, for potential changes to CNSC regulatory requirements, inspection programs and policies for existing CANDU reactors and new builds

The CNSC Task Force prepared the *Nuclear Power Plant Safety Review Criteria* [13] to define measurable criteria for each area of the assessment.

The CNSC Task Force met with licensees on a number of occasions to clarify CNSC expectations.

4 International Response

The worldwide response of nuclear organizations, operators and regulators has been to attempt to learn all the salient lessons from the events at Fukushima. The CNSC Task Force has communicated regularly with other regulatory bodies and followed the work of the international community to date. CNSC staff will continue to review the findings of other organizations as they become available.

4.1 Review of terms of reference of international task forces

Members of the CNSC Task Force have monitored the approaches of selected international task forces. The terms of reference of selected task forces have been reviewed to help validate the CNSC's approach. The selected international task forces were from the United States Nuclear Regulatory Commission (U.S. NRC) [14] and the Western European Nuclear Regulators' Association (WENRA) [15].

The CNSC Task Force found that the three task forces have broadly similar terms of reference. The WENRA approach has provided the basis for many of the reviews currently being performed around the world.

WENRA has developed an approach based on design and safety analysis techniques. The approach places particularly strong emphasis on giving a detailed and systematic evaluation of accident progression that considers successive failures of the mitigating measures and identifies key timings and potential cliff edges[14].

[14] A cliff edge is a large increase in the severity of an event caused by a small change of conditions. Cliff edges can be caused by changes in the magnitude of the event or changes in the plant response. For example, a small change in wave height leads to a large change in conditions if the wave goes over the shore defences (e.g., a seawall).

WENRA explicitly mentions consideration of accidents at multiple reactors on a site but gives little emphasis to this aspect. The CNSC Task Force placed more emphasis on multi-unit events since the multi-unit reactors in Canada share parts of containment.

The U.S. NRC review was focused on the adequacy of its own specific regulatory requirements and did not include (at this stage) input from licensees.

After the above comparison was completed, the European Nuclear Safety Regulators Group (ENSREG) released its "stress test" specification [16]. The specification was based closely on the WENRA stress test and does not change the CNSC Task Force review findings.

The CNSC Task Force found that the CNSC terms of reference and *Nuclear Power Plant Safety Review Criteria* are consistent in general terms with the approaches seen in the other international task forces and include the specific areas of emphasis identified above.

4.2 Early results of other international task forces

Most nuclear regulators and organizations have prepared, or are preparing, lessons-learned reports. Selected reports that were available in time to be considered here have been reviewed and their findings evaluated to help ensure that the CNSC Task Force assessment is comprehensive. Note that many other reports will become available later. CNSC staff will review them, but not in the context of the present report.

One of the earliest and most comprehensive reports is Japan's report to the IAEA Ministerial Conference on Nuclear Safety [1]. The CNSC Task Force has used this report extensively to help it understand the accident and Japan's response to it. Lessons identified by other members of the international community are also considered in the discussion below.

The most important lessons learned and their importance from a Canadian perspective are discussed below. Cross-references are provided to the section of this report where each lesson is addressed.

4.2.1 Identification and magnitude of external hazards

The Japanese government considers that the fundamental cause of the accident at Fukushima Daiichi was a failure to identify the appropriate magnitude of the tsunami hazard.

All external events (not just seismic and tsunami) relevant to Canadian NPPs must be identified and the selection of appropriate magnitude for the events must be verified. External events are assessed in section 6.1.

4.2.2 Diverse power supplies

Fukushima Daiichi units 1 to 4 lost connections to the grid, and the emergency diesel generators were flooded. The units still had air-cooled emergency diesel generators that were probably functional but could not use them as the switchgear had been flooded. It is not enough to have available power supplies; the full train of heat removal equipment from the reactor or spent fuel pool to the ultimate heat sink must be operable.

Existing Canadian NPPs and most of the proposed designs for new reactors rely on active safety systems to sustain core cooling in the long term. These require electrical power to function.

The consequences of the loss of power supplies and the timescales available for their restoration are assessed in section 6.3.

4.2.3 Diverse means of cooling fuel

Fukushima Daiichi unit 1 was able to maintain core cooling for only about 1.6 hours after the loss of all electrical power. Units 2 and 3 had steam-driven coolant make-up capability (with no electrically driven pumps) and maintained core cooling for 70 and 36 hours respectively, but were still not able to prevent core damage.

Existing Canadian NPPs and most of the proposed designs for new NPPs rely on active[15] cooling for reactors, containment and irradiated fuel bays (spent fuel pools). All designs have some degree of passive cooling capability. The effective duration for the various passive heat sinks varies with the design.

Loss of cooling of the irradiated fuel bays is generally a lesser concern than loss of core cooling as much more time is available before fuel overheats. However, irradiated fuel bays generally have fewer alternative cooling options than the core; therefore the issue is still important.

The cooling function, the consequences of its loss and the timescales available for restoration are assessed in section 6.3.

4.2.4 Prevention of hydrogen explosions

Adequate mitigation is needed wherever hydrogen can accumulate, in order to prevent explosions. The Fukushima Daiichi design anticipated hydrogen production in severe accidents by filling the primary containment with nitrogen so that there was no oxygen available for hydrogen combustion. However, hydrogen produced by the damaged cores either leaked from the primary containment or from the containment vent system ducts and accumulated in the secondary containment. There were no provisions for hydrogen mitigation in the secondary containment. In the secondary containment, the hydrogen mixed with air to produce an explosive mixture which subsequently ignited, adding to the damage.

CANDU reactors have some installed capability to compensate for their large inventory of zirconium compared to other reactor designs. Provisions for mitigation of hydrogen are assessed in section 6.3 and 6.4.

4.2.5 Containment venting

The Fukushima Daiichi reactors had a venting system to protect the containment from overpressure. The loss of electrical power caused difficulties in operation, and some periods of overpressure were reported. However, the system appears to have been successful in preventing gross containment failure due to overpressure. Leakage from the venting system (perhaps caused by the earthquake) likely contributed to the hydrogen leakage that led to explosions in the secondary containment.

Controlled containment venting can protect containment from overpressurization during beyond-design-basis accidents. Filtering of fission products to the extent practicable is important in reducing radiation exposure to the public.

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[15] Active cooling relies on equipment with external input, such as electricity. Passive cooling relies on natural forces, such as gravity.

Multi-unit CANDU reactors have a "negative pressure design" achieved by the provision of a large vacuum building supported in the long term by a filtered venting system. This type of design can be effective in limiting the release of radioactive material in design-basis accidents as any leakage is into the containment. However, these systems are not designed to handle the large gas volumes that a severe accident may generate. Moreover, electrical power is required for controlled venting of the containment to maintain a negative pressure.

Provisions for containment venting and their operability are assessed in sections 6.3 and 6.4.

4.2.6 Protection of essential equipment

At the Fukushima Daiichi plant, safety-related equipment – particularly electrical supplies – was lost in the tsunami.

Essential services can be protected from external hazards and internal events by the separation of redundant equipment (including vertical separation), by physical protection (e.g., fire barriers or waterproof rooms) or by hardening[16] (e.g., environmental qualification).

Mitigation of beyond-design-basis accidents and severe accident management are assessed in sections 6.3 and 6.4.

4.2.7 Challenges to multi-unit nuclear power plants

The Fukushima accident emphasized that multi-unit NPPs face unique challenges, and that common-cause failures should be particularly considered for multi-unit sites.

Events involving multi-unit CANDU reactors can be complex and challenging. Containment integrity for multi-unit severe accidents should be assured by adequate venting. The risks and implications of hydrogen explosions should be particularly considered for multi-unit sites and necessary mitigating systems should be properly located and implemented.

Other important considerations for multi-unit NPPs are:

- availability of staff and resources to address a severe accident impacting several units simultaneously, and overall effectiveness of severe accident management guidelines (SAMG)
- shared equipment
- calculation and control of potential source terms[17]
- impact on nuclear emergency plans

Challenges arising from multi-unit NPPs are assessed in sections 6.3 to 6.5.

[16] Equipment can be "hardened" to withstand harsh conditions by using suitable materials and conservative design.
[17] The source term is the amount and isotopic composition of material released (or postulated to be released) from a facility.

4.2.8 Effective severe accident management

Accident management measures were available at the Fukushima Daiichi plant, but were only partially successful due to many factors, mostly related to the extent of the damage.

Challenges in executing severe accident management actions are likely to occur after any major external event due to consequential damage onsite and/or loss of critical infrastructure offsite. Specific challenges will depend on the nature of the event.

There may be additional challenges specific to multi-unit sites where one or more units are damaged. This situation can lead to difficulties of access and additional strains on staff.

Effective accident management requires availability of equipment, either pre-installed, available onsite or available offsite, as appropriate. The equipment should be maintained and tested sufficiently to give reasonable confidence that it will function when required. Accident management guidelines must be prepared and staff trained in their use. There must be sufficient staff to execute the guidelines. Verification of the guidelines should consider the likely environment in which the operators must work (e.g., radiation fields, damaged plant systems) and provide options where practicable (e.g., alternative water injection points or electrical connections). Survivability of essential instrumentation should be assessed to provide reasonable assurance that the essential instrumentation will be available to guide operator actions.

Severe accident management is assessed in section 6.4.

4.2.9 Emergency response

The earthquake, tsunami and subsequent nuclear accident placed enormous strains on the emergency response capability of Japan, the Fukushima prefecture and the NPP operator.

Major earthquakes and tsunamis are not credible threats at Canadian NPPs. Nevertheless, some hazards can lead to widespread disruption (e.g., ice storm or heavy snowfall). Others can be very damaging in a local area (e.g., explosion, tornado). Emergency measures must be capable of reacting to all credible events.

Effective emergency response relies on defined roles and responsibilities and clear lines of communication. Timely information must be available to those who need it, both in terms of the accident consequences and clear guidelines for protective actions. Communication must be considered for all stakeholders: local, national and international.

Emergency response is assessed in section 6.5 (for licensees' responsibilities) and section 7 (for federal, provincial and municipal responsibilities).

4.2.10 Legal and regulatory infrastructure

The Japanese government considered that the Fukushima accident revealed weaknesses in the legal and regulatory infrastructure and regulatory framework in Japan. This, the Japanese government holds, led to the establishment of a new regulatory body independent of the Ministry of the Economy, Trade and Industry. In some areas, regulatory requirements did not exist or were not mandatory. Some parts of the safety case for the NPPs were identified as having received scant attention.

Canada's regulatory framework and processes are assessed in section 8.

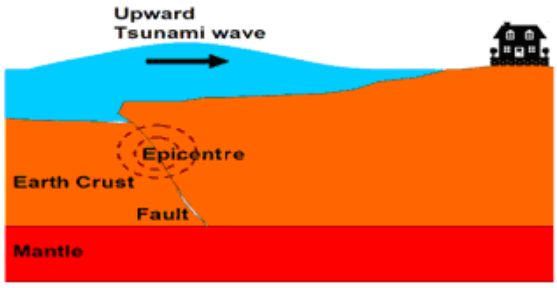
5 Comparison of Canadian and Japanese External Hazards

Canada's risks from external hazards are different from Japan's. The tsunami generated from the magnitude 9.0 earthquake was the direct cause of the severe accident at Fukushima. The sections below were produced in collaboration with staff of the Geological Survey of Canada and discuss the seismic and tsunami hazards for Canada. Other specific hazards taken into account in the NPP designs are discussed in section 6.1 of this report.

5.1 Canadian tsunami hazard profile

A large underwater earthquake may displace the ocean floor, producing a tsunami that propagates outward from the source, as shown in figure 5.1. Destructive earthquake-induced tsunamis are rare in Canada. In Canada, the Pacific Coast (west coast) is at greatest risk from tsunamis because of the high incidence of earthquakes in that region.

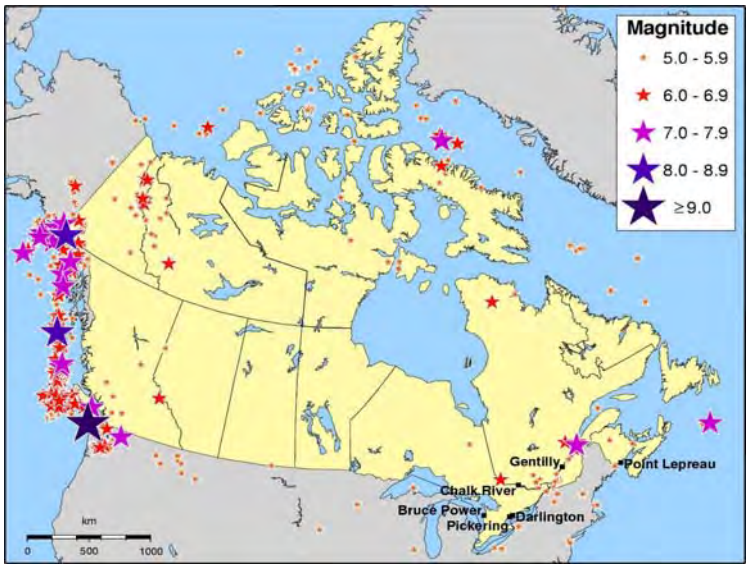
Figure 5.1 Generation of a Tsunami



Most often, tsunamis, including the recent ones in Japan, are generated by subduction[18] earthquakes. The Pacific Coast is exposed to the hazard from both local and distant subduction zones. The distribution of earthquakes greater than magnitude 5.0 in Canada is shown in figure 5.2. Note that the figure shows the 18th century Cascadia earthquake along the Pacific Coast, which was estimated to be about magnitude 9.0. Other data is more recent.

[18] Subduction is the movement of one of the tectonic plates making up the earth's crust under another. Subduction zones are associated with high seismic and volcanic activity.

Figure 5.2 Earthquakes Greater Than Magnitude 5.0



The risk of tsunamis at each of the Canadian NPPs is discussed below.

5.1.1 Bruce, Darlington and Pickering

Bruce, Darlington and Pickering are located in the Great Lakes region of Canada. The tsunami risk along the Great Lakes is very low. The Great Lakes are on the edge of the Canadian Shield, a geologically stable, mid-continental region where the rate of occurrence of earthquakes large enough to generate tsunamis is negligible.

5.1.2 Gentilly-2

The Gentilly-2 facility is located in the St. Lawrence River Valley. There is no evidence of a historical tsunami in this region. An earthquake-generated tsunami event has been considered (and modelled) by scientists (for different purposes) for the St. Lawrence estuary [17]. A magnitude 7.0 earthquake could cause a land shift and surface that would generate a very local tsunami with a height of roughly 2 to 4 metres. However, Gentilly-2 is at some distance from historically large, damaging events (more than 100 km from the active regions of western Quebec and Charlevoix). The Charlevoix seismic zone is the most likely source to generate magnitude 7.0 earthquakes that have the potential to create small tsunamis in the St. Lawrence, and the possibility that a tsunami from there would reach Gentilly-2 is very low.

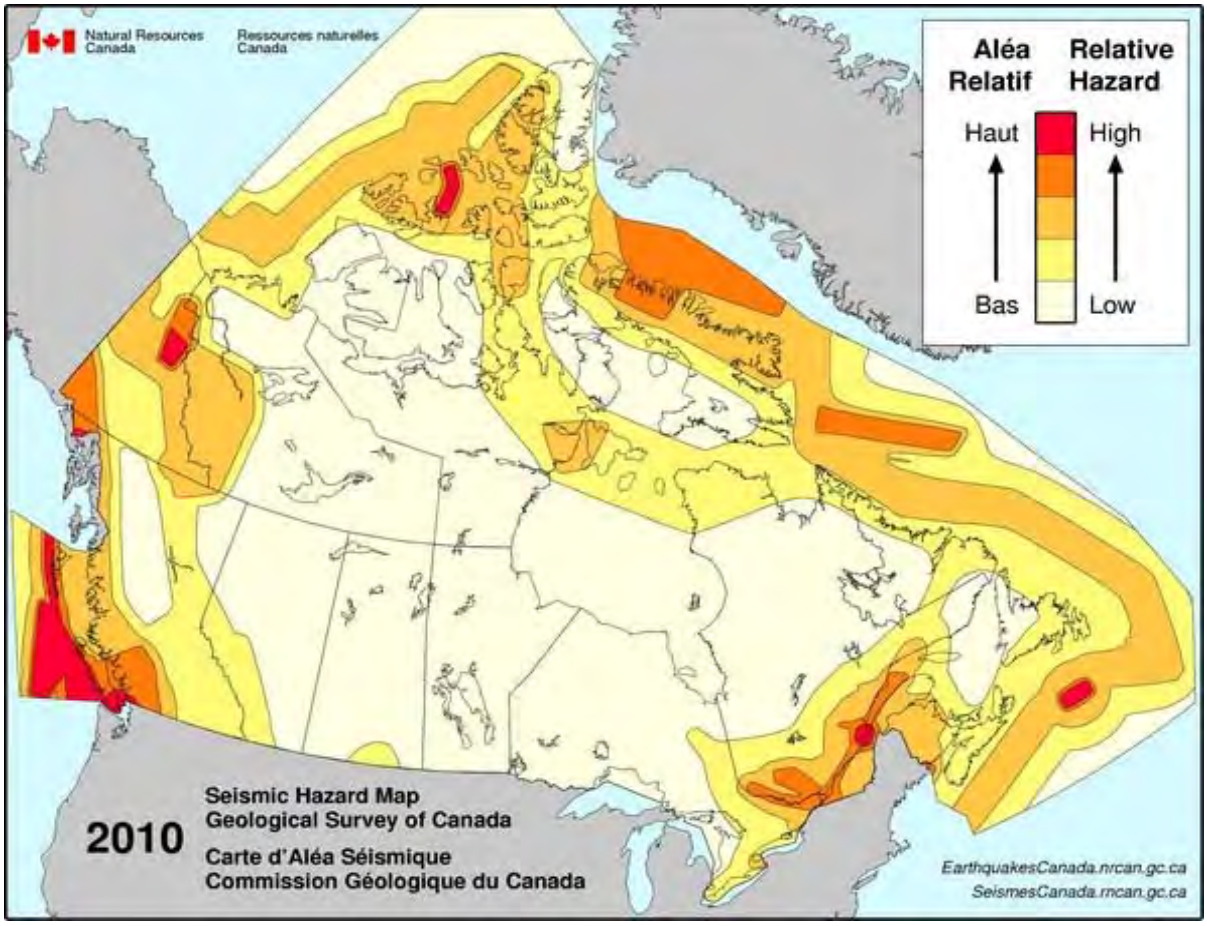
5.1.3 Point Lepreau

Point Lepreau is located in Atlantic Canada on the Bay of Fundy. There are several sources of potential tsunamis for this site. First, trans-Atlantic tsunamis are a possibility. The 1755 great Lisbon earthquake generated destructive waves, but these waves were not large by the time they reached North America's eastern seaboard. There is also the possibility of local earthquakes in the Bay of Fundy and Passamaquoddy Bay generating tsunamis. There is, however, no known evidence of such an event; the probability of a large earthquake in this region generating a local tsunami is considered very low. In addition, the province of Nova Scotia provides some protection from an Atlantic tsunami hitting Point Lepreau because its geographic location acts as a partial buffer.

5.2 Canadian seismic hazard map

The following simplified seismic hazard map for Canada illustrates qualitative seismic hazards everywhere in Canada. The hazard for each NPP is discussed below.

Figure 5.3 Canadian Seismic Hazard Map



5.2.1 Pickering

Pickering is in a region of low to moderate seismic hazard.

The Pickering facility is located in the southern Great Lakes seismic region. Over the past 25 years, on average, five to six magnitude 2.5 or larger earthquakes have been recorded in the region each year. Three moderate-sized (magnitude 5.0) events have occurred in the region in the last 250 years, all of them in the adjacent northern United States. All three of these earthquakes were widely felt in southern Ontario but caused no major structural damage in Ontario.

In the Pickering region, a possible active fault was investigated by drilling and found to be the result of glacial action. The feature poses no additional seismic threat.

5.2.2 Darlington

Darlington is in a region of low to moderate seismic hazard. Details are the same as for Pickering.

5.2.3 Bruce

Bruce is in a region of low seismic hazard.

Over the past 25 years, only 3 magnitude 2.5 or larger earthquakes have occurred within 100 km of the plant. Moderate-sized (magnitude 5.0 to 6.0) earthquakes have occurred at greater distances (more than 300 km) in the northern United States and western Quebec. None of these events generated significant shaking at the Bruce site.

5.2.4 Gentilly-2

The Gentilly-2 facility in Bécancour, Quebec, is in a region of moderate seismic hazard.

The facility is in the St. Lawrence Valley, within a region of moderate seismic activity. Historical records for earthquakes in eastern Canada show that most earthquakes have occurred east of Québec City and near Montreal, and that less activity has occurred between these two places. Past work by the Geological Survey of Canada shows that despite this historical record, a possibility of a significant earthquake in the vicinity of Gentilly-2 still exists because:

- the fault systems along the St. Lawrence River are the same throughout
- small earthquakes appear to concentrate on these faults

Evaluation studies of the geology of the site have shown that no tectonic fault lies under the site.

5.2.5 Point Lepreau

Point Lepreau is in a region of low to moderate seismic hazard.

The Point Lepreau facility is located in the Northern Appalachians Seismic Zone, which includes most of New Brunswick and extends into New England down to Boston. A series of significant earthquakes occurred in 1982 (largest magnitude 5.6, in the Miramichi Highlands, 200 km north of the facility) and was followed by numerous aftershocks. The zone also witnesses a continuing low level of seismic activity, including many larger historic earthquakes in New Brunswick. The closest source of seismic activity is located in Passamaquoddy Bay, 50 km west of Point Lepreau. A series of moderate earthquakes occurred here in the 19th and early 20th century. The largest recorded event had a magnitude of 5.7 in 1904.

5.3 Other external hazards

Canadian NPPs are considered capable of withstanding a large number of external hazards specific to each site. These hazards include flooding, extreme winds, extreme weather including snow and ice storms, and transportation hazards, among others. These types of hazards and NPP assessments are discussed in section 6.1 of the report.

6 Safety Review of Canadian Nuclear Power Plants

The CNSC licenses each Canadian NPP on the basis of comprehensive safety reports and supplementary analyses which demonstrate that the facility design meets regulatory requirements and expectations. The licensing process also ensures that appropriate safety management systems, plans and programs for safe and secure operation are established. Any new analyses, such as those supporting modifications or new research findings, are incorporated into the safety reports and

supporting analyses. To ensure this, the NPP licences require the licensees to update safety reports every three years and submit them for regulatory review. In addition, the CNSC requires each licensee to conduct an integrated safety review (ISR), including a comparison against modern standards), to establish the scope of refurbishment activities.

The safety reports include the evaluation of the underlying defence-in-depth concept for the effective implementation of safety functions in the facility design. There are five levels to the defence-in-depth approach:

- prevention of abnormal operation and failures
- control of abnormal operation and detection of failures
- control of accidents within the design basis
- control of severe plant conditions, including prevention of accident progression and mitigation of the consequences of severe accidents
- mitigation of radiological consequences of significant releases of radioactive materials

The defence-in-depth concept is supported by emphasis on the inherent safety characteristics of the reactor, and on insights from deterministic and probabilistic safety analyses to evaluate and optimize the overall plant design. In principle, application of the defence-in-depth concept assures the prevention and control of incidents and accidents at several engineering and procedural levels in order to ensure the effectiveness of the protection of physical barriers against the release of radioactive material.

In response to the Fukushima Daiichi accident, the Canadian nuclear industry and regulator sought to ensure that the safety basis discussed above remained valid in the light of lessons learned. As reported in section 3.1, CNSC staff sent a written request on March 17 to licensees, under paragraph 12(2) of the *General Nuclear Safety and Control Regulations*, to review initial lessons learned from the earthquake in Japan.

This section of the CNSC Task Force Report provides an assessment of the NPP licensees' responses to the 12(2) letters. The responses are evaluated against the applicable *Nuclear Power Plant Safety Review Criteria* [13] issued by the CNSC Task Force in June 2011. These criteria generally exceed requirements and expectations of the current CNSC regulatory framework. The CNSC Task Force review findings in this section relate exclusively to the lessons learned from the Fukushima accident. Each subsection below provides specific review findings. In section 10 of this report, these review findings are integrated to provide a concise overview of the areas of potential improvement identified by the CNSC Task Force.

6.1 External hazards

The safety review ensures that external hazards are accounted for in the reactor safety cases. The events considered are specific to each site and include seismic, fire, flood, extreme weather events and events caused by human activities (such as an explosion). The CNSC Task Force assessed the magnitudes that had been considered in the design-basis and beyond-design-basis analyses of external hazards. In many cases, the rationale for the magnitude selected for beyond-design-basis hazards was not documented by the licensees. This is further discussed below.

Consequential events must be considered and include external events (such as a cooling water intake blockage caused by severe weather) and internal events (such as a fire or small-break loss-of-coolant accident[19] caused by an earthquake).

6.1.1 Original design basis

All Canadian NPPs use CANDU reactors. The current CANDU fleet was designed and constructed from the 1960s to 1980s. The designs were based on standards available at that time. For the earlier NPPs (Pickering A and Bruce A), the full scope of design-basis external events was not considered. The design bases were embedded in design guides and engineering judgment.

For some plants that were designed in the later part of this period (Pickering B, Darlington, Bruce B, Gentilly-2, and Point Lepreau) design-basis external events were considered. Such events have included design-basis earthquakes (usually based on a recurrence frequency of 1,000 years), floods (design-basis rainfall or water levels, usually based on a recurrence frequency of 100 years or the highest historical numbers) and high winds. The scopes, however, have been limited. The magnitudes of the external events taken into account for the design are in compliance with the standards applicable at the time of original licensing but below modern international best practice. The integrated safety review performed before an NPP is refurbished ensures that the NPP is assessed against modern standards. Upgrades are performed where reasonably practicable. Nevertheless, the CNSC Task Force finds that licensees should identify the gap between the original design basis and associated magnitudes for external hazards and modern best practices and demonstrate how the gap is being addressed.

As discussed in section 5, the CANDU fleet is located well within the North America tectonic plate and no NPPs are located near a subduction tectonic plate boundary as is the case in Japan. The closest tectonic plate boundary is the Mid-Atlantic Ridge. Canadian NPPs are located in areas of much lower seismic hazard risk than Fukushima.

All Canadian NPPs except Point Lepreau are located beside lakes and rivers and are not subject to the hazard of a tsunami. Based on a scientific assessment of the tsunami hazard, NB Power concluded that the maximum credible tsunami is smaller than the storm surge created by a hurricane. This storm surge, combined with a high tide and waves generated by the high winds, does not reach the plant. CNSC staff accept this assessment.

As a prerequisite to refurbishment, ISRs have been completed for Point Lepreau, Gentilly-2 and Bruce A, with similar reviews performed for Pickering. Some of the NPPs were reassessed for external hazards, especially for seismic hazards. Seismic margin assessments (SMAs) (or SMAs based on probabilistic safety assessments) were conducted to assess the safety margin based on earthquakes with a 10,000-year return frequency. Other external hazards, including floods and high winds, were also assessed and some enhancements have been implemented. The NPPs that were reassessed as part of refurbishment activities were reviewed for external hazards, and their design bases are, to the extent practicable, in line with modern standards and practices.

[19] A loss-of-coolant accident (LOCA) takes place when a break in the primary pipework of the reactor allows reactor coolant to escape into containment.

6.1.2 Probabilistic safety assessment

Currently all NPP licensees are required to perform a site-specific Level 2 PSA[20] to meet CNSC regulatory standard S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* [18]. This standard requires consideration of all internal events and external hazards in the PSA. Licensees are required to perform a fire, flood and seismic PSA with a methodology that is acceptable to the CNSC staff. Licensees also have to perform a site-specific external hazards screening to identify other hazards that may require a PSA or a bounding analysis[21]. So far, all NPP licensees have submitted their methodologies on external hazards screening and bounding analysis. Some analyses have been completed and it is expected that the remaining analyses will be completed by the end of 2013. This time scale is acceptable to the CNSC Task Force and will provide a consistent and up-to-date review of all external hazards for all NPPs.

6.1.3 Review findings for external hazards

While the CNSC Task Force has not identified external hazards severe enough to need immediate actions from industry or the CNSC, some of the findings identified opportunities for improvements in the industry's approach as well as in the CNSC's approach. These review findings are summarized below.

Review findings concerning licensees:

1. The original magnitudes considered for the design-basis and beyond-design-basis assessments of external hazards were developed for the original licensing of the facilities. Although in general a lot of conservatism was included in the original designs, some design bases are not consistent with modern best practices.
2. The assessment for the design-basis and beyond-design-basis tornado hazard was found to be weak at some NPPs.
3. External hazards screening and bounding analysis are in different states of development for each NPP. Consequently, analysis of all external hazards is not complete at all NPPs.

Review findings concerning the CNSC:

4. The requirements and expectations for defining magnitudes to be used for design-basis and beyond-design-basis hazards have not been reviewed since original NPP licensing. The methodologies used to establish the criteria for these hazards are not consistent with modern best practices.

6.2 Design-basis accidents

Design-basis accidents, including those that may occur at onsite irradiated fuel storage, were not a major focus area for the CNSC Task Force. As stated in the *Nuclear Power Plant Safety Review Criteria* [13], they have been extensively studied by the industry and the regulator for many years. Nevertheless, design-basis accidents were reviewed to ensure that plant safety is adequate.

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[20] Probabilistic safety assessments may be performed at 3 levels. Level 1 PSA calculates core damage frequency. Level 2 calculates large- and small-release frequencies and Level 3 (rarely performed) calculates offsite health effects.

[21] A bounding analysis uses conservative assumptions and/or modelling to ensure that the results are more severe than would occur in an actual event.

6.2.1 Regulatory requirements

Early Canadian NPPs were originally licensed based on the Atomic Energy Control Board (AECB – predecessor to the CNSC) *Reactor Siting and Design Guide* [19] which defined the single/dual failure approach. Dose limits were set for a single failure – the failure of process equipment. Dose limits were also set for dual failures – failure of process equipment and simultaneous failure of protective equipment, now referred to as safety systems. External events were not analyzed explicitly. Their effects were implicitly assumed to be covered by the failures of process and protective equipment described above. Darlington was originally licensed based on trial use of the AECB consultative document C6 Rev 0, *Requirements for the Safety Analysis of CANDU Nuclear Power Plants* [20]. Dose limits were set for five event classes, with more restrictive limits for more frequent events. Design-basis earthquakes and tornadoes were explicitly considered in that AECB document. Darlington was also designed to withstand a major explosion.

After original licensing, the importance of external hazards was recognized, and assessments of the ability of NPPs to withstand hazards such as earthquakes and fires were performed, for example using seismic margin assessment[22] and fire safe shutdown analysis[23] methods.

More recently, the CNSC issued RD-310, *Safety Analysis for Nuclear Power Plants* [21] and RD-337, *Design of New Nuclear Power Plants* [22]. These two regulatory documents are in line with current international practice and set the dose acceptance criteria for anticipated operational occurrences and design-basis accidents. Safety goals are also set for beyond-design-basis accidents. RD-310 and RD-337 use the term "design-basis accident" to mean an accident with a frequency of occurrence between 10^{-2} and 10^{-5} per year (between 1 in 100 and 1 in 100,000 years).

6.2.2 Results of review of design-basis accidents

The CNSC Task Force has confirmed that the safety analysis of each NPP adequately considers design-basis accidents by analyzing credible failures in process and safety systems. These failures can result in challenges to fuel cooling in the reactor core and spent fuel bays. The predicted consequences for these accidents (with conservative safety analysis assumptions) provide bounding estimates for the consequences of the external hazard accident scenarios within the design basis. The safety report of each NPP shows that the predicted consequences for each design-basis accident meets the CNSC's prescribed acceptance criteria.

From the review of design-basis accidents in light of the Fukushima Daiichi accident, the CNSC Task Force finds that two safety aspects merit further attention:

- External hazards can result in accidents lasting for several days. Current safety analysis tends to show that a stable state is reached after a design-basis accident, but not that it can be maintained long term. Safety analysis should demonstrate that adequate design provisions and operating procedures are in place to ensure the key safety functions of "control, cool and contain" are maintained throughout the accident duration.
- Disruptions to fuel cooling in a shutdown reactor for an extended duration, while the heat transport system is maintained at elevated pressure and temperature conditions, may lead to fuel damage. This has the potential to transition from a design-basis accident to a beyond-design-basis accident, potentially resulting in severe core damage. Safety analysis of such

[22] A seismic margin assessment is a formal method for evaluating the capability of structures and equipment to withstand earthquakes. It was developed by the Electric Power Research Institute.
[23] A fire safe shutdown analysis is a formal method for evaluating the capability to safely shut down and cool a reactor core in the event of a fire.

design-basis accidents should demonstrate that adequate provisions are in place to ensure successful transition of the reactor from a hot pressurized shutdown state to a cold depressurized shutdown state.

Current safety reports do not adequately address the above two safety aspects. This deficiency is considered to be a documentation issue; operating procedures and equipment are in place in all CANDU reactors to ensure that the key safety functions are carried out for extended durations, and to bring the reactor to the cold depressurized shutdown state if required following an accident. The CNSC Task Force finds that future safety report updates should ensure that these issues are addressed more thoroughly.

RD-310 provides a modern, comprehensive treatment of external and internal events and accidents. However, RD-310 has not yet been fully implemented at existing NPPs. The CNSC and licensees are working towards full implementation.

Until full implementation of RD-310-based safety analysis, some lack of consistency in the analysis and reporting of design-basis accidents and events will remain. This arises largely from the differences between licensing requirements when the original licence was issued and the changes applied over the years.

6.2.3 Review findings for design-basis accidents

The CNSC Task Force has verified that, despite some lack of consistency, existing safety reports, supplemented by hazards assessments, show that the NPPs meet or exceed the original design intent.

Adequacy of safety analysis is assessed and reported to the Commission during the relicensing process for each NPP.

This review identified the following findings, all of minor concern:

1. Implementation of a safety analysis framework based on RD-310, *Safety Analysis of Nuclear Power Plants*, is incomplete.
2. Safety analyses have demonstrated that equipment and procedures are adequate to ensure that, for all design-basis accidents where core cooling is lost when a shutdown reactor is hot and pressurized, the reactor can be taken to a stable state. However, analysis to show that the NPP can be taken to a cold, depressurized state is incomplete.
3. Safety analyses have not demonstrated that, for all design-basis accidents, equipment and procedures used to take the reactor to a cold, depressurized state can maintain that state for a prolonged period.

6.3 Beyond-design-basis accidents

A major class of beyond-design-basis accidents are those involving a loss of all heat sinks. The most challenging of these are caused by loss of electrical power. The Fukushima Daiichi accident was of this type and is the focus of this section of the CNSC Task Force Report.

Beyond-design-basis accidents are analyzed to:

- identify possible recovery actions
- demonstrate that there is sufficient time to perform recovery actions
- assess the consequences of failure of recovery actions

The information submitted by licensees in response to the CNSC request for information about beyond-design-basis accidents is summarized below. The topics address the beyond-design-basis accident criteria given in section 2.3 of the CNSC Task Force *Nuclear Power Plant Safety Review Criteria* [13].

6.3.1 Progression and timing of beyond-design-basis accidents

As requested by the CNSC, licensees have performed assessments of beyond-design-basis accidents. Licensees have presented a sequence based on a prolonged loss of electrical power, leading to a loss of all heat sinks. For the purposes of the review of the accident sequence, it is not necessary to postulate any particular external event. It is simply assumed that electrical supplies to power primary and secondary heat sinks are not available.

The accident scenario includes assuming progressive failure of all mitigating measures. While the resulting scenario has an extremely low probability, it provides a means of identifying possible mitigating strategies at each stage of the accident and the time available to implement them.

The accident progression is presented in detail in Appendix B. Potential intervention points where the accident progression could be halted or delayed are noted.

All licensees provided an assessment that was adequate for the CNSC Task Force to perform its review. The event progression described by licensees is in agreement with the CNSC's understanding, except for the timing. The CNSC Task Force assessment of the time available before pressure tube failure indicates that it may be approximately 1 hour shorter than that given by industry. There may be less available recovery time than currently expected. The CNSC Task Force finds that the predictions of the timing of pressure tube failure in CANDU reactors should be verified.

The Fukushima Daiichi accident demonstrated the destructive power of hydrogen explosions. All licensees have plans to install (or have installed) passive autocatalytic recombiners[24] to improve mitigation of the risk from hydrogen explosions. The CNSC Task Force finds that, where not already done, these plans should be accelerated.

6.3.2 Duration of backup services

As discussed in Appendix A, Canadian NPPs have large inventories of water that can be used as passive heat sinks in the event of a loss of electrical power. The duration of these passive heat sinks is different for each NPP and is discussed in more detail in Appendix B. No fuel damage will occur if AC power is restored within 1 hour (and within a much longer period of time for some NPPs). If simple operator actions to enable gravity feed to the boilers are executed promptly within this 1-hour time frame, this time can be increased significantly, and release of radioactive material would not occur before at least 17 hours after the accident[25]. Again, operator actions can significantly extend this period to over a day, even in the absence of normal power supplies.

Although the focus of this section of the CNSC Task Force report is on loss of all electrical power, a much more likely outcome for Canadian NPPs would be that either the normal backup (standby generators) or the emergency backup (emergency power supply) would function and no such loss of

[24] Passive autocatalytic recombiners (PARs) comprise a catalyst-coated metal surface. The catalyst promotes combination of hydrogen and oxygen in the containment atmosphere to produce water. With a sufficient reaction area, PARs can prevent the hydrogen concentration from rising to combustible or explosive levels.
[25] This time is a conservative estimate, and the actual time is likely to be longer.

all electrical power would occur. Staff confirmed that many days' supply of fuel is immediately available to these generators, typically sufficient for three to four days (for each standby generator with no outside supply if operated at full design power).

Following a loss of all electrical power, batteries support essential services until normal or backup power is available. CANDU reactors have the guaranteed capability to support all essential electrical equipment for 40 minutes, although the batteries may last significantly longer. This duration is short compared to other essential supply capabilities. Moreover, once batteries are exhausted, the control and instrumentation functions are lost. Operators must take special measures (such as using self-power instruments) to obtain information on which to base recovery actions. The CNSC Task Force finds that licensees should explore options to extend the duration of power supplies to instrumentation and control equipment that may be needed to mitigate beyond-design-basis accidents, including severe accidents.

6.3.3 Margin to failure of mitigating equipment

The assessment of beyond-design-basis accident progression assumed progressive failure of all mitigating measures, leading inevitably to core meltdown. For this reason this sequence does not provide margin-to-failure information – the information about how close the equipment is to failure. However, the following instances were noted where it may be worthwhile performing additional assessments and/or design changes.

The CNSC Task Force notes that the instrumentation needed to guide accident management actions may not survive the harsh conditions of beyond-design-basis accidents. The CNSC Task Force finds that licensees should assess equipment survivability (not full environmental qualification[26]) to provide reasonable assurance that adequate information will be available to the operator.

Class I/II batteries are not formally qualified for external hazards (except at Pickering A stations where Class I batteries are seismically qualified). Licensees should determine the minimum design requirements for qualification of Class I/II equipment to mitigate beyond-design-basis accidents involving loss of all AC power and verify that the equipment can survive the accident conditions.

As noted above, CANDU reactors have large inventories of water in the calandria vessel and the shield tank that can provide passive heat sinks in beyond-design-basis accidents. However, the equipment was not designed for this purpose. The following paragraphs describe issues that may prevent these heat sinks from meeting their full potential.

After a loss of all heat sinks, and assuming no recovery action by the operator, secondary water inventory boils away, leading to heatup and boiling of the primary coolant. Steam is vented through relief valves into the degasser (or bleed) condenser[27]. The degasser condenser pressurizes and its relief valves open to vent steam into containment. Based on analysis of the licensees' submissions, the degasser condenser relief valve capacity may not be adequate in this beyond-design-basis accident. Inadequate relief capacity would lead to earlier failure of pressure tubes and shorter available recovery times than would be the case if relief capacity was adequate. The CNSC Task Force finds that licensees should perform tests to verify the capacity of the degasser (or bleed) condenser relief valves to respond to a complete loss of heat sinks.

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[26] Environmental qualification is a formal process for ensuring that equipment will function in a harsh environment, for example high temperature, pressure and humidity resulting from an accident.

[27] The degasser (or bleed) condenser is a vessel in the pressure and inventory control system. One of its main functions is to act as a buffer volume to accept steam and water discharged from the primary relief valves.

Further in the accident sequence, after the onset of severe core damage, the core debris falls progressively to the bottom of the calandria vessel. Heat is transferred through the calandria vessel wall into the shield tank (or calandria vault on some designs). The steam generated by boiling in the shield tank would cause the tank to pressurize. The shield tank relief valves may not have sufficient capacity in this beyond-design-basis accident. The shield tank would fail due to overpressure and, if the rupture is low in the vessel, most or all of the available water would be lost, leading to an earlier failure of the calandria vessel than would be the case if adequate relief was available. This reduces the time available for mitigating action and for offsite emergency measures. The CNSC Task Force finds that licensees should verify that there is adequate pressure relief for severe accidents.

6.3.4 Re-evaluation of consequential events

Consequential events (such as a tsunami caused by an earthquake) are considered in NPP probabilistic safety assessments. Selected cases are reported in the NPP safety reports. The CNSC reviews these assessments as they are submitted and has not re-evaluated them for this report.

The key difference for events with a consequential loss of primary coolant would be to reduce the time until core overheating. The timings of the remainder of the analyzed cases would not be significantly changed. However, mitigation by make-up[28] to the boilers would not be effective in the case of significant primary leakage. Given the low likelihood of significant damage to the primary pressure boundary and the limited additional impact of the consequential failure, the CNSC Task Force considers that no additional work is necessary in this area.

6.3.5 Multi-unit considerations

Analysis performed for multi-unit NPPs (Pickering A and B, Bruce A and B, and Darlington) was based on a computer model that represents only a single unit. The effect of a severe accident simultaneously in four units is approximated by modelling the shared part of the containment as one quarter of its true size.

This approach is accepted to give broadly representative results of the accident source term but would not be capable of calculating, for example, the effects of different times of core meltdown in the different units. In some effects, the current modelling may be conservative. For example, all four units would be very unlikely to experience identical failures, such as vessel failure, at the same moment, thus the corresponding containment pressure increases may be over-predicted. Other effects may not be captured, such as higher than average local hydrogen concentrations.

The CNSC Task Force finds that licensees should develop the capability to model severe accidents in multi-unit NPPs. The current models are adequate for single-unit NPPs.

6.3.6 Irradiated fuel bay

The irradiated fuel bays (IFBs) (spent fuel pools) at most NPPs were not designed to accommodate boiling in the pool; therefore a loss of cooling can be tolerated for about 16 hours before the structural design temperature is reached. Above this temperature there is an increasing risk of structural cracking which could lead to leakage from the bay. Any leakage will shorten the time to fuel uncovering. The Darlington IFB was designed to accommodate boiling and this finding does not apply to Darlington.

[28] Make-up is the provision of water to replace coolant inventory lost due to leaks or boil-off.

The CNSC Task Force recommends that licensees develop a strategy to mitigate these concerns by demonstrating that procedures and equipment are in place to provide make-up water that will compensate for possible leakage, and that manual actions can be performed in any high radiation fields that may arise from a low water level. The CNSC Task Force notes that upgrades to provide an enhanced make-up capability are already being considered. These upgrades should consider possible leakage arising from structural failures that may occur when the temperature limits are exceeded.

The licensees' submissions do not generally discuss the need for hydrogen mitigation in the IFB area. In their July 28, 2011, submission, licensees conclude that, as long as water inventory is maintained and the fuel remains submerged, hydrogen generation is not an issue. Nonetheless, the CNSC Task Force finds that the need for hydrogen mitigation in the IFB area should be evaluated.

6.3.7 Licensees' plans for design changes or further assessments

Since original construction, licensees have made many safety improvements to NPPs based on CNSC requirements, industry research, national and international operational experience and generally rising public expectations. In particular, licensees of those stations that have undergone refurbishment have performed a systematic review against modern standards and made modifications that reduce the likelihood and consequences of severe core damage and a large release of radioactive materials.

Notwithstanding the above, licensees have performed assessments against the lessons learned from the Fukushima accident and have proposed, or are evaluating, a number of further safety enhancements, such as additional coolant injection points, additional hydrogen mitigation, and additional onsite and offsite power supplies and pumps. The CNSC Task Force agrees that these enhancements have the potential to improve safety at the plants. More detailed plans and schedules were submitted by licensees in September 2011.

While accepting that the risk from Canadian NPPs is low, the CNSC Task Force identified some additional potential improvements or confirmatory assessments that could further reduce the risk or improve confidence in the ability of reactors to survive beyond-design-basis accidents. These are listed in section 6.3.8.

6.3.8 Review findings for beyond-design-basis accidents

The CNSC Task Force finds that the risk to the public from beyond-design-basis accidents and events at CANDU NPPs is very low. CANDU reactors have a large inventory of water available for passive cooling in the secondary cooling system, the primary cooling system, the moderator and the calandria vault / shield tank.

CANDU reactors have independent and diverse backup power supplies, and thus provide high confidence that power can be restored to vital equipment. With many days' supply of fuel for emergency power generators available onsite, adequate time is available to take long-term mitigating action.

While accepting that the risk from beyond-design-basis accidents at Canadian NPPs is very low, the CNSC Task Force identified a number of areas where additional improvements or confirmatory assessments would further enhance safety:

1. Not all licensees have completed the installation of passive autocatalytic recombiners. Most licensees have taken action to accelerate the installation.
2. Results of studies of the duration of primary boiloff before pressure tube failure are not consistent. The progression of a sustained loss-of-heat-sinks event described by licensees is in

broad agreement with the CNSC's understanding. However, the CNSC Task Force assessment of the time available before pressure tube failure is shorter than that given by industry.

3. In the event of a loss of all normal, backup and emergency AC power, the guaranteed capability of Class I batteries to support all essential electrical equipment is 40 minutes (although it is recognized that some services will last much longer). This duration is short compared to other essential supply capabilities and gives little time to restore AC power. Once batteries are exhausted, most control and instrumentation functions are lost.
4. While key instrumentation is fully qualified for design-basis accidents, survivability in beyond-design-basis accident conditions has not always been demonstrated.
5. Degasser (bleed) condenser relief valves have been tested to ensure that they are capable of providing sufficient relief flow for worst-case design-basis accidents. However, they have not been tested at extreme conditions that may arise in beyond-design-basis accidents. In these cases, relief valve capacity may not be adequate in a sustained loss of all heat sinks, reducing the time before pressure tubes fail. The CNSC previously evaluated this issue and accepted the current design, although the margin to failure was small.
6. Shield tank relief and calandria vault relief have not been verified to be adequate for beyond-design-basis accidents. A large inventory of water surrounds the core of a CANDU reactor – one of the strengths of its design. Nonetheless, if relief valves do not have sufficient capacity in a sustained loss of heat sinks, the shield tank could fail due to overpressure and much of the available water may be lost, leading to an earlier failure of the calandria vessel than would be the case if adequate relief was available.
7. The minimum Class I/II equipment that is needed to mitigate beyond-design-basis accidents involving loss of all AC power has not been systematically identified.
8. Modelling of severe accidents performed for multi-unit NPPs was based on a computer model that represents only a single unit. The modelling approach is accepted as adequately giving broadly representative results but would not be capable of calculating, for example, the effects of different times of core meltdown in the different units.
9. The irradiated fuel bays (spent fuel pools) at most NPPs have temperature limits that lead to relatively short times (16 hours) for which a loss of cooling can be tolerated before the structural design temperature is reached. Above this temperature, an increasing risk of structural cracking could lead to leakage from the bay, thereby shortening the time to fuel uncovering. Additionally, with a low water level, it may not be possible to perform manual actions in elevated radiation fields.
10. The need for hydrogen mitigation in the irradiated fuel bay area has not been adequately evaluated.

6.4 Severe accident management

A severe accident is a beyond-design-basis accident that involves significant core degradation. Severe accident management (SAM) is one of the components of defence in depth used in the overall safety assurance framework. SAM provides for the management of risks posed by unlikely events leading to severe accidents in an NPP. The CNSC's expectations for SAM are given in G-306, *Severe Accident Management Programs for Nuclear Reactors* [23], published in 2006.

The CNSC Task Force reviewed the licensees' provisions for using existing plant capabilities, complementary design features (such as passive autocatalytic recombiners, emergency containment filtered venting system, and calandria vault make-up) and emergency mitigating equipment[29] in the

[29] Emergency mitigating equipment includes portable equipment that may be available onsite or delivered to the site for the purpose of preventing and mitigating severe accidents.

management of a severe accident. The focus of accident management is on halting or delaying the progression of an accident leading to eventual calandria and/or containment failure. Plant monitoring and instrumentation survivability in severe accident conditions were also evaluated. Where additional equipment or design modifications were found to be necessary, the licensees' plans and schedules for implementation were assessed.

Severe accident management includes the development of guidance and procedures for use by plant personnel. The CNSC Task Force verified the status of severe accident management guidelines (SAMG) at Canadian NPPs. Where SAMG have not been fully implemented, the review focused on the licensees' plans and schedules for completion.

The CNSC Task Force also considered plans for the use of external resources, such as equipment, fuel and people, in mitigating severe accidents. Formal plans for inter-utility cooperation in matters such as availability of skilled personnel, provision of technical support and the sharing of equipment were included in this consideration.

All licensees provided their responses to the CNSC request for information pursuant to subsection 12(2) of the *General Nuclear Safety and Control Regulations*. This summary addresses the following topics in each of the licensees' submissions:

- status of SAMG implementation
- plant design capabilities for severe accident management
- assessments of severe accidents
- use of external resources
- irradiated fuel bays
- multi-unit considerations

Further elaboration is provided in sections 6.4.1 to 6.4.6.

6.4.1 Status of severe accident management guidelines

All Canadian NPPs have a comprehensive set of documentation covering normal plant operation, minor upsets, and accident conditions. As part of the SAMG development and implementation, the set of operating documentation is prepared to explicitly cover severe accidents. The SAMG suite includes a number of procedures and supporting documents, with the fundamental goals of:

- maintaining or restoring fuel cooling
- maintaining the integrity of the containment envelope
- minimizing releases of radioactive products to the environment

SAMG were developed by building both on the existing structure of emergency operating procedures and on international experience. A symptom-based approach is used to allow the plant personnel to identify suitable actions to bring the plant under a stable and controlled state.

The CNSC Task Force finds that the SAMG that the CANDU licensees are implementing are generally adequate, but need to be supplemented by explicit considerations of specifics for the multi-unit stations, events affecting spent fuel bays and severe accidents triggered by extreme external events.

6.4.2 Plant design capabilities for severe accident management

Plant design capabilities for severe accident management can be strengthened with complementary design features. A complementary design feature is a physical design feature added to the design as a

standalone structure, system or component (SSC) or added to an existing SSC to cope with plant conditions arising from selected beyond-design-basis accidents, including severe accidents.

Complementary design features include, for example:

- emergency containment filtered ventilation
- passive autocatalytic recombiners (PARs)
- make-up provisions for various water reservoirs, and other areas needing coolant

Emergency mitigating equipment may be employed and includes portable equipment either available on site or to be delivered from an offsite location. Additional, ad hoc means may be used to supplement the existing capabilities to address severe accidents.

6.4.2.1 Containment venting

All NPPs have the means to vent the containment to protect containment structural integrity. However, not all NPPs can filter the vented gases in severe accidents. Emergency containment filtered ventilation (ECFV) is a complementary design feature intended to protect the containment envelope if the internal containment pressure approaches the containment strength limit and to remove radioactive materials from any gases vented from the containment in a severe accident. Such a system has been installed, for example, at Point Lepreau; it is manually actuated, does not require an external source of power and is used to relieve containment pressure for the conditions that could be present in a severe accident. ECFV uses a high-efficiency scrubber and filtration unit to filter out the vast majority of fission products so radiation exposure to the public would be limited to acceptable levels in the event of a release. Similar venting provisions need to be considered for all other Canadian NPPs to provide a means to minimize the release of radioactivity while protecting the containment integrity.

6.4.2.2 Hydrogen management

Hydrogen combustion is a concern with respect to the integrity of the containment. Hydrogen can be produced in certain phases of severe accident progression. To deal with the hazard of large quantities of hydrogen being produced in a severe accident and causing hydrogen explosions, most CANDU plants are equipped with AC-powered igniters, which are intended to control hydrogen concentrations in the containment atmosphere by initiating limited “burns” before a potentially explosive concentration is reached. Recently, NPP licensees have initiated installation of passive autocatalytic recombiners (PARs). These are devices intended to passively (without the need of external power) remove hydrogen from the containment atmosphere. All Canadian NPPs have either installed PARs or are in the process of installation. The CNSC Task Force expects that all NPP licensees will provide confirmatory assessments demonstrating adequacy of PARs for severe accidents, and consider installation of PARs in the spent fuel bay areas.

6.4.2.3 Coolant make-up provisions

Make-up provisions (such as dedicated lines intended to replenish water inventory in important plant systems) are an important line of defence against accidents progressing to severe core damage. Water can be added to a variety of systems to prevent, slow down or terminate the core fuel degradation process. These systems include steam generators, calandria, shield tank, calandria vault and the spent fuel bay. Water is typically provided either by in-containment reserves (such as a dousing tank) or by an external connection to the reactor building. Keeping in mind that effective make-up for lost coolant may prevent core damage, the CNSC Task Force requests all licensees to perform a systematic assessment of all existing and potential means to provide make-up coolant to various

reactor systems. The potential for creating a path for unfiltered releases (containment bypass) through a make-up line needs to be critically assessed.

6.4.2.4 Plant monitoring and instrumentation

The existing plant monitoring and control instrumentation has been designed and maintained to ensure correct functional performance under the conditions assumed in the station design basis. Correct performance of key instrumentation is essential in diagnosing the plant state and emerging safety challenges, such as containment pressure buildup or hydrogen and fission product accumulation. Because beyond-design-basis and severe accident conditions are more severe, functioning of the existing instrumentation is not assured. Assessments of existing instrument survivability or of needs for installing hardened[30] instrumentation should be performed.

6.4.3 Assessments of severe accidents

Explicit assessment of severe accident progression is required to develop an understanding of likely challenges to key defence-in-depth systems (calandria, containment), timing of events, required coolant make-up capability, extent of fuel damage and the probable source term. Integral mechanistic models are available to simulate accident progression. All licensees either completed or are in the process of performing Level 2 PSAs as required by regulatory standard S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* [18], which involve deterministic analysis of credible severe accident scenarios. However, the existing modelling capabilities may not be adequate to consider events affecting multiple reactors on the same site (multi-unit events), accidents with spent fuel, or releases of radioactive products from a degraded reactor core into water. The assessments of severe accidents should be periodically updated, similar to the existing practice used for safety reports.

A focused review of beyond-design-basis accidents is given in section 6.3.

6.4.4 Use of external resources

External resources can be brought in to supplement or replace the onsite resources and may include fuel, water, electric power or equipment such as pumps or generators. The resources currently available to the licensees on site are adequate to cope with design-basis accidents and many beyond-design-basis events. In case of an external event affecting the whole site, or a severe accident, which will progress over several days, it would be necessary to bring in offsite resources. Explicit arrangements should be in place to facilitate access to additional resources.

6.4.5 Irradiated fuel bays

Fuel bays contain significant quantities of irradiated fuel. Because of decay, fission product inventories in the spent fuel decrease over time. Nevertheless, the long-lived radioactive materials could pose a significant threat if the spent fuel is uncovered and subsequently overheats. To mitigate this threat, provisions are taken to ensure reliable cooling of the spent fuel bays and to maintain their structural integrity in credible external events, such as earthquakes. The CNSC Task Force expects all Canadian NPP licensees to perform comprehensive deterministic and probabilistic analyses of events

[30] Hardened instrumentation is capable of surviving the harsh conditions of a severe accident.

affecting irradiated fuel bays, in order to demonstrate that the mitigation is sufficient for events as discussed in section 6.3.6.

6.4.6 Multi-unit considerations

As events at the Fukushima plant have demonstrated, the multi-unit plants face unique challenges. Specifically, events affecting more than one unit at a time need to be considered; such events would exacerbate challenges that the plant personnel would face in time of an accident. The events and consequences of an accident at one unit may affect the accident progression or hamper accident management activities at the neighbouring unit; available resources (personnel, equipment and fuel) would need to be shared among several units. Explicit plans should be in place to address these challenges.

6.4.7 Review findings for severe accident management

All NPP licensees undertook a review of the existing procedural guidance and design capabilities of operating NPPs to cope with accidents involving significant core damage. The soundness of the provisions in place has been confirmed. At the same time, several possibilities for further enhancements have also been identified.

In particular, the CNSC Task Force is satisfied that:

- Severe accident management guidance has been, or will shortly be, fully implemented at all plants. This includes development of procedural guidance to the operating staff and technical support groups, specific training and appropriate drills.
- In addition to original design capabilities, which already catered to mitigation of some beyond-design-basis accidents, further design improvements have either been implemented or are being planned. Notably, a filtered venting system for containment, qualified for severe accident conditions, can prevent challenges to containment integrity and minimize the release of radioactive materials. Diversifying the coolant make-up capabilities will further increase the capacity of available heat sinks and thus delay any reactor core degradation. Another positive development is the acceleration of installation of the hydrogen passive autocatalytic recombiners.
- All NPP licensees have completed or are working on analyses of severe accidents, as part of the effort to comply with regulatory standard S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*.
- The NPP licensees are cooperating in establishing formal agreements and designating or building a regional warehouse to provide necessary equipment and resources in case of emergency.

The CNSC Task Force also appreciates that all utilities have clear guidance in place that assigns responsibility for decisions regarding containment venting to the plant operator.

Based on the reviews of the submitted information, the CNSC Task Force has identified several findings, most of which are common to all licensees. These review findings identify a need either for additional information on the already ongoing activities, or for licensees to consider further enhancements to the capability of power plants to cope with severe accidents.

The CNSC Task Force finds that:

1. Current assessments do not adequately consider events affecting multiple reactors on the site, events at spent fuel bays, as well as events triggered by extreme external hazards. Having detailed assessments of the severe accident management procedural guidance and design

capabilities to cater to beyond-design-basis and severe accidents were shown to be of high priority during the Fukushima event.

2. Plant design capabilities for severe accident management, such as containment venting, hydrogen mitigation, coolant make-up provisions, instrumentation, and the control areas have not been fully evaluated and documented. Such design capabilities would allow minimization of the consequences of a severe accident, should one occur.
3. The scope of analyses of severe accidents does not fully cover accidents triggered by extreme external events, multi-unit events, and spent fuel bay accidents. The modelling capabilities for multi-unit events are not fully adequate. Improvements would also give a better estimation of the source terms of radioactivity and combustible gases.
4. Licensees' emergency response organizations do not have access to a regional warehouse that could make available offsite equipment and resources that may be needed in case of a severe accident. Availability of emergency equipment was shown to be crucial during the Fukushima event and could allow terminating a severe accident early enough to prevent any radioactive releases to the environment.
5. Severe accident analyses and assessments of external hazards are not systematically produced and periodically updated. This aspect of the plant safety case has not received much attention in the past and was shown to be important in understanding the site-specific challenges and possible progression of a severe accident.

The CNSC Task Force also finds that, in relation to the regulatory framework in the areas related to plant design for severe accidents, as well as to the management of accidents:

6. Current power reactor operating licences do not have specific licence conditions requiring implementation of accident management provisions, including those for severe accidents.
7. Relevant sections in the existing and planned regulatory documents, such as G-306, *Severe Accident Management Programs for Nuclear Reactors*; RD-310, *Safety Analysis for Nuclear Power Plants*; and RD-337, *Design of New Nuclear Power Plants*, have not been re-evaluated and revised to account for the lessons learned following the Fukushima accident. There is currently no regulatory document giving specific requirements for accident management.

6.5 Emergency response

This section of the review addresses the licensees' responsibilities for emergency response. Section 7 of this report deals with the current status of emergency preparedness and response measures in Canada.

The CNSC Task Force reviewed the NPP licensees' submissions against its *Nuclear Power Plant Safety Review Criteria* for emergency response, and:

- the *Nuclear Safety and Control Act*
- section 6(k) of the *Class I Nuclear Facilities Regulations*
- applicable site-specific licences
- CNSC guidance document G-225, *Emergency Planning at Class I Nuclear Facilities and Uranium Mines and Mills* (based on IAEA standard GS-G-2.1, *Arrangements for Preparedness for a Nuclear or Radiological Emergency* [24]
- regulatory document RD-353, *Testing the Implementation of Emergency Measures* [25]

In addition, all licensees' nuclear emergency preparedness programs and plans were reviewed against the requirements of their respective provincial offsite emergency response plans.

As required by the CNSC *Nuclear Safety and Control Act* and CNSC Regulations, all licensees of Class I nuclear facilities must provide information pertaining to their proposed emergency measures

and must include them in their respective licence applications. The information included in the applications describes the proposed facility, activities, substances and circumstances to which their emergency plans apply. The emergency plans should also be commensurate with the complexity of the associated undertakings, and the probability and potential severity of the emergency scenarios associated with the operation of these facilities. Therefore, these emergency plans must contain a description of the proposed measures to prevent or mitigate the effects of accidental releases of nuclear and/or hazardous substances on the environment, the health and safety of persons, and the maintenance of security, including measures to notify and assist offsite authorities and test the implementation of these measures.

Licensees regularly review their emergency plans and revise them to address changes in their operational activities as well as to take into account other relevant factors and circumstances such as operating experience. A licensee's emergency plan must be accepted by the CNSC in order for an NPP to be licensed.

Each licensee's emergency plan is specific to its particular site and organization; however, they all typically cover the following topics:

- documentation of the emergency plan
- basis for emergency planning
- personnel selection and qualification
- emergency preparedness and response organizations
- staffing levels
- emergency training, drills and exercises
- emergency facilities and equipment
- emergency procedures
- assessment of emergency response capability
- assessment of accidents
- activation and termination of emergency responses
- protection of facility personnel and equipment
- interface arrangements with offsite organizations
- arrangements with other agencies or parties for assistance
- recovery program
- public information program
- public education program

For more detailed information about the contents of emergency plans for Class I nuclear facilities, refer to the CNSC regulatory guidance document G-225, *Emergency Planning at Class I Nuclear Facilities and Uranium Mines and Mills* [26].

6.5.1 Adequacy of emergency plans for beyond-design-basis or multi-unit accidents

The current emergency plans for all NPPs in Canada exceed the requirements for design-basis accidents for emergency planning; this means that design-basis accidents would not cause offsite dose consequences. However, all licensees routinely conduct exercises to simulate scenarios with offsite effects that would subsequently require the provinces to activate their provincial plans and implement local area evacuations. The emergency scenarios needed to trigger this degree of response are in fact beyond-design-basis types. Therefore, they demonstrate that the licensees' emergency response programs are capable of dealing with a beyond-design-basis accident.

The CNSC Task Force is confident that the licensees' emergency response organizations are capable of responding to beyond-design-basis events provided they are single-unit accidents only. None of the multi-unit station licensees, however, have explicitly considered multi-unit accident scenarios in development of their emergency plans.

6.5.2 Integration of SAMG in emergency response organizations

The integration of SAMG into emergency plans, for those licensees who have implemented SAMG, is effective. In practice, this integration offers enhanced technical support to the emergency response organizations, and the additional staff are integrated into the existing structure.

6.5.3 Alternate emergency facilities

All licensees have stated that they have alternate locations identified for their emergency centres. However, this is not always documented in their emergency plans and procedures. Although some licensees indicated their primary emergency facilities are designed to withstand design-basis external hazards and/or meet the relevant commercial or industrial building code, none provided information regarding the robustness of their alternate facilities.

The CNSC Task Force finds that, in some cases, information is lacking about the robustness of licensees' primary facilities, and that none of the licensees have robustness criteria for their alternate facilities.

6.5.4 Availability of support and supplies

In all cases, the licensees have indicated that they have agreements in place with their respective stakeholders for support and supplies. However, with few exceptions, arrangements for supplies or services have not been consistently formalized or documented in their emergency plans and procedures. All licensees mentioned in their submissions that they are working together, through a CANDU Owners Group working group, to develop and formalize an industry-wide "mutual assistance" agreement.

6.5.5 Capability without external power

Not all licensees' emergency facilities and equipment have backup power available in the event of a loss of external power. Those licensees that do have them, however, know and understand the limitations of their backup power supplies and are now evaluating and investigating their ability to maintain backup power for extended outages. Those that do not have backup power for their emergency facilities and/or equipment are aware of this weakness and are working towards correcting this shortcoming. Also, in some cases, the information regarding backup power for all emergency centres and/or equipment is not fully documented in their emergency plans and procedures. The licensees need to include this information to ensure that response personnel know the limitations of their facilities and what arrangements are in place to replenish fuel for generators.

Emergency facilities and equipment that are designated as essential for emergency response must always be available, accessible and ready to operate. Therefore, the absence of reliable and backup sources of power from any emergency facilities or equipment is a weakness that must be corrected. The CNSC Task Force acknowledges that those licensees who have identified weaknesses in this area are in the process of assessing their needs and options.

6.5.6 Source term estimation

Post-accident source term estimation is a method that can be used to quantify a potential release of radioactive material before it occurs. Both Bruce Power (BP) and Ontario Power Generation (OPG) use software and in-plant gamma survey measurements to perform post-accident source term estimations; however, these are designed for an accident in only one unit. Hydro-Québec and New Brunswick Power (NB Power) do not perform source term estimation in support of offsite emergency response. Source term estimation is a "best practice" and it would be beneficial if all licensees were able to provide source term information to offsite authorities in emergency situations.

6.5.7 Plume dispersion and dose modelling

All licensees have plume modelling capability that can be used to guide field survey teams and to inform offsite authorities about the area that radiation releases may spread to in the event of an accident.

The approach to dose modelling is different across all licensees. BP and OPG perform dose modelling based on source term estimates, the monitoring of venting radiation, and field surveys. Hydro-Québec performs dose modelling based on the monitoring of venting radiation, fixed radiation surveillance station data and field surveys. NB Power does not perform dose modelling.

The multi-unit site licensees have indicated that their software is capable of providing plume modelling for multi-unit events as plume modelling is independent of the source term. However, dose modelling is directly affected by the source term and, therefore, dose modelling for multi-unit scenarios will need to be re-assessed to ensure accuracy.

The CNSC Task Force finds that all licensees have plume modelling capability. In regard to dose modelling to support offsite authorities, Hydro-Québec should ensure that source term estimates are included in dose modelling, and NB Power should develop comprehensive dose modelling.

6.5.8 Station boundary and field radiation monitoring

All Canadian NPP licensees perform field radiation monitoring by dispatching dedicated monitoring teams to designated locations, both onsite and offsite, to collect measurements using gamma dose rate meters and air samplers as determined by the plume modelling results. Only one licensee, Hydro-Québec, has an automated system that provides real-time field monitoring data in addition to the results collected by its field monitoring teams. In all cases, field radiation monitoring results are relayed to the provincial authorities, as well as the CNSC, to be used by the offsite authorities to assess and to determine what protective actions should be recommended for the public. Some other licensees have identified the use of automated boundary monitoring and are assessing the potential benefits of installing such instrumentation.

The CNSC Task Force considers that all licensees have satisfactory arrangements in place to perform field radiation monitoring. However, for most licensees, the current method depends on station staff physically going into the field to collect samples and take readings. The use of automated real-time field monitoring at a station boundary is seen as a best-practice approach that allows critical data to be available sooner to appropriate authorities.

6.5.9 Containment venting process

There are two containment venting strategies: nominal containment venting, which keeps containment pressure below its structural limit, and alternate containment venting, which is a coordinated process involving offsite stakeholders to determine the optimal venting strategy to protect the public and the environment.

In all cases, the senior authorized person on shift (e.g., shift manager, shift supervisor, chef de quart) is fully authorized to perform nominal venting. If nominal venting is not required, NPP staff coordinate with offsite authorities before venting. The CNSC Task Force is satisfied that the containment venting decision process and authority is effective and is appropriately documented by the licensees.

6.5.10 Coordination of communications

Communications protocols between the licensees and the offsite response organizations, including provinces, municipalities and the CNSC, are well documented in both the licensees' emergency response plans and procedures, and those of the offsite organizations. During the planning and preparedness phases of emergency management, all licensees work closely with their respective offsite emergency response stakeholders to maintain good working relationships. In addition, the provinces, the Government of Canada and the licensees work cooperatively through joint emergency information centres to provide the public and the media with information about the status of the crisis and other relevant information.

The CNSC Task Force finds that the current coordination of communications between licensees and offsite authorities, related to decision making and public/media affairs, is well established and functions efficiently, as has been observed during coordinated exercises between licensees and their respective offsite organizations.

6.5.11 Review findings for emergency response

The CNSC Task Force has verified that that there are no significant gaps in emergency planning at Canadian NPPs. Overall, the licensees maintain and operate comprehensive and well-documented emergency plans, and these plans and their elements are regularly tested through self-audited drills and exercises. The CNSC also conducts inspections of these exercises and verifies that both the onsite and the offsite support components of the licensees' emergency response plans have been adequately implemented.

Although a number of opportunities for further enhancement are listed below, the emergency response program documentation, plans and procedures for all NPPs in Canada are meeting the expectations and intent of CNSC guidance and regulatory expectations, as well as their site-specific licences and the requirements of their respective provincial offsite emergency response plans. There are no emergency response issues that require immediate action.

The CNSC Task Force finds that:

1. Emergency response organizations are capable of responding to single-unit, beyond-design-basis events. Evaluation and revision of emergency plans in regard to multi-unit accidents and severe external events, including an assessment of the minimum complement requirements, have not been performed. As a result, it has not been conclusively demonstrated that emergency response organizations will be capable of responding effectively in a severe event and/or multi-unit accident.

2. The performance of the emergency response organization under severe event and/or multi-unit accident conditions has not been challenged by designing and conducting exercises that are based on such conditions.
3. Automated real-time station boundary radiation monitoring systems with appropriate backup power and communications systems are seen as a best practice approach and allow critical data to be available rapidly. However, such systems are not available at all sites.
4. Not all licensees' emergency facilities and equipment have backup power available in the event of a loss of external power. Backup power sources for primary and alternate emergency facilities, and all emergency response equipment that require electrical power to operate (e.g., electronic dosimeters, two-way radios), have not been systematically identified. The applicable emergency plans and procedures do not, in all cases, adequately document the requirements and limitations.
5. Arrangements and agreements for external support are not always formalized and not always documented in the applicable emergency plans and procedures.
6. Hydro-Québec does not currently have source term estimation capability included in its dose modelling tools. NB Power does not currently have source term and dose modelling tools.

As a result of this assessment of licensees' emergency preparedness and response programs, it has become apparent that the main cross-cutting issue for this focused report is in the regulatory framework area. Each licensee has its own means and methods of meeting the emergency preparedness and response expectations, and there is no regulatory requirement or standard to ensure consistency among the licensees. This is a common theme in many emergency preparedness areas since the current CNSC emergency preparedness criteria are based on a CNSC guidance document: G-225, *Emergency Planning at Class I Nuclear Facilities and Uranium Mines and Mills*. Converting the CNSC "guidance" document to a CNSC "regulatory" document, and adding more detailed and specific requirements, could be the basis for strengthening and standardizing emergency preparedness and response at NPPs in Canada.

In addition, whereas a licensee's onsite emergency plans are submitted to the CNSC as part of the licence application and renewal process, there is no formal requirement for the CNSC to review the offsite plans. Although the CNSC has always considered the preparedness of the offsite authorities when reviewing a licence application, the requirement is not explicit and poses a potential gap.

As a result, the CNSC Task Force also finds that:

7. The suite of emergency preparedness regulatory requirement documents, currently comprising guidance document G-225, *Emergency Planning at Class I Nuclear Facilities and Uranium Mines and Mills*, and regulatory document RD-353, *Testing the Implementation of Emergency Measures*, are lacking detailed and specific requirements needed to strengthen and standardize emergency preparedness and response in Canada.

7 Nuclear Emergency Management in Canada

This section of the review addresses the current status of emergency preparedness and response measures in Canada, specifically the offsite preparedness and response. The *Nuclear Power Plant Safety Review Criteria* generally exceed the applicable requirements and expectations of the current CNSC regulatory framework. The CNSC Task Force review findings in this section relate exclusively to the lessons learned from the Fukushima accident. The licensees' onsite preparedness and response is addressed in section 6.5.

The management of a nuclear emergency in Canada involves overlapping municipal, provincial and federal jurisdictions. The CNSC Task Force reviewed the plans and capabilities of lead provincial and

federal agencies to identify any outstanding issues related to coordinated nuclear emergency management. The review included ensuring that agencies' responsibilities and communications channels have been defined and that information needs are well established. Review findings related to further improvements are given, where applicable.

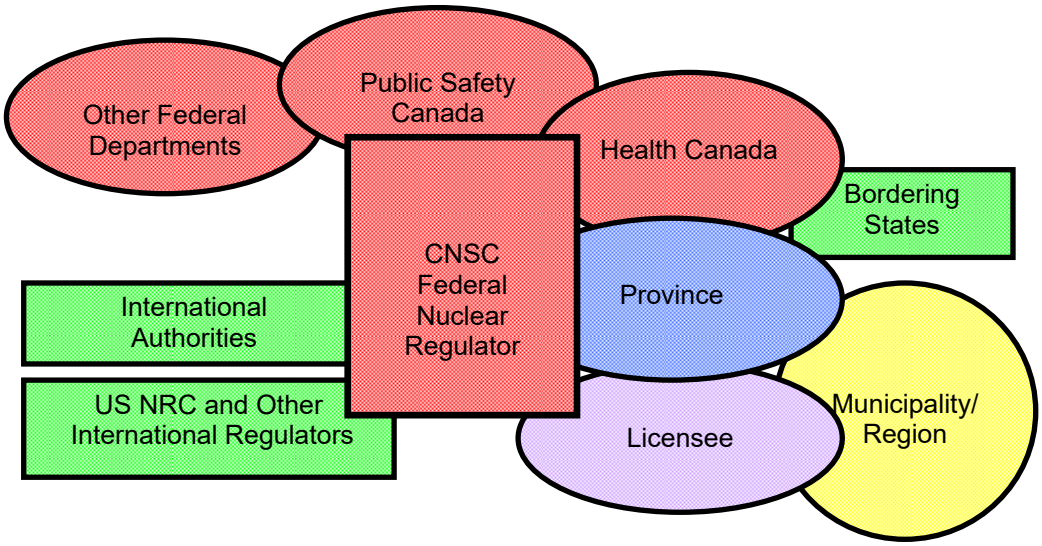
In addition, the review of international lessons learned has identified the following topics related to emergency response:

- enhancement of coordination between federal, provincial and municipal authorities
- international considerations in an emergency

Figure 7.1 shows the stakeholders involved in managing a nuclear emergency and their linkages. In simple terms:

- Onsite preparedness and response is the responsibility of the NPP licensee.
- Offsite preparedness and response is the responsibility of the province, in coordination with municipalities, where the NPP is located.
- At the request of the province, the Government of Canada will provide support to the province via the resources of multiple federal agencies.
- The CNSC continues to have regulatory oversight of the licensee during an emergency.

Figure 7.1 Nuclear Emergency Management Stakeholders



7.1 Nuclear power plant licensees

The *Nuclear Safety and Control Act* empowers the CNSC to establish a comprehensive licensing and compliance system to assure health, safety, security and protection of the environment. It also requires the nuclear industry to protect its workers and the public from unacceptable levels of radiation.

In particular, the *Class I Nuclear Facilities Regulations* require NPP licensees to maintain onsite emergency plans and a response capability. In addition, licensees must also provide support to offsite authorities in their planning and response to a nuclear emergency with offsite consequences.

Emergency plans and programs are reviewed by the CNSC. They become binding upon the licensee, as a condition in the operating licences, and are subject to the CNSC's licensing and compliance oversight processes.

7.2 Government of Canada

The following federal departments play a major role in managing a nuclear emergency.

7.2.1 Health Canada

Health Canada (HC) is designated as the lead agency for federal nuclear emergency preparedness. In this context, Health Canada's Radiation Protection Bureau is specifically resourced for this responsibility and the department maintains and administers the *Federal Nuclear Emergency Plan* (FNEP) [27]. It should be noted that Health Canada was assigned this responsibility prior to the introduction of the *Emergency Management Act* [28] and prior to the creation of Public Safety Canada as a federal department for coordinating the federal whole-of-government approach to emergency management.

The FNEP is intended to complement the relevant nuclear emergency plans of other jurisdictions inside or outside of Canada. It describes the measures federal departments and agencies should follow to manage and coordinate the federal response to a nuclear emergency. The FNEP can be activated if federal support to a Canadian province or territory is required, as a consequence of any domestic, trans-boundary or international incident.

The FNEP describes the roles and responsibilities of federal departments and agencies. The FNEP primarily addresses preparedness and response. It does not address the recovery phase. In addition, annexes to the FNEP describe interfaces between the Government of Canada and the provincial emergency management organizations in the provinces that host NPPs (Quebec, Ontario and New Brunswick). The FNEP has not been tested in a full-scale national exercise since 1999.

The FNEP was last updated in 2002. Accordingly, it does not reflect the introduction of the *Emergency Management Act* and the role of Public Safety Canada as the lead federal department responsible for coordinating federal response to an emergency. Similarly the Federal Emergency Response Plan (FERP), administered by Public Safety Canada, does not refer to the FNEP. A memorandum of understanding between Health Canada and Public Safety Canada on the use of the FNEP was put in place as a temporary measure.

Health Canada began a process to update the FNEP in 2011. There is ongoing effort and consultation between Health Canada, Public Safety Canada and other federal departments to review and update the FNEP and to align it with Public Safety Canada plans and responsibilities.

In addition to managing the FNEP, Health Canada is responsible for operating various radiological monitoring networks: the Fixed Point Surveillance Network, the Canadian Radiation Monitoring Network and the Canadian Comprehensive Test-Ban Treaty (CTBT) Radiation Monitoring Network.

7.2.1.1 Fixed Point Surveillance Network

The Fixed Point Surveillance Network is the result of a project to build a real-time radiation detection system across Canada. This network monitors public doses from radioactive materials in the air and would also help make Canada better prepared in case of nuclear or radiological incidents.

The network consists of radiation detection equipment located at 77 locations across the country and a single data centre that collects, analyzes and stores the data measured at each of these monitoring stations. This data centre is located at Health Canada's Radiation Protection Bureau in Ottawa and communicates with the stations on a daily or as-needed basis. Currently, the network includes monitoring stations installed by Health Canada plus several stations that are owned and operated by industrial partners who share their data with Health Canada.

7.2.1.2 Canadian Radiation Monitoring Network

The Canadian Radiation Monitoring Network is a national network of monitoring stations that routinely collect air, precipitation, drinking water, atmospheric water vapour, and milk for radioactivity analysis and measure external gamma dose. This network was initiated in 1959 to monitor environmental releases of radioactivity from atmospheric nuclear weapons testing and accidental releases from nuclear facilities.

Currently, the network provides information on natural background radiation levels, and provides a mechanism for measuring routine or accidental releases of radioactivity in the environment. There are 26 environmental monitoring stations, plus additional sites in the vicinity of nuclear reactors.

7.2.1.3 Comprehensive Test-Ban Treaty Radiation Monitoring Network

Since 1998, Health Canada has been contributing to the International Monitoring System, an element of the Verification Regime overseen by the Comprehensive Nuclear Test-Ban Treaty Organization (CTBTO). This compliance treaty seeks a universal ban on all nuclear detonation as an effective means to stop further development of nuclear weapons.

Canada is responsible for the installation and operation of four CTBTO radiation monitoring stations across the country as well as a radionuclide laboratory. Health Canada's Radiation Protection Bureau is responsible for the radionuclide laboratory and monitoring stations at St. John's, NL; Yellowknife, NT; Vancouver, BC; and Resolute, NU. These installations collect and transmit monitoring data to the CTBTO to monitor for evidence of any nuclear explosion. However, the data can also be used for a national response to nuclear emergencies.

7.2.2 Public Safety Canada

Under the *Emergency Management Act*, the Minister of Public Safety is responsible for coordinating the Government of Canada's response to an emergency. The *Federal Emergency Response Plan* (FERP) [29] outlines the processes and mechanisms to facilitate an integrated Government of Canada response to an emergency and to eliminate the need for federal government institutions to coordinate a wider whole-of-government response.

The FERP is designed to harmonize federal emergency response efforts with those of the provinces and territorial governments, non-government organizations and the private sector.

In addition, the Minister of Public Safety is responsible for promoting and coordinating emergency management plans of federal departments and agencies. All federal ministers are responsible for developing emergency management plans in relation to risks in their areas of accountability. Individual departmental activities and plans that directly or indirectly support the FERP's strategic objectives contribute to the integrated Government of Canada response.

As previously stated, the FNEP (led by Health Canada) and the FERP (led by Public Safety Canada) are not completely integrated, and a memorandum of understanding between Health Canada and

Public Safety Canada on the use of the FNEP was put in place as temporary measure. There is an ongoing effort and consultation between Health Canada and Public Safety Canada to address the integration of both plans.

7.2.3 Other federal stakeholders

There are 19 federal departments and agencies involved under the FNEP. The roles of two of them, Health Canada and Public Safety Canada, are described above. In keeping with the FNEP, federal policies and legislation, the remaining 17 federal departments and agencies listed in the FNEP are also responsible for independently developing, maintaining and implementing their own nuclear emergency response plans.

Several federal departments and agencies have designated responsibilities under the *Federal Nuclear Emergency Plan*.

7.2.4 Summary – Government of Canada

- A comprehensive federal nuclear emergency plan (FNEP) is in place to address preparedness and response.
- The FNEP has not been updated since 2002 and does not reflect the changes in responsibilities associated with the creation of Public Safety Canada and the *Emergency Management Act.*
- The effectiveness of the FNEP has not been tested in a full-scale national exercise since 1999.
- The federal nuclear emergency management plans, procedures and arrangements primarily address preparedness and response. There are no guidelines and plans for the recovery phase.

7.3 Provincial governments

The provincial governments are responsible for overseeing the health, safety and welfare of their inhabitants and the protection of the environment. Accordingly, they assume lead responsibility for the arrangements necessary to respond to the offsite effects of a nuclear emergency by enacting legislation, maintaining emergency plans and procedures, and providing direction to the municipalities. In addition, the provincial governments coordinate support from the licensees and from the Government of Canada during the preparedness activities as well as during the response.

The provinces, in cooperation with the local jurisdictions, have established procedures to deal with any significant offsite nuclear impacts, primarily related to providing for urgent protective action. These procedures include:

- limiting access to the affected zone(s)
- providing temporary shelter to the affected population
- evacuating buildings or premises in areas near the NPP
- blocking thyroid uptake of radiation
- implementing ingestion control measures such as quarantining farm animals, banning the sale of affected foodstuff, and restricting the use of affected drinking water
- establishing emergency worker centres and reception centres

7.3.1 Ontario

The Province of Ontario's *Emergency Management and Civil Protection Act* [30] governs emergency preparedness and response in Ontario. This legislation requires the government to formulate an emergency plan for emergencies arising in connection with NPPs. Emergency Management Ontario (EMO) is the lead organization for coordinating all the aspects of nuclear emergency management.

7.3.1.1 Plans

Ontario's nuclear emergency plans are structured as a *Provincial Nuclear Emergency Response Plan* (PNERP) Master Plan [31] with NPP-specific implementing plans. The PNERP Master Plan is the overarching plan giving the general principles, concepts and organization for the nuclear emergency management. The PNERP implementing plans for Pickering, Darlington and Bruce address site-specific aspects. PNERP planning, however, is based on a single-unit accident and does not explicitly consider multi-unit accidents.

EMO chairs the Nuclear Emergency Management Coordinating Committee (NEMCC), which comprises members from the NPPs, designated municipalities/region, ministries and federal departments and agencies such as the CNSC, Health Canada and Public Services Canada. This committee meets quarterly to discuss issues of mutual interest pertaining to nuclear emergency management in Ontario.

The PNERP Master Plan and the implementing plans for Pickering, Darlington and Bruce NPPs were last updated and approved by the Ontario Cabinet in 2009.

7.3.1.2 Planning zones

The planning zones used by the Province of Ontario are each generically described as being a certain radial distance from the NPP, but in practice they are defined in a geographically logical manner. For NPPs in Ontario, the following planning zones are used:

- **Contiguous zone** is the offsite area immediately surrounding the nuclear facility where an increased level of preparedness and response is required (nominally 3 km).
- **Primary zone** is the area around the nuclear facility where exposure control measures may be required (nominally 10 km). The approximate population is 7,500 in the Bruce primary zone, 122,000 in the Darlington primary zone and 261,000 in the Pickering primary zone.
- **Secondary zone** is the area where ingestion control measures may be required (50 km).

7.3.1.3 Event assessment

The NPP licensee is required to communicate the following information to the Provincial Emergency Operations Centre, initially, and then on an hourly basis:

- categorization of the accident
- status of safety systems and containment
- repressurization estimates or reactor/vacuum building pressures
- source term estimates
- field monitoring data
- weather data (current and forecast)

The Scientific Section at the Provincial Emergency Operations Centre has the required expertise and the required software to use data provided by the NPP licensee to perform plume modelling and projection of the likely offsite effects. This provides a valuable assessment of an event on an ongoing

basis and helps the Provincial Emergency Operations Centre to decide on the appropriate protective measures. Health Canada, the CNSC and the provincial ministries of Labour and the Environment are also represented at the Scientific Section. This enables the section to also incorporate the technical advice and data coming from these organizations.

7.3.1.4 Public alerting

A 2009 update to the PNERP now requires that the entire primary zone population must be able to receive alerts within 15 minutes. As per the provincial standards defined in the PNERP, the population within the 3 km radius requires a very stringent notification due to proximity to the hazard – the capability to alert practically 100 percent of the population both indoors and outdoors at any time of the day or year. The population within the remainder of the primary zone (3–10 km) must be notified on an area-wide basis – the signal will cover that geographical area, but does not presume notification of practically 100 percent of the population. The new requirements for indoor public alerting in Durham region are not yet being met.

7.3.1.5 Protective measures

The PNERP addresses exposure control measures to protect against external irradiation and inhalation of radioactive material. Measures include evacuation, sheltering, and thyroid blocking with stable iodine in potassium iodide pills (KI pills). The PNERP also addresses ingestion control measures, such as protecting the food chain from radioactive material and preventing the ingestion of contaminated food and water.

In particular, the PNERP requires designated municipalities (Durham Region, City of Toronto and Municipality of Kincardine) to facilitate the availability of KI pills for the primary zone institutions, emergency centres and for any member of the zone population who wishes to possess a supply. However, the mode of distribution is left to the designated municipalities to determine.

In all cases in Ontario, the designated communities have stocked the pills for the general public at central locations (pharmacies in Durham, reception centre in Kincardine) and have pre-distributed the pills to locations such as schools and long-term care facilities. The KI pills are not pre-distributed to households, although the general public can obtain them from pharmacies at any time.

The decision to implement the administration of KI would be taken by the Chief Medical Officer of Health for Ontario. The directive to obtain and ingest would then be issued through the Provincial Emergency Operations Centre’s emergency bulletin and emergency information systems.

7.3.1.6 Summary – Ontario

- Ontario has a comprehensive and up-to-date nuclear emergency response plan.
- Ontario’s PNERP is well integrated with NPP emergency plans.
- Ontario has set the most stringent requirements for public alerting among the provinces with NPPs.
- The requirements for indoor public alerting in Durham region are not being met. In addition, the implementation of the new 10 km public alerting requirement has just recently begun.
- Ontario has a Nuclear Emergency Management Coordinating Committee (NEMCC) comprising all municipal/regional, provincial and federal stakeholders. This forum provides an opportunity to discuss issues pertaining to the nuclear emergency management on a quarterly basis.
- The last full-scale nuclear exercise in Ontario was in 2007.

- Ontario is the only province in which KI pills are not pre-distributed to households in the designated planning zones.
- PNERP planning is based on a single-unit accident and does not explicitly consider multi-unit accidents.

7.3.2 Quebec

In the Province of Quebec, the *Plan national de sécurité civile du Québec* [32], in accordance with the Quebec provincial *Loi sur la sécurité civile* [33], provides the terms of reference for all emergencies. The Organisation de la sécurité civile du Québec (OSCQ) is responsible for emergency planning and the government response to all hazards.

The provincial nuclear emergency plan, *Plan des mesures d'urgence nucléaire externe à la centrale nucléaire Gentilly-2* (PMUNE-G2), addresses the specifics of planning and response for a nuclear emergency.

The last full-scale nuclear exercise in Quebec was in 2005.

7.3.2.1 Plans

The provincial PMUNE-G2 addresses the specifics of planning and response for a nuclear emergency. It is composed of a master plan (plan directeur) and sub-plans (lignes directrices).

The PMUNE-G2 defines the government ministries and agencies that have responsibilities in a nuclear emergency at the Gentilly-2 NPP. It describes the objectives of minimizing the consequences, protecting the public and providing support to the municipalities. At the regional level, the Direction générale de la sécurité civile et de la sécurité incendie is responsible for preparing and maintaining the PMUNE-G2. The coordination for the health portfolio is carried out by the Agence de la santé et des services sociaux de la Mauricie et du Centre-du-Québec. Its mission is to offer the necessary health services to protect the lives and the health of individuals who are facing the crisis.

Under the PMUNE-G2, the OSCQ would open the government operations centre in Québec City to coordinate the actions of the various government organizations in the province to maintain a link with the federal departments and agencies. A regional response centre located in Trois-Rivières would be open by the Organisation régionale de sécurité civile (ORSC) to coordinate local responses and provide support to the affected municipalities.

The original PMUNE-G2 master plan was released in 1996. A revision process was started in 2005. A revised plan is under review and expected to be formally approved by the end of 2011.

7.3.2.2 Planning zones

The planning zones used by the Province of Quebec are each generically described as being a certain radial distance from the NPP, but in practice they are defined in a geographically logical manner. The planning zones defined by the provincial plan (PMUNE-G2) are as follows:

- **Plume exposure planning zone** (Zone de planification d'urgence pour l'exposition au panache: ZPU-P) is an area around the NPP where the emphasis is on exposure control measures (nominally 8 km). The approximate population in the G2 ZPU-P is 10,000.
- **Ingestion planning zone** (Zone de planification d'urgence pour l'exposition par ingestion: ZPU-I) is an area around the NPP where the emphasis is on the ingestion control measures (nominally 70 km).

7.3.2.3 Accident/event assessment

The ORSC has the capability to run plume modelling through software and predict the offsite effects. As per the PMUNE-G2, the ORSC recommends the protective actions for the public and the environment.

These calculations and recommendations are done by the ORSC's radiological risk assessment team (or Équipe d'evaluation du risque radiologique) in the ORSC headquarters in Trois-Rivières. They use real-time plant measurements to predict the offsite effects.

7.3.2.4 Public alerting

Public alerting is the responsibility of the municipalities. The municipalities perform alerts by organizing first responders to go door to door and by issuing media notifications. There is no provincially mandated time requirement, although the PMUNE-G2 indicates it should be done as quickly as possible.

The Municipality of Bécancour, with assistance from Hydro-Québec, is investigating the use of an automated system to alert the residents living in the 8 km zone.

7.3.2.5 Protective measures

The PMUNE-G2 lists exposure control measures, such as evacuation, sheltering, and thyroid blocking (KI pills), to protect the public against external irradiation and inhalation of radioactive material. The PMUNE-G2 also addresses ingestion control measures, such as protecting the food chain from radioactive material and preventing the ingestion of contaminated food and water. As per the *Loi sur la sécurité civile*, it is the responsibility of the municipalities of Quebec to develop and maintain a plan which contains protective measures to take when faced with an emergency.

In particular, stable iodine tablets (KI) are pre-distributed to the residents within the plume exposure planning zone (8 km), and a comprehensive public information program for KI and other protective measures is in place. In addition, KI pills are stocked in locations such as daycare centres, schools and provincial and municipal centres. The decision to recommend the use of tablets by the population is made by the Regional Director of public health. The provincial Service Québec department and the municipalities are responsible for retransmitting this directive to the public through first responders (police, firefighters) and the media (radio, TV).

7.3.2.6 Summary – Quebec

- Quebec has a comprehensive nuclear emergency response plan. A revision is expected to be approved later this year.
- The planning basis adopted by Quebec is in depth and recent.
- Quebec's PMUNE-G2 is well integrated with Hydro-Québec-G2's emergency plan.
- There is no provincially set requirement for public alerting in Quebec.
- Currently, the municipality of Bécancour relies on using first responders going door to door and on issuing notifications through the media to alert the public. The municipality is investigating use of an automated system.
- The last full-scale nuclear exercise in Quebec was in 2005.

7.3.3 New Brunswick

The primary agencies for emergency management and public security in the Province of New Brunswick are the New Brunswick Emergency Measures Organization (NB EMO) and the New Brunswick Security and Emergencies Directorate (NB SED). NB EMO is the provincial lead agency for emergency management and business continuity, including radiological and nuclear emergencies. The NB SED is the provincial lead agency for security and the protection of critical infrastructure. These two agencies consolidate their efforts under the mandate of the New Brunswick Department of Public Safety.

The last full-scale nuclear exercise in New Brunswick was held in 2006.

7.3.3.1 Plans

Under the provincial *Emergency Measures Act* [34], NB EMO has the lead responsibility for developing provincial emergency plans and coordinating all aspects of an emergency. The *New Brunswick Point Lepreau Nuclear Off-site Emergency Plan*, [35] *Volume 1 Policy* and *Volume II Procedures* are in draft form and meant to be regularly updated.

The plan defines specific responsibilities of the Department of Public Safety and the supporting roles of some 20 organizations. Representatives from these organizations make up the Provincial Emergency Action Committee (PEAC) which directs, controls and coordinates emergency operations, as well as assisting and supporting municipalities as required.

7.3.3.2 Planning zones

The New Brunswick Nuclear Emergency Plan uses a nominal 20 km zone for planning purposes. The approximate population in the zone is 3,000.

Of note, NB Power at Point Lepreau uses three planning zones. NB EMO has indicated that the provincial plans will incorporate these zones shortly. These zones are described as:

- Precautionary protective action zone (4 km)
- Urgent protective action zone (12 km)
- Long-term protective action zone (20 km)

7.3.3.3 Accident/event assessment

Currently, NB EMO does not have a capability to run plume and dose modelling to predict the offsite effects making it difficult to make proactive rather than reactive decisions on protective measures. However, there is a provision for the province to consider pre-emptive, planned evacuation (before the situation deteriorates) in scenarios of fuel damage, potential fuel damage or plant instability. However, this provision depends on the qualitative assessment of NB Power. Following a release, NB EMO would use radiation survey data collected by NB Power to decide on protective measures such as sheltering, evacuation or KI.

7.3.3.4 Public alerting

A telephone-based, auto-dial system is used for alerting the public in the 20 km zone. Members of the public can opt to be texted or have their cell or home phones dialled. The system also notifies all businesses and institutions, such as schools, within the emergency planning zone. A provincial

warden service is also used to provide assistance in the event of a nuclear incident at the NPP, and could be used for door-to-door alerting.

7.3.3.5 Protective measures

The NB plan lists exposure control measures to protect against external irradiation and inhalation of radioactive material. Measures include evacuation, sheltering, thyroid blocking (KI pills). The plan also addresses ingestion control measures, such as protecting the food chain from radioactive material and preventing the ingestion of contaminated food and water.

Under the NB plan, KI pills are pre-distributed to all the residences within the 20 km zone. The pills are also stocked at other locations such as long-term health facilities, hospitals and RCMP posts. The Department of Heath and Wellness, in consultation with the PEAC, makes decisions on recommending administration of the KI pills to the public. Notification to the public is carried out by the NB EMO community notification system and followed by wardens, media or public safety announcements and Web bulletins.

7.3.3.6 Summary – New Brunswick

- NB has a basic provincial plan in draft form. An update is in progress and is expected to be published in the fall of 2011.
- Point Lepreau NPP and NB EMO plans are integrated, but there appears to be a disconnect relating to emergency planning zones (4, 12, 20 km).
- NB has no event assessment/modelling capability.
- There is no provincially set requirement for public alerting in New Brunswick.
- An effective automated public alerting system is in place, with backup plans using area wardens.
- The last full-scale nuclear exercise in New Brunswick was held in 2006.

7.4 International stakeholders

7.4.1 Bordering states

U.S. states and Canadian provinces that share borders have mechanisms in place to communicate and work together in the event of any emergency affecting the population on both sides of the border. The states have direct links to liaise and communicate with the provinces. In case of a nuclear emergency, protocols are in place to exchange information between them.

Public Safety Canada (formerly Emergency Preparedness Canada) has signed a memorandum of understanding with the U.S. Federal Emergency Management Agency. Under the umbrella of the *Agreement Between the Government of Canada and the Government of the United States of America on Cooperation in Comprehensive Civil Emergency Planning and Management*, the Canada–United States Joint Radiological Emergency Response Plan was established in 1996. The plan establishes the basis for cooperative measures to effectively deal with a potential or actual peacetime radiological event involving Canada, the United States, or both countries. It is designed to alert the appropriate federal authorities within each country of the existence of a threat from a potential or actual radiological event in order to facilitate cooperation between organizations of the federal government of each country in providing support to states and provinces affected by the radiological event.

7.4.2 International Atomic Energy Agency

Canada is a signatory of the IAEA's *Convention on Early Notification of a Nuclear Accident* (1986), which establishes a notification system for nuclear accidents that have the potential for international trans-boundary release that could be of radiological safety significance for another country. The accident's time, location, radiation releases, and other data essential for assessing the situation must be reported, both directly to the IAEA and to other countries either directly or through the IAEA.

Canada is also a signatory of the IAEA's *Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency* (1986), which sets out an international framework for cooperation between countries and with the IAEA to facilitate prompt assistance and support in the event of nuclear accidents or radiological emergencies. It requires countries to notify the IAEA of their available experts, equipment, or other materials they could offer in assistance. In case of a request for assistance from an affected country, each country decides whether it can offer the requested assistance. The IAEA, in particular the Incident and Emergency Centre, serves as the focal point for such cooperation by channelling information, supporting efforts, and providing its available services.

Protocols and plans are in place to ensure that the CNSC will be in close communication with the IAEA for any domestic nuclear emergency.

7.4.3 International regulators

During international and domestic nuclear emergencies, the CNSC will need to be in direct or indirect communication with the international regulators.

7.4.3.1 United States Nuclear Regulatory Commission

There is a memorandum of understanding (MoU) between the United States Nuclear Regulatory Commission (U.S. NRC) and the CNSC. As per this MoU, the two sister organizations agree to exchange information. During the Fukushima nuclear emergency, exchange of information between the U.S. NRC and CNSC was very useful.

7.4.3.2 Regulators regulating CANDU reactors

As per the lessons learned from Fukushima Daiichi nuclear emergency, any domestic or international emergency involving CANDU reactors will require the CNSC to communicate with the international regulators regulating the CANDU reactors. Canada chairs the annual CANDU Senior Regulators' Meeting, facilitated by the IAEA and attended by high-ranking regulatory staff in all countries with CANDU reactors. Specific MoUs are in place with most of these regulatory agencies.

7.4.4 Summary – international stakeholders

- The CNSC has MoUs in place with most international stakeholders.
- U.S. states and Canadian provinces have arrangements in place for emergencies.
- The United States and Canada have an arrangement in place specifically for nuclear emergencies.

7.5 Review findings for nuclear emergency management in Canada

The CNSC Task Force has verified that there are no significant gaps in nuclear emergency planning at the provincial and federal levels. Although some opportunities for improvement were identified, overall each province has developed well-documented emergency plans, and these plans and their elements are well integrated in the NPP's onsite emergency plans. At the federal level, Health Canada's FNEP is a mature and comprehensive plan, but it has not been kept up to date. In addition, Public Safety Canada's FERP does not explicitly integrate the FNEP in the overall federal emergency planning and preparedness scheme.

Review findings concerning the CNSC:

1. The *Class I Nuclear Facilities Regulations* do not currently require submission of offsite emergency plans with an NPP operating licence application. Whereas an NPP licensee's onsite emergency plans are submitted to the CNSC as part of the licence application and renewal process, there is no formal requirement for the offsite plans to be submitted to the CNSC.
2. The memoranda of understanding with regulatory counterparts in countries with CANDU reactors have not been reviewed to identify what support, if any, they would require from the CNSC during a nuclear emergency.

Review findings concerning multiple or other jurisdictions:

3. Federal and provincial nuclear emergency planning authorities are not making regularly planned full-scale NPP-focused exercises a priority. It was generally observed at the provincial and federal level that there has been a reduction in the frequency of full-scale NPP-focused exercises. Although all provincial and federal plans reviewed appear to be satisfactory, the implementation, and thus the capability to respond, has generally not been tested in an exercise for several years.
4. Federal and provincial nuclear emergency planning authorities do not fully address recovery phase guidelines and procedures in their emergency plans, as they primarily address only preparedness and response.
5. Federal and provincial nuclear emergency planning authorities have not yet undertaken a formal lessons-learned process to gain knowledge from offsite management of the Fukushima nuclear emergency and update plans accordingly.
6. There is no formal, transparent, national-level oversight process for offsite nuclear emergency plans, programs and performance. Whereas NPP licensees' onsite emergency plans, programs and performance are included in the CNSC regulatory oversight process, there is no similar system of oversight for offsite emergency plans.
7. There is no established national guidance or standard for offsite nuclear emergency planning. Whereas NPP licensees are provided with CNSC guidance on emergency planning, there is no Canadian guidance for offsite nuclear emergency plans.
8. The Health Canada Federal Nuclear Emergency Plan (FNEP) has not been updated since 2002 and is not formally integrated with the Public Safety Canada Federal Emergency Response Plan (FERP). The FNEP and FERP integration has not been validated in a full-scale, NPP-focused exercise.
9. The Province of Ontario planning basis for the current nuclear emergency plans and offsite arrangements is a single-unit accident scenario and does not explicitly consider a multi-unit accident scenario.
10. There are ongoing public alerting issues in the 3 km zone around the Pickering NPP. Also, the new 10 km public alerting requirement has not been fully implemented.
11. The potassium iodide (KI) pills for residents of the planning zone in Ontario are stocked at local pharmacies in the Durham region or the reception centre in Kincardine. The effectiveness of this approach, as opposed to pre-distribution to all households, has not been confirmed.
12. There is no automated public alerting system around the Gentilly-2 NPP.

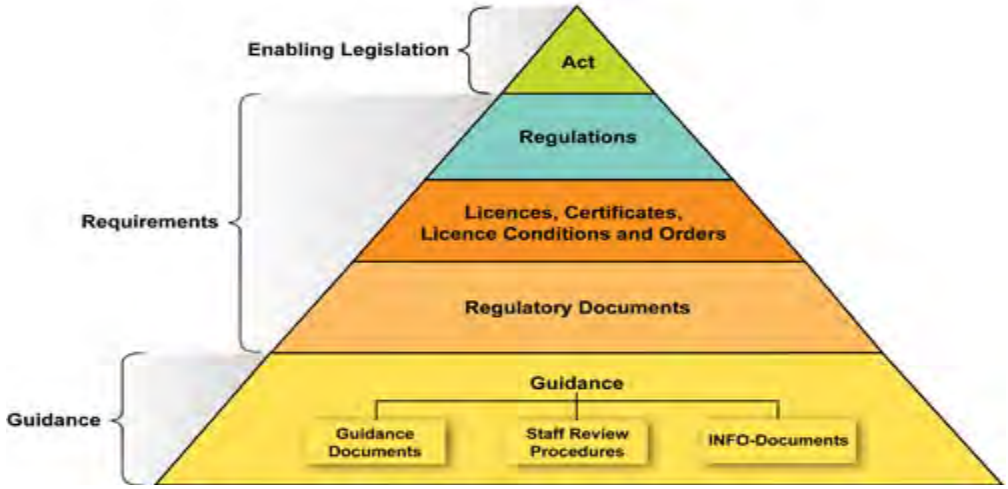
13. The Province of Quebec has not recently updated its nuclear emergency plan.
14. The Province of New Brunswick does not have the capability for predicting offsite effects.
15. The Province of New Brunswick has not recently updated its nuclear emergency plan.

8 The CNSC Regulatory Framework and Processes

The CNSC Task Force has undertaken a preliminary review of the regulatory framework for existing and potential new build NPPs in Canada. The *Nuclear Power Plant Safety Review Criteria* generally exceed the applicable requirements and expectations of the current CNSC regulatory framework. The CNSC Task Force review findings in this section relate exclusively to the lessons learned from the Fukushima accident.

The CNSC regulatory framework consists of a series of requirements and guidance and is illustrated in figure 8.1. Requirements are set out in legislation, regulations, licences and regulatory documents. Guidance on how applicants and licensees can meet regulatory requirements is provided in guidance documents. Info-documents provide more general information on the regulatory regime and processes for the broader public.

Figure 8.1 Elements of the Regulatory Framework



8.1 Act and regulations

The legislation consists of the *Nuclear Safety and Control Act* (NSCA) [36] and its Regulations. These have been reviewed. The NSCA is a robust piece of enabling legislation that sets out the legal framework for regulating the Canadian nuclear industry. All persons wishing to carry out nuclear related activities in Canada are required, by law, to have a licence from the Commission. The Commission is also authorized to make regulations.

Class I nuclear facilities are defined in the *Class I Nuclear Facilities Regulations* [37] and, in addition to NPPs, cover facilities such as small reactors, fuel processing plants and nuclear waste facilities. The CNSC Task Force finds that consideration should be given to modifying the *Class I Nuclear Facilities Regulations* to require submission of offsite emergency plans with an application for a licence to construct or to operate a NPP.

A Commission Member Document (CMD) on *Implementation of Periodic Safety Reviews for Licensing of Nuclear Power Plants* is being prepared. This seeks the Commission's approval to incorporate the periodic safety review (PSR) approach by developing a regulatory document that will be implemented by introducing a licence condition when each power reactor operating licence (PROL) is next renewed. A PSR consists of a systematic and comprehensive comparison against modern standards and technological developments that assures continued plant safety and viability of the licensing basis. In view of the importance of periodically reviewing plant safety against modern standards, the CNSC Task Force finds that consideration should be given to introducing the requirement to perform a PSR in the *Class I Nuclear Facilities Regulations*.

Other regulations made under the NSCA that apply to NPPs include the *General Nuclear Safety and Control Regulations* [9] and the *Radiation Protection Regulations* [38]. No changes to the *General Nuclear Safety and Control Regulations* have been identified as a result of this review. However, the CNSC Task Force finds that section 15 of the *Radiation Protection Regulations* should be reviewed for potential revisions to ensure consistency with international guidance.

Overall, the CNSC Task Force finds that the Act and Regulations are sound. This finding is consistent with a finding by the IAEA International Regulatory Review Service mission to Canada in 2009 [39], that stated "The Canadian legislative and regulatory framework is comprehensive, with an appropriate range of instruments allowing for an effective application of the legal regime."

8.2 Licences, licence conditions and orders

The NSCA authorizes the Commission to establish classes of licences and, therefore, the CNSC has the authority and flexibility to rapidly amend licences to impose additional requirements in order to continuously improve the safety performance of the nuclear industry. This is regarded as a strength of the Canadian system.

The licences that apply to NPPs are power reactor operating licences (PROLs). The CNSC is currently in the process of revising the format of the PROLs to more comprehensively cover the safety and control areas that describe how the NPPs are operated safely. The CNSC is also revising the content of the PROLs to minimize the number of administrative amendments. In parallel with this, each PROL is to be supported by a licence condition handbook (LCH) that describes the compliance verification criteria that will be used to confirm safe operation. Generic templates for both the PROL and NPP LCH have been approved for use.

The CNSC Task Force has reviewed the PROL and NPP LCH templates and finds that some additional requirements and compliance verification criteria should be inserted when the documents are next revised. The licences could be converted to the new format either when they are next renewed, which will take until October 30, 2014, for all licensees. Alternatively, all PROLs could be amended simultaneously when the handbooks are revised and subsequently approved. Given that the industry is already moving to implement the programs needed to meet the new requirements and, given the considerable effort that is required to prepare or revise the LCH for each PROL, the CNSC Task Force finds that the PROLs and LCHs should be amended to the new format when the licences are next renewed.

The CNSC Task Force finds that two new safety requirements should be added to the PROL template. The first is a requirement that the licensees implement and maintain an accident management program. The second is a requirement that the licensees implement and maintain a severe accident management program. The CNSC Task Force also finds that a new licence condition should be added that requires the licensee to implement and maintain a public information program that includes a

proactive disclosure protocol. Similar additions should be made to the NPP LCH template to include compliance verification criteria for the same.

The CNSC Task Force has considered the need for an order to be issued to the industry to implement lessons learned from the Fukushima event. Given that the industry has responded appropriately and voluntarily and is implementing various improvements, the CNSC Task Force finds that no order is required. Instead, CNSC staff will perform regulatory oversight of licensee actions, as per established processes, and verify compliance with the evolving regulatory requirements.

8.3 Regulatory and guidance documents

The CNSC Task Force has reviewed the regulatory and guidance documents published by the CNSC that are referenced in the PROL or LCH.

Specific review findings related to the CNSC regulatory documents by the CNSC Task Force are given in the supporting document on the CNSC regulatory framework [40]. This document should be used by the CNSC Regulatory Framework Steering Committee in prioritizing document reviews and by the document review teams in revising specific regulatory documents.

The overall finding is that there is no overall need for the regulatory framework to be revisited in order to identify the minimum, necessary and sufficient number of regulatory and guidance documents (RDs and GDs) to support the power reactor regulatory program. Should the framework be revisited by the Regulatory Framework Steering Committee in the future, the Task Force finds that the PROL and NPP templates should be used as the basis for identifying needs for RDs or GDs. The PROLs and LCHs currently contain some regulatory requirements or expectations that are not found in RDs or GDs; when the framework is revised, the opportunity should be taken to remedy this.

The CNSC Task Force finds that certain documents should be updated. Examples include RD-337, *Design of New Nuclear Power Plants*; RD-310, *Safety Analysis for Nuclear Power Plants*; S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*; G-306, *Severe Accident Management Programs for Nuclear Reactors*; G-225, *Emergency Planning at Class I Nuclear Facilities and Uranium Mines and Mills*; and RD-353, *Testing the Implementation of Emergency Measures*. Other regulatory documents should be updated during their next scheduled revision.

The CNSC Task Force finds that the Commission should approve for publication RD-99.3, *Requirements for Public Information and Disclosure* [41] and GD-99.3, *Guide to the Requirements for Public Information and Disclosure*. GD-99.3 will supersede G-217, *Licensee Public Information Programs* [42], while RD-99.3 will detail the requirements for public information programs and public disclosure as part of that program. The information to be disclosed under these documents includes the impact of natural events such as earthquakes, routine and non-routine releases of radiological and hazardous materials to the environment and unplanned events, including those exceeding regulatory limits. This therefore covers severe accidents such as Fukushima.

In recent years, as some of the older reactors approach the end of their designed life, licensees have applied for life extension for their NPPs. As a prerequisite to the life extension, licensees are required by RD-360, *Life Extension of Nuclear Power Plants* [43] to conduct an integrated safety review[31] (ISR). As part of the ISR, licensees perform a review of NPPs against modern standards and

[31] An integrated safety review is effectively a single application of a periodic safety review as described in IAEA safety guide NS-G-2.10, *Periodic Safety Review of Nuclear Power Plants.*

practices. Identified gaps are reviewed and practicable upgrades are incorporated into the integrated improvement plan. Licensees are expected to fill the gaps as far as reasonably practicable.

The ISR provides an opportunity to re-evaluate the entire safety case for an NPP. The CNSC Task Force considers that such reviews should be done on a regular basis by means of periodic safety reviews. A 10-year frequency, in line with international practice, is judged reasonable and could be integrated into the licensing process.

8.4 Other parts of the regulatory framework

This review addresses other requirements or expectations contained in the PROLs and LCHs, principally standards issued by the Canadian Standards Association or requirements or guides issued by the International Atomic Energy Agency. Time has not permitted a review of these other standards, but the CNSC Task Force finds that they should be examined in due course, once the changes needed to the other elements of the regulatory framework have been identified.

8.5 Compliance

A primary activity of CNSC staff is to verify compliance by licensees with regulatory requirements. CNSC staff conduct inspections, reviews, performance assessments and event follow-up to verify compliance. The CNSC Task Force finds that CNSC staff should review the compliance program for needed improvements once the identified changes to the regulatory framework have been implemented. This review will include, but not be limited to, updating the baseline compliance program, under which satisfactory performance of all safety and control areas is verified on a regular basis. In particular, enhanced focus on the following areas is anticipated:

- licensees' accident management programs and provisions, as discussed under section 8.2, including station accident manuals and procedures
- "operational" aspects of nuclear safety, to maintain regulatory overview of the design capabilities to provide fundamental safety functions such as control of fission reaction, cooling of fuel (including in the irradiated fuel bays) and confinement of radioactivity
- holistic evaluation of the overall station safety case against modern standards and best practices

8.6 Processes

In parallel with the review findings aimed at improvements to the various parts of the regulatory framework, the processes for licensing and compliance should also be revisited.

In the broader scope, it may be useful for the environmental assessment process to include consideration of severe accidents, should this be regarded as responsive to public concerns.

8.7 Review findings for the regulatory framework and processes

The CNSC Task Force has performed a review of the CNSC regulatory framework and processes. The review included the *Nuclear Safety and Control Act* and associated Regulations, the CNSC's regulatory documents, power reactor operating licences and their licence condition handbooks, and key regulatory processes. The CNSC Task Force finds that the NSCA does not need revision and there is no need to revisit the structure of the regulatory framework as a result of the lessons learned

from the Fukushima Daiichi accident. The Canadian regulatory framework is strong and comprehensive and is effectively applied even in the case of severe accidents.

Key review findings related to improving the CNSC regulatory framework are:

1. The *Class I Nuclear Facilities Regulations* do not have explicit requirements for submission of offsite emergency plans.
2. The *Radiation Protection Regulations* are not fully consistent with international guidance and do not fully describe the regulatory requirements needed to address radiological hazards during the various phases of an emergency.
3. Canada does not have a formal periodic safety review process. As demonstrated by international practice, regulatory oversight of nuclear power plants may be further enhanced through implementation of a periodic safety review process.
4. Existing licence conditions in power reactor operating licences do not explicitly address accident management, severe accident management and public information.
5. RD-99.3, *Requirements for Public Information and Disclosure*, and its guide, GD-99.3, *Guide to the Requirements for Public Information and Disclosure*, have not been approved for publication, leaving a potential gap in regulatory requirements and guidance for licensees' public information programs.
6. The three-year regulatory framework plan does not currently accommodate the CNSC Task Force review findings.
7. A small number of regulatory documents (RDs) or guidance documents (GDs) are lacking requirements or guidance needed to address the lessons learned.
8. The lessons learned are not yet fully considered for the next revision of other NPP-related RDs or GDs.
9. The lessons learned are not yet fully considered as part of the preparation of new RDs or GDs.
10. Canadian Standards Association standards that apply to NPPs have not been reviewed by the CNSC staff as a result of lessons learned.

The key review finding for the CNSC-managed processes is:

11. Licence condition handbooks are lacking requirements and guidance needed to address lessons learned.

9 Implications for New Builds

Section 8 provides an overall assessment of the CNSC's processes related to the licensing and compliance of nuclear facilities and gives related review findings. This section considers more specific review findings related to the design and analysis of new NPPs and related factors. The lessons learned presented in this section are preliminary and are drawn largely from the assessments performed either by, or on behalf of, the CNSC Task Force for existing reactors (i.e., CANDU technology). In preparation for a formal update to RD-337, *Design of New Nuclear Power Plants*, CNSC staff are undertaking a more comprehensive review of the technology-neutral requirements for new builds. As part of this review, CNSC staff will take into account all lessons learned to date from Fukushima to revise RD-337.

Below, the CNSC Task Force identifies overall review findings. These are followed by specific findings for staff follow-up on particular aspects of design and analysis.

The overall finding is that, to date, there are no lessons learned from Fukushima that challenge the fundamental approach to reactor safety and regulation (i.e., application of the defence-in-depth approach together with multiple physical barriers) for new NPPs in Canada. Nevertheless, it is

important to learn from all events that occur, especially those that have significant consequences for public safety and the environment. The CNSC will change its requirements for new NPPs in response.

The overall review finding is that, while recognizing that the fundamental approach is sound, CNSC staff should reconsider the detailed requirements for the design and analysis of new NPPs in the light of the events of Fukushima to ensure that these are adequate and consistent with best international practices. Staff can undertake this activity during the formal review of RD-337.

The underlying basis and principles by which reactors are designed and regulated is robust – the "extended" defence-in-depth approach together with the application of multiple barriers to the release of radioactivity and radioactive substances is fundamentally sound. The extended approach requires that the design of new NPPs include specific provisions to reduce the probability and mitigate the consequences of severe accidents. This overall approach is applied in international standards such as those of the IAEA, and in Canada is documented in more detail in RD-337, published in 2008. These regulatory requirements for new NPPs represent modern-day practices. Since the publication of RD-337, the CNSC has been participating in international forums and learning from international experience, as well as contributing to the preparation of new standards. Therefore, the CNSC is in the process of updating RD-337 and developing and writing a sister guide, GD-337.

The Fukushima event highlighted the importance of many aspects related to plant design robustness, severe accident phenomena, the management of severe accidents and more generally emergencies, the need for, and adequacy of, complementary design features, and the robustness of the plant to unexpected circumstances including severe external events. Below are specific review findings by the CNSC Task Force for CNSC staff relating to the design and analysis of new NPPs. Many of these findings address issues identified in section 6 for current NPPs. In the former context they point to the need for consideration of improvements or confirmatory assessment. In this context, they point to the need to consider the issues through suitable regulatory requirements for new builds.

1. The safety goals in RD-337, *Design of New Nuclear Power Plants*, are based on single-unit events. Site-based safety goals or other safety criteria that take into account the site characteristics (including population distribution) and the possibility of multiple-unit accidents are not explicitly considered.
2. Although RD-337 already has explicit requirements for the design of complementary design features consistent with international practice, these may not be complete. In addition, there are no explicit requirements for such features for irradiated fuel bays, including combustible gas management.
3. Whereas the safety goals are likely adequate for the design of individual units, these may not be sufficient for a robust demonstration of the offsite response. A separate, more demanding, release value would result in more challenging evaluations of the offsite response.
4. The Fukushima event highlighted the difficulties that can arise when an NPP relies solely on active engineered systems. The need for specific regulatory requirements for passive safety features has not been assessed.
5. The requirements in RD-337 for the design, placement and engineering robustness of irradiated fuel bays is not complete for the entire spectrum of beyond-design-basis scenarios.
6. The CNSC has not documented an overall, systematic approach to the evaluation of all types of external events that could occur in Canada. A systematic approach would encompass both design-basis events and beyond-design-basis events.
7. The Fukushima event highlighted the need for margins to cliff-edges to be understood, particularly when exceeding such cliff-edges may have catastrophic consequences. CNSC currently has no explicit requirements for the assessment of such margins for new nuclear power plants.

8. The CNSC has no requirements for the analysis of multi-unit accidents, particularly those that could arise from common-cause events.
9. The CNSC requirements for the design that would facilitate accident management and severe accident management are incomplete. For example, there are no explicit provisions for the use of portable equipment and the availability of connections for temporary supplies of electrical power and water.
10. The CNSC does not have explicit requirements for complementary design features that could be called upon to protect the containment. One such feature is filtered containment venting.
11. The CNSC does not have comprehensive requirements for minimum times before significant operator interventions are required. Such requirements would be commensurate with the type of intervention, for example, the need for offsite portable equipment to be brought onsite.
12. Previous accidents have identified the importance of operators having access to reliable plant information. The CNSC currently does not have explicit requirements for "hardened" plant monitoring features and instrumentation that would function reliably under severe accident conditions, and for the control room equipment expected to be available.
13. The CNSC does not have design requirements for automated real-time onsite field radiation monitoring.
14. The CNSC does not have explicit requirements for the emergency heat removal system for beyond-design-basis conditions, including the mission time during which it must be available.
15. The CNSC does not have a full set of requirements for plant and site layout that would facilitate protection against external hazards.
16. CNSC requirements for operational limits and conditions do not integrate into one structure the command and control needs during normal operation, the emergency operating procedures and severe accident management guidelines. Furthermore, there is currently no requirement for further guidance similar to the "extensive damage mitigation guidelines" used in the United States, which can be used when extensive damage has occurred across a site.

10 Conclusions and Recommendations

The CNSC Task Force confirms that the CANDU units are robust and have a strong design relying on multiple layers of defence. The design ensures that there will be no impact on the public from external events that have been regarded as credible during the lifetime of the station. The design also offers protection against external events that have a very low probability of occurring. However, the design basis for certain external events at certain stations may now need to be updated.

The post-Fukushima review has examined events more severe than those that have historically been regarded as credible and their impact on the NPPs. The CNSC Task Force has proposed changes to design or procedures wherever gaps were found in order to minimize or eliminate their impact.

The actions taken by the industry and proposed for the future will ensure that the impact on the public is as low as reasonably practicable for extreme events, so as not to add to the consequences to society beyond those caused directly by the events themselves.

The CNSC Task Force has made a number of detailed review findings that relate exclusively to the lessons learned from the Fukushima accident; all of these findings are listed in sections 6 to 9 of the report. The review findings have been determined through comparison with the *Nuclear Power Plant Safety Review Criteria*. These criteria generally exceed the applicable requirements and expectations of the current CNSC regulatory framework.

Overall, the CNSC Task Force concludes that Canadian NPPs are safe and pose a very small risk to the health and safety of Canadians or to the environment. The CNSC Task Force is confident that the

recommendations in this report will further enhance the safety of nuclear power in Canada and will reduce the associated risk to as low as reasonably practicable.

Under the oversight of the CNSC and its staff, Canadian nuclear power plants have been running safely for over 40 years. As has always been the case, they will only be licensed if the CNSC is satisfied that they will continue to be operated safely.

The CNSC Task Force recommendations below apply to currently operating reactors and must be considered for new builds. The recommendations below are based on the findings given in sections 6 to 9 of the report. Appendix D summarizes how the findings correspond to the recommendations.

10.1 Strengthening reactor defence in depth

1. Licensees should systematically verify the effectiveness of, and supplement where appropriate, the existing plant design capabilities in beyond-design-basis accident conditions, including:
   a) overpressure response of the main systems and components
   b) containment performance to prevent unfiltered releases of radioactive products
   c) control capabilities for hydrogen and other combustible gases:
      i accelerate installation of the hydrogen management capability and sampling provisions
      ii include spent fuel bays and any other areas where hydrogen accumulation cannot be precluded
   d) make-up capabilities for the steam generators, primary heat transport system and connected systems, moderator, shield tank, and spent fuel bays
   e) design requirements for the self-sufficiency of a plant site such as availability and survivability of equipment and instrumentation following a sustained loss of power and capacity to remove heat from a reactor
   f) control facilities[32] for personnel involved in management of the accident
   g) emergency mitigating equipment and resources that could be stored offsite and brought onsite if needed

2. Licensees should conduct more comprehensive assessments of site-specific external hazards to demonstrate that:
   a) considerations of magnitudes of design-basis and beyond-design-basis external hazards are consistent with current best international practices
   b) consequences of events triggered by external hazards are within applicable limits

   Such assessments should be updated periodically to reflect gained knowledge and modern requirements.

3. Licensees should enhance their modelling capabilities and conduct systematic analyses of beyond-design-basis accidents to include analyses of:
   a) multi-unit events
   b) accidents triggered by extreme external events
   c) spent fuel bay accidents

   The analyses should include estimation of releases, into the atmosphere and water, of fission products, aerosols and combustible gases.

[32] Control facilities are the locations where control of the reactor and accident mitigation measures can be undertaken; for example, main control room, secondary control areas and emergency centres.

10.2 Enhancing emergency response

4. Licensees should assess emergency plans to ensure emergency response organizations will be capable of responding effectively in a severe event and/or multi-unit accident, and conduct sufficiently challenging emergency exercises based on them.
5. Licensees should review and update their emergency facilities and equipment, in particular:
   a) ensure operability of primary and backup emergency facilities and of all emergency response equipment that require electrical power and water
   b) formalize all arrangements and agreements for external support and document these in the applicable emergency plans and procedures
   c) verify or develop tools to provide offsite authorities with an estimate of the amount of radioactive material that may be released and the dose consequences, including the installation of automated real-time station boundary radiation monitoring systems with appropriate backup power
6. Federal and provincial nuclear emergency planning authorities should undertake a review of their plans and supporting programs, such as:
   a) ensuring plan revision activities are expedited and making regular full-scale exercises a priority
   b) establishing a formal, transparent, national-level oversight process for offsite nuclear emergency plans, programs and performance
   c) reviewing the planning basis of offsite arrangements in view of multi-unit accident scenarios
   d) reviewing arrangements for protective action including resolving the issues pertaining to public alerting, validating the effectiveness of potassium iodide (KI) pill-stocking and distribution strategies and verifying, or developing the capability for predicting, offsite effects

10.3 Improving regulatory framework and processes

7. The CNSC should initiate a formal process to amend the *Class I Nuclear Facilities Regulations* to require NPP licensees to submit offsite emergency plans with an application to construct or operate a nuclear power plant.
8. The CNSC should amend the *Radiation Protection Regulations* to be more consistent with the current international guidance and to describe in greater detail the regulatory requirements needed to address radiological hazards during the various phases of an emergency.
9. The CNSC should update the regulatory document framework through:
   a) updating selected design-basis and beyond-design-basis requirements and expectations, including those for:
      i external hazards and the associated methodologies for assessment of magnitudes
      ii probabilistic safety goals
      iii complementary design features for both severe accident prevention and mitigation
      iv passive safety features
      v fuel transfer and storage
      vi design features that would facilitate accident management
   b) developing a dedicated regulatory document on accident management
   c) strengthening the suite of emergency preparedness regulatory documents
   d) reviewing applicable Canadian Standards Association standards

10. The CNSC should amend all power reactor operating licences to include specific licence conditions, requiring implementation of accident management provisions, severe accident management and public information.
11. The CNSC should further enhance the regulatory oversight of nuclear power plants through implementation of a periodic safety review process.
12. The CNSC should review memoranda of understanding with regulatory counterparts in countries with CANDU reactors to outline what support, if any, they would require from the CNSC during a nuclear emergency.
13. The CNSC should enhance cooperation with other nuclear regulators in addressing the lessons learned from the Fukushima accident and thus further strengthen the capability to respond efficiently to any nuclear emergency.

Glossary

accident

Any unintended event (including operating errors, equipment failures or other mishaps), the consequences or potential consequences of which are not negligible from the point of view of protection or safety.

For the purposes of this document, accidents include design-basis accidents and beyond-design-basis accidents. Accidents exclude anticipated operational occurrences, which have negligible consequences from the perspective of protection or safety.

anticipated operational occurrence

An operational process deviating from normal operation which is expected to occur at least once during the operating lifetime of a reactor facility but which, in view of the appropriate design provisions, does not cause any significant damage to items important to safety or lead to accident conditions.

beyond-design-basis accident

Accident conditions less frequent and more severe than a design-basis accident. A beyond-design-basis accident may or may not involve core degradation.

Class I nuclear facility

A Class I nuclear facility refers to a Class IA and a Class IB nuclear facility as described in the *Class I Nuclear Facilities Regulations*.

common-cause event

An event that leads to common-cause failures.

common-cause failure

A concurrent failure of two or more structures, systems or components due to a single specific event or cause such as natural phenomena (such as earthquakes, tornadoes or floods), design deficiency, manufacturing flaws, operation and maintenance errors, human-induced destructive events and others.

complementary design feature

A design feature from the design-basis envelope that can be used to cope with beyond-design-basis accidents, including severe accidents.

conservatism

Use of assumptions, based on experience or indirect information, about a phenomenon or behaviour of a system being at or near the limit of expectation, which increases safety margins or makes predictions regarding consequences more severe than if best-estimate assumptions had been made.

containment

A method or physical structure designed to prevent the release of radioactive substances. This term is typically used in power reactors.

core damage

Core degradation resulting from event sequences more severe than design-basis accidents.

core damage frequency

An expression of the likelihood that, given the way a reactor is designed and operated, an accident could cause the fuel in the reactor to be damaged.

crediting

Assuming the correct operation of a structure, system or component or correct operator action, as part of an analysis.

defence in depth

A hierarchical deployment of different levels of diverse equipment and procedures to prevent the escalation of anticipated operational occurrences and to maintain the effectiveness of physical barriers placed between a radiation source or radioactive material and workers, members of the public or the environment, in operational states and, for some barriers, in accident conditions.

design basis

The range of conditions and events taken into account in the design of structures, systems and components of a nuclear facility, according to established criteria, such that the facility can withstand them without exceeding authorized limits by the planned operation of safety systems.

design-basis accident

Accident conditions for which a reactor facility is designed according to established design criteria, and for which damage to the fuel and the release of radioactive material are kept within regulated limits.

deterministic safety analysis

An analysis of reactor facility responses to an event performed using predetermined rules and assumptions (e.g., those concerning the initial facility operational state, availability and performance of the facility systems and operator actions). Deterministic safety analysis can use either conservative or best-estimate methods.

diversity

The presence of two or more redundant systems or components to perform an identified function, where the different systems or components have different attributes so as to reduce the possibility of common-cause failure.

emergency exercise

Simulation of emergency events in order to test the integrated performance of an emergency response scenario.

emergency drill

Testing of a procedure or other specific aspect of an emergency response.

emergency response

The integrated set of infrastructural elements necessary to provide the capability for performing a specified function or task required in order to prevent, mitigate or control the effects of an accidental release.

emergency response organization

Group of inter-related responders whose function is to mitigate the consequences of an emergency. An emergency response organization involves predefined coordination of roles and responsibilities.

external event

Any event that proceeds from the environment external to a reactor facility and that can cause failure of structures, systems and/or components. External events include, but are not limited to, earthquakes, floods and hurricanes.

external hazard

An event of natural or human-induced origin that originates outside the site and whose effects on the reactor facility should be considered as potentially hazardous.

fail-safe design

Design whose most probable failure modes do not result in a reduction of safety.

heat sink

A system or component that provides a path for heat transfer from a source, such as heat generated in the fuel, to a large heat-absorbing medium, such as water.

independent system

A system whose ability to perform its required function is unaffected by the operation or failure of another system.

internal event

An event internal to the reactor facility that results from human error or failure in a structure, system or component.

malevolent act

An illegal action or an action that is committed with the intent of causing wrongful harm.

mission time

The duration within which a system or component is required to operate or be available to operate and fulfill its function following an event.

mitigation

Measures aimed at limiting the scale of core damage, preventing interaction of the molten material with containment structures, maintaining containment integrity, and minimizing offsite releases, in the event of an accident.

normal operation

Operation of a reactor facility within specified operational limits and conditions including startup, power operation, shutdown, maintenance, testing and refuelling.

postulated initiating event

An event identified in the design (e.g., of a reactor) as leading to either an anticipated operational occurrence or accident conditions. This means that a postulated initiating event is not necessarily an accident itself; rather it is the event that initiates a sequence that may lead to an anticipated operational occurrence, a design-basis accident, or a beyond-design-basis accident, depending on the additional failures that occur.

practicable

Technically feasible and justifiable while taking cost-benefit considerations into account.

pressure boundary

A boundary of any pressure-retaining vessel, system or component of a nuclear or non-nuclear system.

prevention

In the context of severe accident management, measures aimed at averting or delaying the onset of a severe accident.

probabilistic safety assessment (PSA)

A comprehensive and integrated assessment of the safety of a reactor facility. The safety assessment considers the probability, progression and consequences of equipment failures or transient conditions to derive numerical estimates that provide a consistent measure of the safety of the reactor facility, as follows:

- A Level 1 PSA identifies and quantifies the sequences of events that may lead to the loss of core structural integrity and massive fuel failures.
- A Level 2 PSA starts from the Level 1 results and analyzes the containment behaviour, evaluates the radionuclides released from the failed fuel and quantifies the releases to the environment.
- A Level 3 PSA starts from the Level 2 results, analyzes the distribution of radionuclides in the environment, and evaluates the resulting effect on public health.

process system

A system whose primary function is to support (or contribute to) the production of steam or electricity.

safety analysis

Analysis by means of appropriate analytical tools that establishes and confirms the design basis for the items important to safety, and ensures that the overall reactor facility design is capable of meeting the acceptance criteria for each reactor state.

safety case

An integrated collection of arguments and evidence to demonstrate the safety of a facility. A safety case will normally include a safety assessment, but could also typically include information (including supporting evidence and reasoning) on the robustness and reliability of the safety assessment and the assumptions made therein.

safety function

A specific purpose that must be accomplished for safety.

safety margin

A margin to a value of safety variable for a barrier or a system at which damage or loss would occur. Safety margins are considered for those systems and barriers whose failure could potentially contribute to radiological releases.

safety system

A system provided to ensure the safe shutdown of a reactor or the residual heat removal from the core, or to limit the consequences of anticipated operational occurrences and design-basis accidents.

severe accident

A beyond-design-basis accident that involves significant core degradation.

severe accident management (SAM) program

A program that establishes both of the following:

1. the actions to be taken to prevent severe damage to the reactor core, to mitigate the consequences of the core damage should it occur, and to achieve a safe, stable state of the reactor over the long term
2. the preparatory measures necessary for implementation of such actions

shutdown state

A subcritical reactor state with a defined margin to prevent a return to criticality without external actions.

structures, systems and components

A general term encompassing all of the elements, except human factors, of a facility or activity that contribute to protection and safety.

Structures are the passive elements, such as buildings, vessels and shielding. A system comprises several components, assembled in such a way as to perform a specific (active) function. Components are the discrete elements of a system, such as wires, transistors, integrated circuits, motors, relays, solenoids, pipes, fittings, pumps, tanks and valves.

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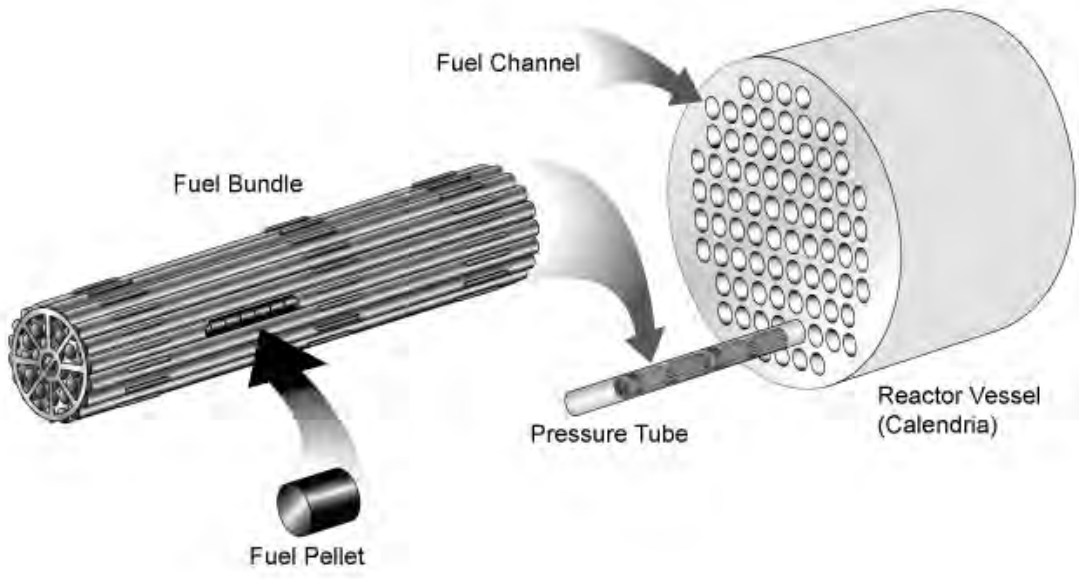
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Appendix A CANDU Overview

All Fukushima Daiichi reactor units are boiling-water reactors (BWRs) designed by General Electric about 40 years ago. A BWR is a light-water reactor (LWR) in which light water[33] serves both as the reactor coolant and the moderator[34]. The fuel is arranged in long vertical assemblies located inside the reactor pressure vessel.

All currently operating Canadian nuclear power plant (NPP) reactor units are CANDU (Canadian Deuterium-Uranium) reactors. The CANDU reactor is a heavy-water moderated, natural uranium fuelled reactor with pressure tubes. The core consists of an array of horizontal pressure tubes located inside a large, horizontally mounted cylindrical vessel, the calandria. The pressure tubes contain the fuel (figure A.1) and coolant. The calandria contains the heavy-water moderator, besides the pressure tubes.

Figure A.1 Arrangement of Fuel Bundles in a CANDU Calandria



Pressurized heavy water coolant is pumped through the pressure tubes, cooling the fuel and carrying heat from the fuel to the outlet header and to the steam generators (figure A.2).

Each pressure tube is isolated and insulated from the heavy water moderator by a concentric calandria tube (figure A.3).

[33] Light water is normal water composed of one oxygen and two hydrogen atoms (H_2O). In heavy water, the hydrogen atoms are replaced by deuterium atoms (D_2O). Deuterium is a heavy isotope of hydrogen with one proton and one neutron in the nucleus, compared to normal hydrogen which has only a single proton.
[34] The moderator in a nuclear reactor is the material used to slow down neutrons emitted in the fission process.

Figure A.2 Simplified Schematic and Location of Major Systems

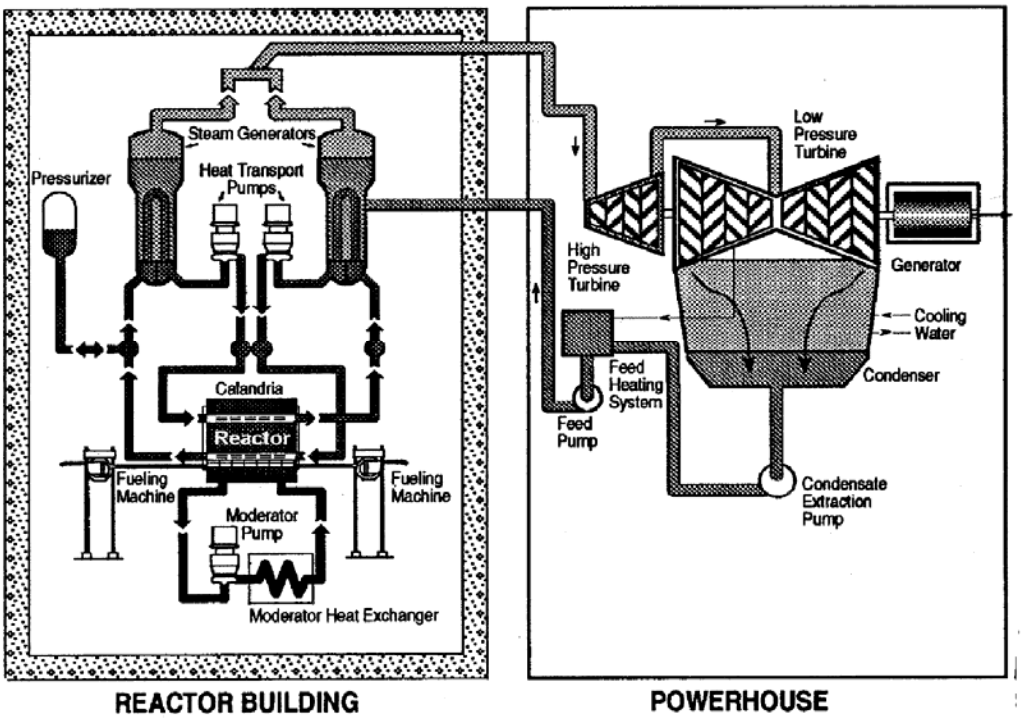
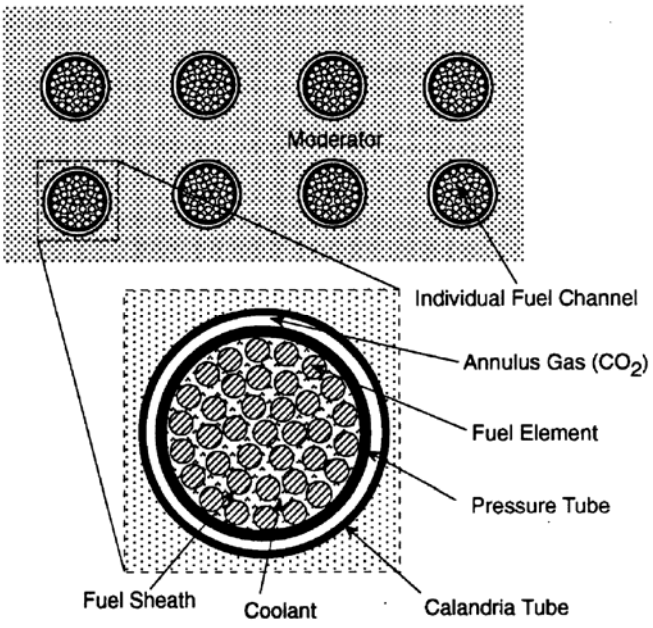


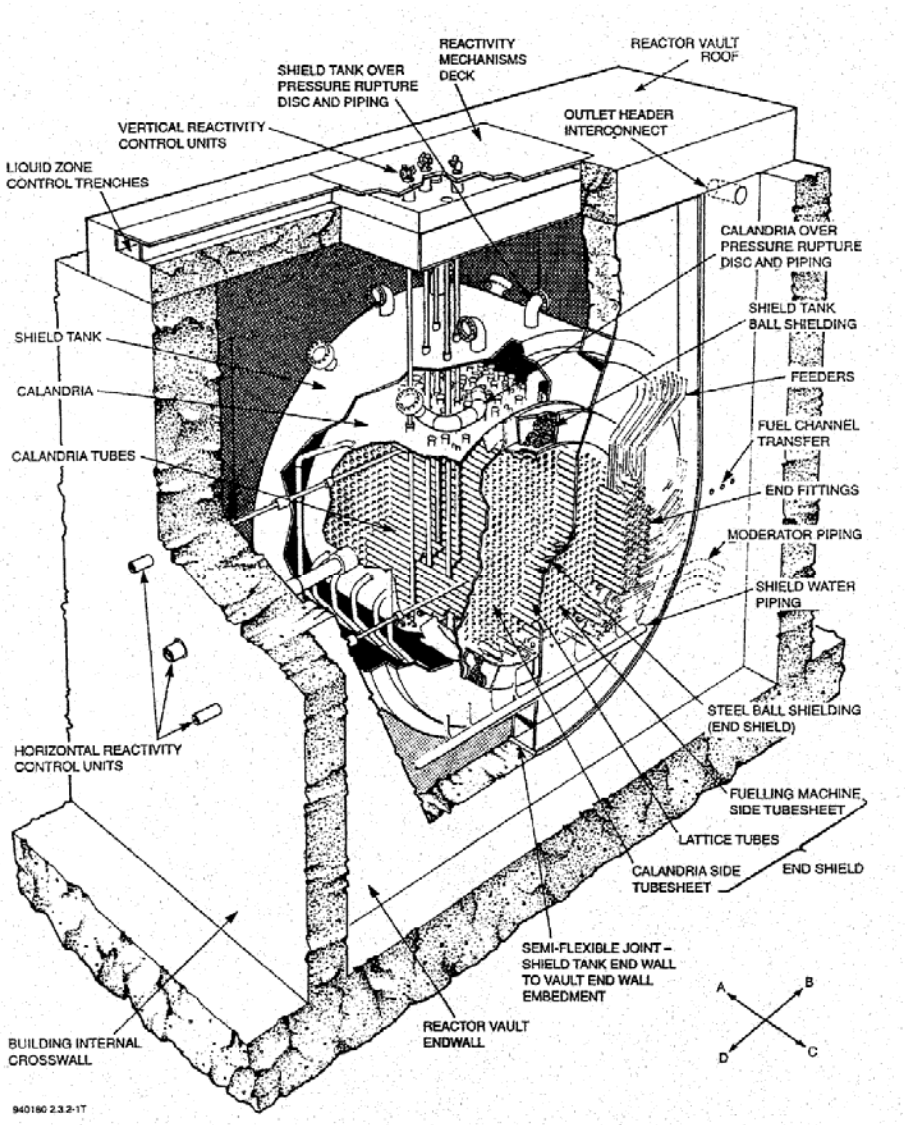
Figure A.3 Arrangement of Fuel Elements, Pressure and Calandria Tubes



The annular space between the pressure and calandria tubes is filled with carbon dioxide gas. In CANDU reactors, the moderator system is separated from the high-temperature, high-pressure

coolant in the pressure tubes. Therefore, the CANDU reactors are based on a pressure-tube design, not on a pressure-vessel design. The pressurized portion of the reactor is limited to the fuel channels, which are of relatively small diameter, while the calandria (figure A.4) operates at nearly atmospheric pressure. Pressure tube leaks can be readily detected by monitoring the moisture content and pressure in the annular, gas-filled space between the pressure tube and calandria tube.

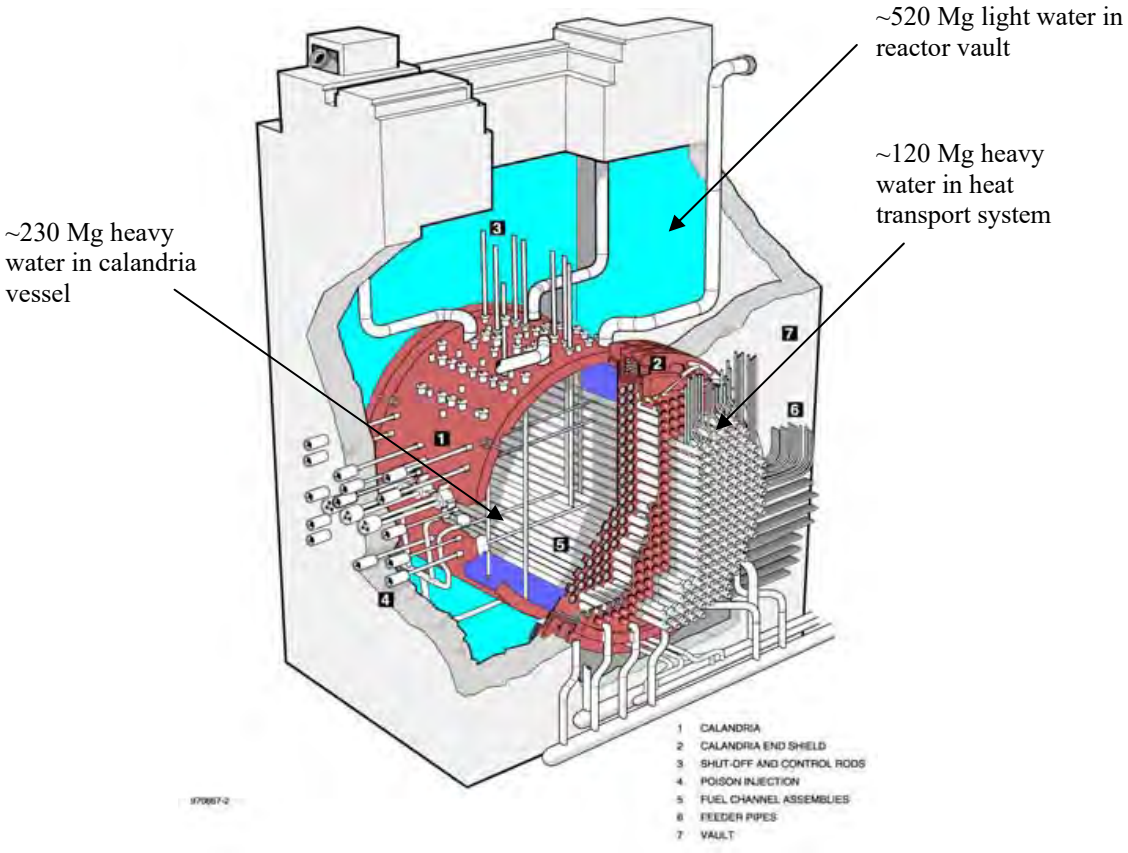
Figure A.4 Calandria Assembly



Due to this physical separation from the coolant, the moderator operates at low temperature (60°–70°C) and low (atmospheric) pressure. This allows the moderator to act as an emergency heat sink capable of removing decay heat even if normal and emergency cooling fail. Also, since the moderator is cool, it cannot add any significant amount of energy to the containment system under accident conditions, such as might occur if a pressure tube ruptured. In CANDU designs, the calandria is surrounded either by a light-water-filled steel shield tank (used for biological and thermal shielding) or by a steel-lined concrete vault called a “calandria” vault. In all stations with calandria vaults, except Pickering A, the vault is filled with light water and can also act as an additional heat sink in

severe accident scenarios. Figure A.5 shows the approximate inventory[35] of heavy and light water in the CANDU 6 reactor, which surrounds the fuel and calandria vessel.

Figure A.5 Schematic of a CANDU 6 Reactor Core



In CANDU designs, the moderator provides a low-pressure environment for the reactivity control devices (such as control rods) located or introduced into guide tubes positioned interstitially between rows of calandria tubes. In addition, the location of neutronics measurement devices in the moderator avoids subjecting this equipment to a hot, pressurized environment.

CANDU reactors incorporate two[36] diverse, fail-safe and passive shutdown systems (Shutdown System No. 1 and Shutdown System No. 2) which are independent of each other and from the reactor regulating system. The first shutdown system consists of shutoff rods which are vertically oriented above the reactor core and are gravity-driven with spring assistance.

The second shutdown system uses high-pressure liquid poison[37] injected into the moderator. Injection is accomplished by opening fast-acting valves between a high-pressure helium tank and the poison tanks. When the valves open, the liquid poison is injected into the reactor moderator through

[35] The inventory is given in megagrams (Mg). 1 Mg = 1 tonne or metric ton.
[36] Pickering A Shutdown System 2 is not based on the liquid poison injection, but on the moderator dump system. Since Pickering A has a moderator dump system, a spray cooling system is provided to cool the calandria tubes.
[37] Liquid poison (usually boron or gadolinium) is a strong absorber of neutrons and quickly stops (or "poisons") the nuclear reaction.

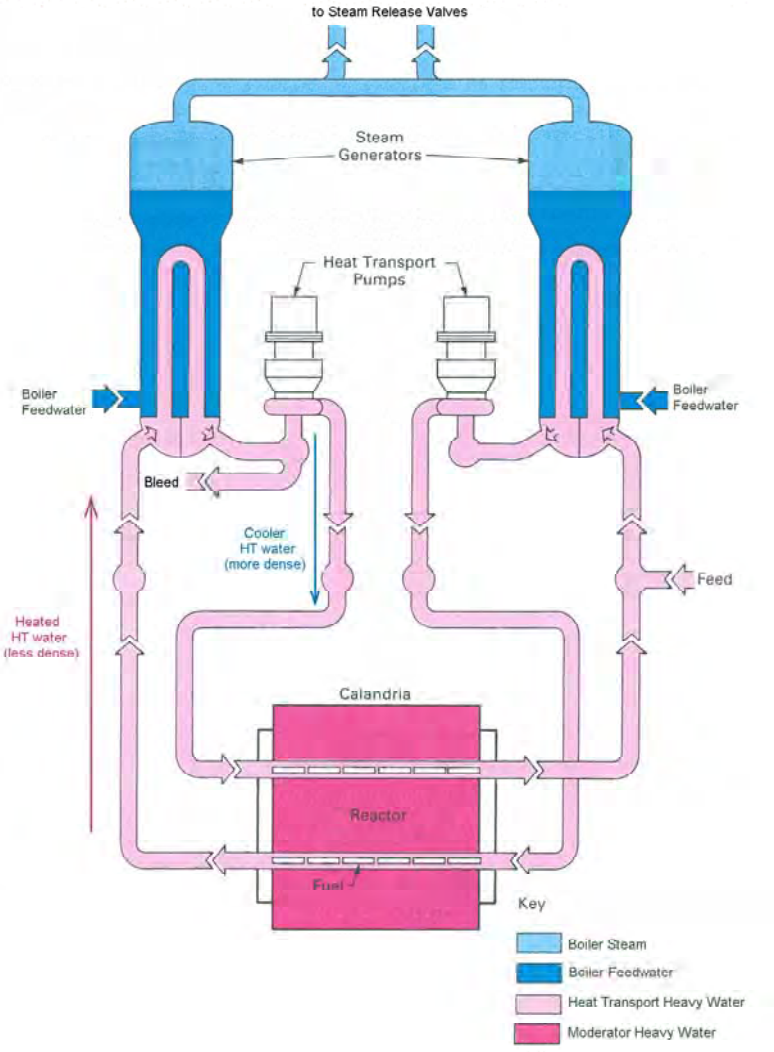
horizontally oriented nozzles that span the core. The nozzles are designed to inject the poison in four different directions in the form of a large number of individual jets. This disperses the poison rapidly throughout a large fraction of the core. Neither Shutdown System No. 1 nor Shutdown System No. 2 requires an electrical trigger. Both shutdown systems are fail-safe – they operate automatically if the electricity is turned off – with the poison being injected by compressed helium and, with the rods, hung above the core with electromagnets, being drawn down by gravity.

Because of the use of natural uranium as fuel, any significant alteration of the CANDU reactor's original fuel channel geometry (e.g., increase or decrease of spacing in the CANDU core's lattice pitch arrangement) decreases the probability of sustaining a chain reaction. In addition, criticality[38] of CANDU fuel bundles in light water is impossible. Since most of the water inside containment is light water, criticality is not a concern in severe accidents.

In CANDU reactors, a large number of horizontal pressure-tube fuel channels are connected by individual feeder pipes to horizontal headers. The headers are connected to pumps and steam generators. The headers and steam generators are located above the core. The positioning of the steam generators above the core promotes natural circulation flow called thermosyphoning (i.e., movement due to the coolant's own density differences), which can remove decay heat if shutdown cooling is lost. Thermosyphoning is illustrated in figure A.6. When electrical power is lost to a heat transport pump motor, the pump continues to spin down under inertia, assisted by a large flywheel integral to the pump. This ensures that flow drops more slowly than power (falling rapidly due to reactor trip) so that fuel is adequately cooled. It also establishes forward flow through the fuel channels initially. As the coolant (heavy water) passes over the fuel in the fuel channels, it is heated and decreases in density. It flows out of the channel and up to the boilers. In the boilers, heat is transferred to the secondary side so the coolant gets cooled and its density increases. It flows back to the fuel channels and "pushes" out the less dense hotter water in the channel. Thus, as with other designs, the CANDU reactors have the capability of passively removing decay heat provided that water can be injected to the boilers and that there is no significant leakage of primary coolant.

[38] A reactor is "critical" when the fission chain reaction is self-sustaining. The number of neutrons created in the core is balanced by the number lost when reactor materials absorb them or when they pass outside the core. When the reactor is "subcritical", the fission chain reaction quickly drops to a very low value.

Figure A.6 Simplified Schematic of Thermosyphoning

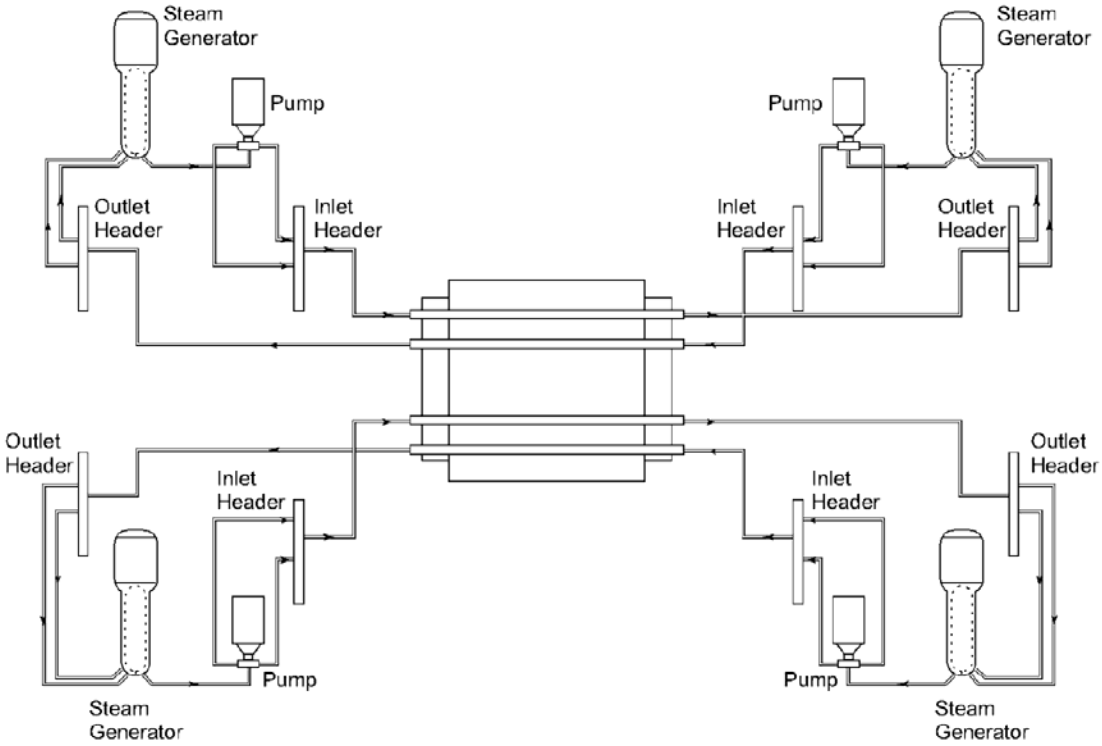


A complete station blackout occurred in a pressurized heavy-water reactor similar to a CANDU (Douglas Point design) in March 1993 at the Narora Atomic Power Station in India. Decay heat removal during the blackout was mainly due to the flow coastdown followed by thermosyphoning. During the accident, caused by a fire in the Turbine Building, the emergency crew was able to manually open the valves allowing injection of fire water to the steam generators. Five hours into the accident, when entry in the primary containment was deemed safe, fire water was connected to the shield cooling system. The reactor was maintained in a safe shutdown condition, with adequate subcriticality for 17 hours, until the shared emergency diesel generator was restarted and normal shutdown cooling was started.

Similarly, during the August 14, 2003, blackout of southern Ontario and the northeastern United States, the fuel in the Pickering B reactors was cooled by thermosyphoning for up to nine hours. According to Ontario Power Generation's (OPG) estimates, thermosyphoning would have continued to be an effective heat sink for many more hours if restoration of offsite power had been delayed.

In most CANDU designs, the subdivision of the reactor core into two loops, each supplying coolant to half the core, provides that in a loss-of-coolant accident (LOCA), the break affects half the core. In addition, there are two core-passes per loop (as shown in figure A.7), which means that only a quarter of the core would likely suffer a major mismatch between heat generation and removal under the LOCA conditions. CANDU reactors have emergency core cooling systems to provide core cooling in the event of a LOCA in one unit. The systems are designed to prevent severe core damage for all break sizes up to the diameter of the largest pipe in the heat transport system.

Figure A.7 Heat Transport System, CANDU 6



With the pressure-tube concept, on-power refuelling becomes possible, since, with an appropriate design, fuel channels can be “opened” individually and at full power to replace some of the fuel. On-power refuelling was therefore adopted for the CANDU design.

A fundamental principle in CANDU reactor design, and a regulatory requirement, is the separation of process systems – the systems for power production – from safety systems. The objective is to reduce the likelihood of common-cause events which could initiate an operating upset and impair the performance of safety systems in accident conditions. In addition to the requirement for the separation of process and safety systems, the systems which perform safety functions are divided into two groups. The two groups are physically separated so that, within the limits of design, no directional or localized common-cause event (such as a tornado) can disable more than one group.

Normal practice in CANDU systems is to triplicate the instrumentation and equipment associated with important process and special safety systems, such as the reactor regulating system or shutdown systems. The instrumentation wiring of triplicated shutdown systems is physically separated into three channels. Separation or distance requirements exist to keep each channel and each piece of redundant equipment away from its counterpart, so that a common-cause event (such as

electromagnetic interference, a fire or a flood) does not affect both pieces of redundant equipment simultaneously.

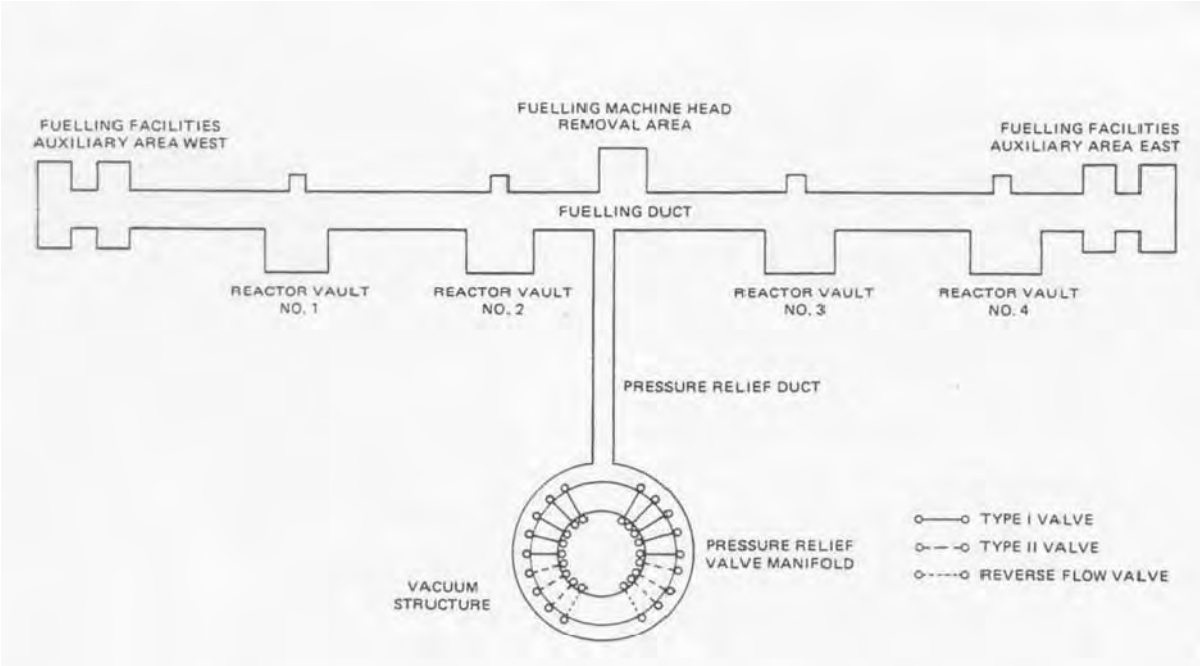
CANDU fuel channels are housed in a cylindrical calandria vessel containing the heavy water moderator, which is itself surrounded by a large shield tank filled with light water. These three components represent main sources of cooling and can act as barriers to accident progression. They can be defended by actions taken as part of severe accident management, another component of defence in depth in CANDU reactors.

CANDU reactors have the following major electrical power systems, listed in ascending order of reliability:

- **Class IV**, which supplies AC power to all essential and non-essential loads during normal plant operation: Class IV power is supplied from the reactor's own turbine generator and also from the electrical grid.
- **Class III**, which supplies AC power to the essential loads required to bring the plant to a safe shutdown state and maintain the reactor in a shutdown condition: Class III loads are normally supplied from Class IV but, in the event that Class IV power is lost, it is supplied by standby generators which are automatically started and loaded.
- **Class II**, which supplies uninterruptible AC power to the essential auxiliary services: Class II power is normally supplied from Class I (batteries) through inverters to ensure there is no interruption to Class II loads.
- **Class I**, which supplies uninterruptible DC power to the essential auxiliary services: Class I power is normally supplied from Class III power through rectifiers and is backed up by batteries to ensure uninterruptible supply to Class I loads.
- **Emergency power system (EPS)**, which supplies AC power to essential systems (known as group 2 systems), required for reactor safe shutdown and decay heat removal under conditions where all other power supplies (i.e., Class I to IV) are not available: The EPS is independent of the other power supplies.

The most challenging technical issues for severe accident management in CANDU reactors are hydrogen management; containment venting; and, where applicable, the response of the multi-unit, negative pressure containments. Relative to LWRs of comparable output, CANDU reactor cores contain a large mass of zirconium and its alloys, of the order of 50 Mg, used to fabricate the fuel elements, fuel bundles, pressure tubes and calandria tubes. Oxidation of a large fraction of zirconium inventory in a severe accident, should it occur, has the potential to result in significant concentrations of hydrogen in the containment atmosphere. For multi-unit stations, the actual concentrations would depend not only on how much oxidation takes place but also on how hydrogen is distributed throughout the reactor units, pressure relief duct, vacuum building and the fuelling machine duct (figure A.8). All multi-unit CANDU plants are currently equipped with hydrogen ignition systems. Some operators had either installed or were actively pursuing the provision of additional hydrogen mitigation by installing passive autocatalytic recombiners, (PARs) prior to the Fukushima Daiichi accident. In view of the Fukushima accident, the PARs installation across the CANDU fleet is expected to be expedited.

Figure A.8 Outline of a Multi-unit Containment Envelope



In a multi-unit station, all the reactor vaults are connected together by the fuelling machine duct and pressure relief duct. This shared containment volume is isolated from the vacuum building by pressure relief valves. During normal operation there is vacuum in the vacuum building and a slightly sub-atmospheric pressure in the ducts and reactor vaults. An accident, such as a loss-of-coolant accident, in one of the reactor vaults causes the pressure in the shared containment volume to rise. The pressure difference between the reactor vault and the vacuum building automatically opens the relief valves, connecting the reactor vaults and ducts to the vacuum building. Steam and gases released in the accident are swept into the vacuum building. In the vacuum building, the rise in pressure releases a large spray of cold water from a dousing tank in the vacuum building roof. The cold water condenses the steam and absorbs the energy released by the accident. The pressure in the reactor vaults, ducts and vacuum building remain below atmospheric pressure for many hours, ensuring there can be no leakage of radioactive material to the environment.

All multi-unit CANDU containments have an emergency filtered air discharge system (EFADS) which can be used to vent the containment atmosphere following an accident such as loss of coolant. The challenge facing this design in severe accidents is that EFADS were not designed to operate in severe accident conditions over prolonged periods of time or under elevated pressure. Their filters may be clogged by aerosols expected to be generated in large amounts in severe accidents. In addition, EFADS are active systems that require AC power to function. Prior to the Fukushima accident, the Point Lepreau station was undergoing refurbishment. As part of this refurbishment, the licensee had installed an additional, external containment filtered venting system, which enhances the plant's ability to response to severe accidents. Some multi-unit stations had been considering the same type of design modification.

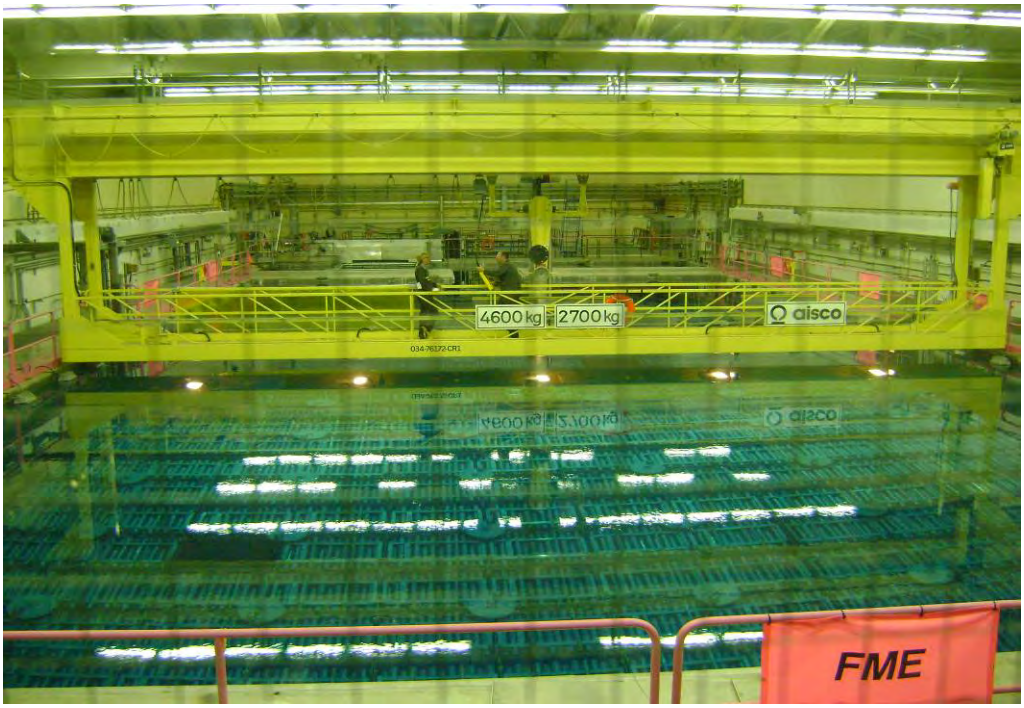
It should be recognized that every NPP design in the world has a set of challenges to contend with in mitigation of highly unlikely severe accidents. CANDU reactors have many positive features but also some areas where further improvement is possible. This report addresses possible enhancements arising from the review of the lessons learned from the Fukushima Daiichi accident.

The irradiated (or spent) nuclear fuel removed from CANDU reactors is stored under water in irradiated fuel bays (IFBs), equivalent to spent fuel pools in other reactor types. The water serves as a shield from radiation and also cools the used nuclear fuel. After about a day in the IFB, the used nuclear fuel generates less than 1 percent of the heat that it generated while in the core. This amount further decreases with time. The resulting cooling requirements are greatly reduced and, as a result, there are significant safety margins when the used nuclear fuel is in the IFB. After about 6–10 years in wet storage in the IFB, the used nuclear fuel can be safely transferred to dry storage in concrete canisters, containers or silos. All used nuclear fuel in Canada is currently held onsite in interim storage facilities, which are safe, secure and environmentally sound.

The IFBs are designed and sized to safely accommodate spent fuel produced at the site until it can be transferred to dry storage. The IFBs are the size of Olympic pools and about 10 metres deep. A typical CANDU reactor IFB is shown in figure A.9. The walls and floor are constructed of carbon-steel-reinforced concrete approximately 2 metres thick. Inner walls and floors are lined with a watertight liner consisting of stainless steel, a fibreglass-reinforced epoxy compound, or a combination of the two. The IFB structure is seismically qualified to maintain its safety function during and following a design-basis event. The IFBs have several designed safety systems to ensure cooling requirements are met.

The IFBs are located outside of the reactor buildings to prevent additional, cascading failures from events or accidents should they occur in the containment. It is important to note that, while CANDU IFBs are generally located at ground level, those at Japan's Fukushima Daiichi site (Mark I type BWRs) are located at a higher elevation, as shown in figure 2.2. It thus follows that the BWR design makes spent fuel pools more vulnerable to seismic events and accidents originating in the reactor building.

Figure A.9 Typical CANDU Irradiated Fuel Bay



Appendix B Progression of a Loss of Heat Sink Accident

The focus of the evaluation of beyond-design-basis accidents is on a complete loss of heat sinks. This appendix provides a description of the various stages of the accident, identifying where the operator could intervene to terminate or slow down the accident progression in a CANDU reactor. It assumes progressive failure of all engineering and procedural safety features. As such, it is not a realistic accident, but is nevertheless instructive in exploring levels 1 to 4 of defence in depth.

This description of the event sequence is thought to be broadly correct, particularly in the early stages. The exact sequence, timing and consequences will vary between reactors. The description of the later stages is particularly uncertain.

B.1 Secondary boil-down

At the start of the accident, all main feedwater and main heat transport pumps are lost due to an assumed loss of electrical power. The reactor trips immediately on loss of circulation of primary coolant.

After the reactor trip, heat removal continues as the boilers still contain a lot of water. Conditions remain stable for up to 5.5 hours (the exact time depends on the station), until the boilers finally boil dry. Core cooling is adequate throughout this period.

Simple operator actions are also possible that will extend the period of secondary boil-down for several hours. Depressurizing the boilers (a simple control room action) allows gravity feed from the deaerator tank[39] into the boilers. Point Lepreau and Gentilly-2 also have the option of gravity feed from the dousing tank, which would extend the secondary boil-down period to about four days. Restoration of electrical power within the period of secondary boil-down would allow a complete recovery with no fuel damage.

B.2 Primary boil-down

After the boilers are dry, the primary coolant heats up and primary pressure rises. Relief valves open and water is discharged into the bleed condenser[40]. Effectively, the primary water inventory is boiled away, just as the secondary side had boiled away earlier.

About 4 hours after boiler dryout, the bleed condenser relief valves open, discharging primary coolant into the containment. Restoration of electrical power before this time would allow a recovery with limited or no core damage.

Reduction of primary water inventory eventually leads to a loss of coolant circulation and fuel begins to heat up. The hot fuel heats the pressure tubes, one or two of which quickly fail, depressurizing the reactor into the moderator. The moderator pressure increases, breaking rupture disks at the top of the calandria vessel; a fraction of the moderator and primary coolant is discharged into the containment. In reactors with passive accumulators, following the depressurization of the primary heat transport system, emergency core cooling is injected which will cool the fuel for a while, but the accumulator water is soon depleted.

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[39] The deaerator is a large tank of feedwater which removes dissolved or entrained air from feedwater. Its high elevation permits it to be used as a passive source of gravity feed, meaning that gravity moves the water down to the boiler.

[40] The degasser (or bleed) condenser is a vessel in the pressure and inventory control system. One of its main functions is to act as a buffer volume to accept steam and water discharged from the primary relief valves.

B.3 Moderator boil-down

After accumulator water is depleted, or immediately for reactors with pumped injection (Pickering A, B and Darlington), the intact pressure tubes will soften, become deformed and come into contact with the surrounding calandria tubes. This provides a path for heat from the core to be removed by the moderator. Without adding more water, the moderator can remove decay heat for a further 5.5 hours after boiler dry-out (the exact time depends on the station). Restoration of moderator cooling early in this period can prevent reactor meltdown. Bruce A units 1 and 2 already have the capability to provide make-up water to the moderator. Other stations are evaluating options to provide a make-up capability.

In the absence of make-up, the moderator continues to boil away. The level in the calandria vessel falls, progressively uncovering the fuel channels which then begin to overheat. The core debris from failed high elevation channels can overload and fail lower elevation channels and this can lead to the relocation of a substantial amount of high temperature debris into the remaining moderator water. Rapid generation of steam can lead to containment failure at this stage.

Substantial fuel overheating occurs and the reaction of zirconium in the fuel sheath with steam will generate hydrogen. Fission products and hydrogen are released into the containment.

B.4 Shield tank / calandria vault boil-down

After the moderator water is depleted, the core falls to the floor of the calandria vessel. The calandria vessel is surrounded by a water-filled tank called the shield tank or calandria vault, depending on the station. This water provides a further heat sink for the core debris. For some designs, the shield tank relief is incapable of relieving the volume of steam generated and the shield tank will fail shortly after boiling begins. This time is difficult to estimate. Reactors with a calandria vault can delay further damage until the calandria vault water is depleted. NB Power has installed a calandria vault make-up capability at the Point Lepreau facility which can delay calandria vault failure for four days, even if all earlier heat sinks were ineffective.

As core damage and fuel debris temperature increase, additional fission products are released to the containment.

B.5 Shield tank / calandria vault failure

After failure of the shield tank / calandria vault, the core debris falls to the concrete floor beneath. If the space is water filled, rapid generation of steam can lead to high pressure in the containment. In the absence of water, or after the water has boiled away, the molten core material begins to attack the concrete. Ablation (erosion) of concrete generates large quantities of heat and non-condensable gas, including hydrogen and carbon monoxide, which are flammable. The rate of generation of combustible gas is beyond the capability of passive autocatalytic recombiners, and hydrogen explosions cannot be precluded. It should be noted that the capacity of containment filtered venting systems is not adequate to control pressure. If containment has not already failed, it will fail due to overpressure or a hydrogen explosion at this stage. It is estimated that interaction between the core and concrete would cease before the reactor building basemat[41] is penetrated.

[41] The basemat is the thick concrete floor of the reactor building.

Appendix C CNSC Emergency Operations Centre Lessons Learned

This summary is based on the CNSC Reports *Fukushima Nuclear Emergency EOC After Action Report*, CNSC, published on August 16, 2011, and *Fukushima Nuclear Emergency EOC Improvement Plan*, CNSC, published on August 28, 2011.

C.1 Background

On the morning of March 11, 2011, the Canadian Nuclear Safety Commission (CNSC) became aware that natural disasters had adversely affected some of the nuclear power plants on the east coast of Japan. By midday, after consulting with senior management, the CNSC Emergency Operations Centre (EOC) was activated in accordance with the *CNSC Emergency Response Plan CAN – 2.1*. Staff from the CNSC assembled to form the CNSC Nuclear Emergency Organization (NEO) and worked to assess the situation in Japan and develop the strategy for the Canadian response.

Until April 4, for a total of 23 days, approximately 150 staff worked in the EOC on a 24/7 basis to monitor and assess the situation in Japan. CNSC specialists were able to provide expertise in the fields of reactor technology and radiation protection. The CNSC also reached out and cooperated with the nuclear regulators in the United States, United Kingdom and France to exchange the latest technical information.

Following the deactivation of the EOC and return to routine operations, the CNSC's Emergency Management Programs Division (EMPD) undertook a lessons-learned process to capture the important operational experience from the EOC activation and strengthen the CNSC Nuclear Emergency Management Program. The process was focused on the activation, operations and deactivation of the CNSC NEO, the EOC and the CNSC emergency response plans and procedures.

C.2 Methodology

The process of debriefing comprised four distinct activities encompassing all levels, positions and functions of the emergency management organization. The focus of these debriefing sessions was to identify what went well and what could have been done better.

C.2.1 Lessons Learned email account

During the EOC activation period, an EOC Lessons Learned email account was created on the CNSC network to enable NEO members to forward their comments and/or suggestions to identify the opportunities for improvement. Many comments were sent to this account.

C.2.2 NEO members debriefing session

On May 5, the EMPD held a debriefing session exclusively for the NEO members. The session was primarily focused on the EOC as a facility and the NEO structure as an organization. A discussion was also held on the specific roles and functional areas of the NEO. This session was attended by approximately 50 NEO members representing all positions and functions.

C.2.3 Executive and Emergency Director debriefing session

The members of the CNSC's Japan Executive Team (JET) and the directors general who performed the duty of Emergency Director during the EOC activation were debriefed on May 11. This debriefing session took into consideration the comments collected from the NEO members and the comments and suggestions received via the EOC Lessons Learned email account. The focus of this session was at a higher level (senior management) and on the products and tools required to improve the CNSC emergency response.

C.2.4 EMPD staff debriefing session

A debriefing session was also held for EMPD staff on May 20. The focus of this session was on the CNSC nuclear emergency response program, EOC organization, plans/procedures and the NEO structure.

C.3 Key observations

1. For an emergency occurring in a distant country, the activation of the CNSC NEO/EOC was timely and appropriate. The CNSC nuclear emergency management system worked as designed and planned. Overall the feedback received was positive, confirming the effectiveness and efficiency of the following.
2. The NEO concept of operations proved to be an effective as well as efficient organization. It proved to be flexible as it could be expanded or contracted as per the situation.
3. The EOC used the 3rd floor conference room at CNSC Headquarters in Ottawa as its centre of operations. This location proved to be an adequate facility for the NEO with, generally, the necessary tools and technology for staff to perform their functions. Availability of all meeting rooms on the 3rd floor ensured appropriate accommodation for all NEO functional teams.
4. The CNSC nuclear emergency response plans and procedures proved adequate and ensured proper linkages with our internal and external stakeholders.
5. The role and direction of an ad-hoc executive team (JET) was essential in providing guidance and strategic direction to the NEO.
6. The CNSC response to this emergency demonstrated an excellent coordination between all branches at the CNSC. Staff from Corporate Services Branch, Regulatory Affairs Branch, Technical Support Branch and Regulatory Operations Branch worked closely and effectively together. In particular, the coordination and integration between the Finance and Administration Directorate and Directorate of Security and Safeguards were well executed throughout the duration of the event, assuring the business continuity side of the emergency. The alternate site for the EOC was in a state of readiness and available at the CNSC's Telesat offices in Ottawa. This site would have been used had there been a need to relocate due to an incident at Headquarters.
7. Feedback obtained from the debriefing sessions indicated that on-the-job training of new NEO members during the three weeks activation was useful. Because the event was in a distant country and the NEO/EOC was activated for a prolonged period of time, a conscious decision was made to use this opportunity to train new NEO members. On-the-job training for the experienced NEO members proved to be good refresher training. The participation of many new NEO members is reflected in many of the comments sent to the EOC related to training.
8. No major changes to the EOC and its structure are required at this time. However, some technological improvements (hardware as well as software) are required in the EOC to enhance the emergency response capability and capacity.
9. The activation, operations and deactivation of the NEO in the EOC were successful. However, several opportunities for improvement were identified in the *Fukushima Nuclear Emergency EOC Improvement Plan*.

C.4 Conclusion

A comprehensive after-action process was undertaken to capture the lessons learned from the CNSC's EOC activation for the Fukushima event. A final report with suggested improvement actions was presented to the CNSC Management Committee on June 16. The CNSC Management Committee reviewed the submission and approved 39 cross-cutting EOC improvement actions that are now tracked in an EMPD-managed improvement plan.

Appendix D Correspondence of Report Recommendations to Detailed Findings

The table below shows the relationship between the CNSC Fukushima Task Force recommendations from section 10 and the detailed findings from sections 6 to 9.

10.1 Strengthening reactor defence in depth	
Recommendation 1	**Review finding(s)**
1. Licensees should systematically verify the effectiveness of, and supplement where appropriate, the existing plant design capabilities in beyond-design-basis accident and severe accident conditions, including: a) overpressure response of the main systems and components	**Section 6.3.8 (#5)** Degasser (bleed) condenser relief valves have been tested to ensure that they are capable of providing sufficient relief flow for worst-case design-basis accidents. However, they have not been tested at extreme conditions that may arise in beyond-design-basis accidents. In these cases, relief valve capacity may not be adequate in a sustained loss of all heat sinks, reducing the time before pressure tubes fail. The CNSC previously evaluated this issue and accepted the current design, although the margin to failure was small.
	Section 6.3.8 (#6) Shield tank relief and calandria vault relief have not been verified to be adequate for beyond-design-basis accidents. A large inventory of water surrounds the core of a CANDU reactor – one of the strengths of its design. Nonetheless, if relief valves do not have sufficient capacity in a sustained loss of heat sinks, the shield tank could fail due to overpressure and much of the available water may be lost, leading to an earlier failure of the calandria vessel than would be the case if adequate relief was available.
b) containment performance to prevent unfiltered releases of radioactive products	**Section 6.4.7 (#2)** Plant design capabilities for severe accident management, such as containment venting, hydrogen mitigation, coolant make-up provisions, instrumentation, and the control areas have not been fully evaluated and documented. Such design capabilities would allow minimization of the consequences of a severe accident, should one occur.
c) control capabilities for hydrogen and other combustible gases: i) accelerate installation of the hydrogen management capability and sampling provisions	**Section 6.3.8 (#1)** Not all licensees have completed the installation of passive autocatalytic recombiners. Most licensees have taken action to accelerate the installation.
ii) include spent fuel bays and any other areas where hydrogen accumulation cannot be precluded	**Section 6.3.8 (#10)** The need for hydrogen mitigation in the irradiated fuel bay area has not been adequately evaluated.
d) make-up capabilities for the steam generators, primary heat transport system and connected systems, moderator, shield tank, and spent fuel bays	**Section 6.3.8 (#9)** The irradiated fuel bays (spent fuel pools) at most NPPs have temperature limits that lead to relatively short times (16 hours) for which a loss of cooling can be tolerated before the structural design temperature is reached. Above this temperature, an increasing risk of structural cracking could lead to leakage from the bay, thereby shortening the time to fuel uncovering. Additionally, with

10.1 Strengthening reactor defence in depth	
	a low water level, it may not be possible to perform manual actions in elevated radiation fields.
	Section 6.4.7 (#2) Plant design capabilities for severe accident management, such as containment venting, hydrogen mitigation, coolant make-up provisions, instrumentation, and the control areas have not been fully evaluated and documented. Such design capabilities would allow minimization of the consequences of a severe accident, should one occur.
e) design requirements for the self-sufficiency of a plant site such as availability and survivability of equipment and instrumentation following a sustained loss of power and capacity to remove heat from a reactor	**Section 6.2.3 (#2)** Safety analyses have demonstrated that equipment and procedures are adequate to ensure that, for all design-basis accidents where core cooling is lost when a shutdown reactor is hot and pressurized, the reactor can be taken to a stable state. However, analysis to show that the NPP can be taken to a cold, depressurized state is incomplete.
	Section 6.2.3 (#3) Safety analyses have not demonstrated that, for all design-basis accidents, equipment and procedures used to take the reactor to a cold, depressurized state can maintain that state for a prolonged period.
	Section 6.3.8 (#3) In the event of a loss of all normal, backup and emergency AC power, the guaranteed capability of Class I batteries to support all essential electrical equipment is 40 minutes (although it is recognized that some services will last much longer). This duration is short compared to other essential supply capabilities and gives little time to restore AC power. Once batteries are exhausted, most control and instrumentation functions are lost.
	Section 6.3.8 (#4) While key instrumentation is fully qualified for design-basis accidents, survivability in beyond-design-basis accident conditions has not always been demonstrated.
	Section 6.3.8 (#7) The minimum Class I/II equipment that is needed to mitigate beyond-design-basis accidents involving loss of all AC power has not been systematically identified.
f) control facilities for personnel involved in management of the accident	**Section 6.4.7 (#2)** Plant design capabilities for severe accident management, such as containment venting, hydrogen mitigation, coolant make-up provisions, instrumentation, and the control areas have not been fully evaluated and documented. Such design capabilities would allow minimization of the consequences of a severe accident, should one occur.

10.1 Strengthening reactor defence in depth	
g) emergency mitigating equipment and resources that could be stored offsite and brought onsite if needed	**Section 6.4.7 (#4)** Licensees' emergency response organizations do not have access to a regional warehouse that could make available offsite equipment and resources that may be needed in case of a severe accident. Availability of emergency equipment was shown to be crucial during the Fukushima event and could allow terminating a severe accident early enough to prevent any radioactive releases to the environment.
Recommendation 2	**Review finding(s)**
2. Licensees should conduct more comprehensive assessments of site-specific external hazards to demonstrate that: a) considerations of magnitudes of design-basis and beyond-design-basis external hazards are consistent with current best international practices	**Section 6.1.3 (#1)** The original magnitudes considered for the design-basis and beyond-design-basis assessments of external hazards were developed for the original licensing of the facilities. Although in general a lot of conservatism was included in the original designs, some design bases are not consistent with modern best practices.
	Section 6.1.3 (#3) External hazards screening and bounding analysis are in different states of development for each NPP. Consequently, analysis of all external hazards is not complete at all NPPs.
b) consequences of events triggered by external hazards are within applicable limits	**Section 6.1.3 (#2)** The assessment for the design-basis and beyond-design-basis tornado hazard was found to be weak at some NPPs.
	Section 6.2.3 (#1) Implementation of a safety analysis framework based on RD-310, *Safety Analysis of Nuclear Power Plants*, is incomplete.
	Section 6.4.7 (#5) Severe accident analyses and assessments of external hazards are not systematically produced and periodically updated. This aspect of the plant safety case has not received much attention in the past and was shown to be important in understanding the site-specific challenges and possible progression of a severe accident.
Such assessments should be updated periodically to reflect gained knowledge and modern requirements.	
Recommendation 3	**Review finding(s)**
3. Licensees should enhance their modelling capabilities and conduct systematic analyses of beyond-design-basis accidents to include analyses of: a) multi-unit events	**Section 6.4.7 (#1)** Current assessments do not adequately consider events affecting multiple reactors on the site, events at spent fuel bays, as well as events triggered by extreme external hazards. Having detailed assessments of the severe accident management procedural guidance and design capabilities to cater to beyond-design-basis and severe accidents were shown to be of high priority during the Fukushima event.

10.1 Strengthening reactor defence in depth	
	Section 6.4.7 (#3) The scope of analyses of severe accidents does not fully cover accidents triggered by extreme external events, multi-unit events, and spent fuel bay accidents. The modelling capabilities for multi-unit events are not fully adequate. Improvements would also give a better estimation of the source terms of radioactivity and combustible gases.
	Section 6.3.8 (#8) Modelling of severe accidents performed for multi-unit NPPs was based on a computer model that represents only a single unit. The modelling approach is accepted as adequately giving broadly representative results but would not be capable of calculating, for example, the effects of different times of core meltdown in the different units.
b) accidents triggered by extreme external events	**Section 6.3.8 (#2)** Results of studies of the duration of primary boiloff before pressure tube failure are not consistent. The progression of a sustained loss-of-heat-sinks event described by licensees is in broad agreement with the CNSC's understanding. However, the CNSC Task Force assessment of the time available before pressure tube failure is shorter than that given by industry.
	Section 6.4.7 (#1) Current assessments do not adequately consider events affecting multiple reactors on the site, events at spent fuel bays, as well as events triggered by extreme external hazards. Having detailed assessments of the severe accident management procedural guidance and design capabilities to cater to beyond-design-basis and severe accidents were shown to be of high priority during the Fukushima event.
c) spent fuel bay accidents The analyses should include estimation of releases, into the atmosphere and water, of fission products, aerosols and combustible gases.	**Section 6.4.7 (#1)** Current assessments do not adequately consider events affecting multiple reactors on the site, events at spent fuel bays, as well as events triggered by extreme external hazards. Having detailed assessments of the severe accident management procedural guidance and design capabilities to cater to beyond-design-basis and severe accidents were shown to be of high priority during the Fukushima event.

10.2 Enhancing emergency response	
Recommendation 4	**Review finding(s)**
4. Licensees should assess emergency plans to ensure emergency response organizations will be capable of responding effectively in a severe event and/or multi-unit accident, and conduct sufficiently challenging emergency exercises based on them.	**Section 6.5.11 (#1)** Emergency response organizations are capable of responding to single-unit, beyond-design-basis events. Evaluation and revision of emergency plans in regard to multi-unit accidents and severe external events, including an assessment of the minimum complement requirements have not been performed. As a result, it has not been conclusively demonstrated that emergency response organizations will be capable of responding effectively in a severe event and/or multi-unit accident.
	Section 6.5.11 (#2) The performance of the emergency response organization under severe event and/or multi-unit accident conditions has not been challenged by designing and conducting exercises that are based on such conditions.
Recommendation 5	**Review finding(s)**
5. Licensees should review and update their emergency facilities and equipment, in particular: a) ensure operability of primary and backup emergency facilities and of all emergency response equipment that require electrical power and water	**Section 6.5.11 (#4)** Not all licensees' emergency facilities and equipment have backup power available in the event of a loss of external power. Backup power sources for primary and alternate emergency facilities, and all emergency response equipment that require electrical power to operate (e.g., electronic dosimeters, two-way radios), have not been systematically identified. The applicable emergency plans and procedures do not, in all cases, adequately document the requirements and limitations.
b) formalize all arrangements and agreements for external support and document these in the applicable emergency plans and procedures	**Section 6.5.11 (#5)** Arrangements and agreements for external support are not always formalized and not always documented in the applicable emergency plans and procedures.
c) verify or develop tools to provide offsite authorities with an estimate of the amount of radioactive material that may be released and the dose consequences, including the installation of automated real-time station boundary radiation monitoring systems with appropriate backup power	**Section 6.5.11 (#3)** Automated real-time station boundary radiation monitoring systems with appropriate backup power and communications systems are seen as a best practice approach and allow critical data to be available rapidly. However, such systems are not available at all sites.
	Section 6.5.11 (#6) Hydro-Québec does not currently have source term estimation capability included in its dose modelling tools. NB Power does not currently have source term and dose modelling tools.
Recommendation 6	**Review finding(s)**
6. Federal and provincial nuclear emergency planning authorities should undertake a review of their plans and supporting programs, such as: a) ensuring plan revision activities are expedited and making regular full-scale exercises a priority	**Section 7.5 (#5)** Federal and provincial nuclear emergency planning authorities have not yet undertaken a formal lessons-learned process to gain knowledge from offsite management of the Fukushima nuclear emergency and update plans accordingly.
	Section 7.5 (#8)

10.2 Enhancing emergency response	
	The Health Canada Federal Nuclear Emergency Plan (FNEP) has not been updated since 2002 and is not formally integrated with the Public Safety Canada Federal Emergency Response Plan (FERP). The FNEP and FERP integration has not been validated in a full-scale, NPP-focused exercise.
	Section 7.5 (#3) Federal and provincial nuclear emergency planning authorities are not making regularly planned full-scale NPP-focused exercises a priority. It was generally observed at the provincial and federal level that there has been a reduction in the frequency of full-scale NPP-focused exercises. Although all provincial and federal plans reviewed appear to be satisfactory, the implementation, and thus the capability to respond, has generally not been tested in an exercise for several years.
	Section 7.5 (#13) The Province of Quebec has not recently updated its nuclear emergency plan.
	Section 7.5 (#15) The Province of New Brunswick has not recently updated its nuclear emergency plan.
b) establishing a formal, transparent, national-level oversight process for offsite nuclear emergency plans, programs and performance	**Section 7.5 (#4)** Federal and provincial nuclear emergency planning authorities do not fully address recovery phase guidelines and procedures in their emergency plans, as they primarily address only preparedness and response.
	Section 7.5 (#6) There is no formal, transparent, national-level oversight process for offsite nuclear emergency plans, programs and performance. Whereas NPP licensees' onsite emergency plans, programs and performance are included in the CNSC regulatory oversight process, there is no similar system of oversight for offsite emergency plans.
c) reviewing the planning basis of offsite arrangements in view of multi-unit accident scenarios	**Section 7.5 (#7)** There is no established national guidance or standard for offsite nuclear emergency planning. Whereas NPP licensees are provided with CNSC guidance on emergency planning, there is no Canadian guidance for offsite nuclear emergency plans.
	Section 7.5 (#9) The Province of Ontario planning basis for the current nuclear emergency plans and offsite arrangements is a single-unit accident scenario and does not explicitly consider a multi-unit accident scenario.
d) reviewing arrangements for protective action including resolving the issues pertaining to public alerting, validating the effectiveness of potassium iodide (KI) pill-stocking and distribution strategies and verifying, or developing the capability for predicting, offsite effects	**Section 7.5 (#10)** There are ongoing public alerting issues in the 3 km zone around the Pickering NPP. Also, the new 10 km public alerting requirement has not been fully implemented.

10.2 Enhancing emergency response	
	Section 7.5 (#11) The potassium iodide (KI) pills for residents of the planning zone in Ontario are stocked at local pharmacies in the Durham region or the reception centre in Kincardine. The effectiveness of this approach, as opposed to pre-distribution to all households, has not been confirmed.
	Section 7.5 (#12) There is no automated public alerting system around the Gentilly-2 NPP.
	Section 7.5 (#14) The Province of New Brunswick does not have the capability for predicting offsite effects.

10.3 Improving regulatory framework and processes	
Recommendation 7	**Review finding(s)**
7. The CNSC should initiate a formal process to amend the *Class I Nuclear Facilities Regulations* to require NPP licensees to submit offsite emergency plans with an application to construct or operate a nuclear power plant.	**Section 7.5 (#1)** The *Class I Nuclear Facilities Regulations* do not currently require submission of offsite emergency plans with an NPP operating licence application. Whereas an NPP licensee's onsite emergency plans are submitted to the CNSC as part of the licence application and renewal process, there is no formal requirement for the offsite plans to be submitted to the CNSC.
	Section 8.7 (#1) The *Class I Nuclear Facilities Regulations* do not have explicit requirements for submission of offsite emergency plans.
Recommendation 8	**Review finding(s)**
8. The CNSC should amend the *Radiation Protection Regulations* to be more consistent with the current international guidance and to describe in greater detail the regulatory requirements needed to address radiological hazards during the various phases of an emergency.	**Section 8.7 (#2)** The *Radiation Protection Regulations* are not fully consistent with international guidance and do not fully describe the regulatory requirements needed to address radiological hazards during the various phases of an emergency.
Recommendation 9	**Review finding(s)**
9. The CNSC should update the regulatory document framework through: a) updating selected design-basis and beyond-design-basis requirements and expectations, including those for: i) external hazards and the associated methodologies for assessment of magnitudes	**Section 8.7 (#6)** The three-year regulatory framework plan does not currently accommodate the CNSC Task Force review findings.
	Section 8.7 (#7) A small number of regulatory documents (RDs) or guidance documents (GDs) are lacking requirements or guidance needed to address the lessons learned.
	Section 8.7 (#8) The lessons learned are not yet fully considered for the next revision of other NPP-related RDs or GDs.

10.3 Improving regulatory framework and processes	
	Section 8.7 (#9) The lessons learned are not yet fully considered as part of the preparation of new RDs or GDs.
	Section 9 (#8) The CNSC has no requirements for the analysis of multi-unit accidents, particularly those that could arise from common-cause events.
	Section 6.1.3 (#4) The requirements and expectations for defining magnitudes to be used for design-basis and beyond-design-basis hazards have not been reviewed since original NPP licensing. The methodologies used to establish the criteria for these hazards are not consistent with modern best practices.
	Section 9 (#6) The CNSC has not documented an overall, systematic approach to the evaluation of all types of external events that could occur in Canada. A systematic approach would encompass both design-basis events and beyond-design-basis events.
	Section 9 (#7) The Fukushima event highlighted the need for margins to cliff-edges to be understood, particularly when exceeding such cliff-edges may have catastrophic consequences. CNSC currently has no explicit requirements for the assessment of such margins for new nuclear power plants.
	Section 9 (#15) The CNSC does not have a full set of requirements for plant and site layout that would facilitate protection against external hazards.
ii) probabilistic safety goals	**Section 9 (#1)** The safety goals in RD-337, *Design of New Nuclear Power Plants*, are based on single-unit events. Site-based safety goals or other safety criteria that take into account the site characteristics (including population distribution) and the possibility of multiple-unit accidents are not explicitly considered.
	Section 9 (#3) Whereas the safety goals are likely adequate for the design of individual units, these may not be sufficient for a robust demonstration of the offsite response. A separate, more demanding, release value would result in more challenging evaluations of the offsite response.
iii) complementary design features for both severe accident prevention and mitigation	**Section 9 (#2)** Although RD-337 already has explicit requirements for the design of complementary design features consistent with international practice, these may not be complete. In addition, there are no explicit requirements for such features for irradiated fuel bays, including combustible gas management.

10.3 Improving regulatory framework and processes	
	Section 9 (#10) The CNSC does not have explicit requirements for complementary design features that could be called upon to protect the containment. One such feature is filtered containment venting.
	Section 9 (#14) The CNSC does not have explicit requirements for the emergency heat removal system for beyond-design-basis conditions, including the mission time during which it must be available.
iv) passive safety features	**Section 9 (#4)** The Fukushima event highlighted the difficulties that can arise when an NPP relies solely on active engineered systems. The need for specific regulatory requirements for passive safety features has not been assessed.
v) fuel transfer and storage	**Section 9 (#5)** The requirements in RD-337 for the design, placement and engineering robustness of irradiated fuel bays is not complete for the entire spectrum of beyond-design-basis scenarios.
vi) design features that would facilitate accident management	**Section 9 (#9)** The CNSC requirements for the design that would facilitate accident management and severe accident management are incomplete. For example, there are no explicit provisions for the use of portable equipment and the availability of connections for temporary supplies of electrical power and water.
	Section 9 (#11) The CNSC does not have comprehensive requirements for minimum times before significant operator interventions are required. Such requirements would be commensurate with the type of intervention, for example, the need for offsite portable equipment to be brought onsite.
	Section 9 (#12) Previous accidents have identified the importance of operators having access to reliable plant information. The CNSC currently does not have explicit requirements for "hardened" plant monitoring features and instrumentation that would function reliably under severe accident conditions, and for the control room equipment expected to be available.
	Section 9 (#13) The CNSC does not have design requirements for automated real-time onsite field radiation monitoring.

10.3 Improving regulatory framework and processes	
b) developing a dedicated regulatory document on accident management	**Section 6.4.7 (#7)** Relevant sections in the existing and planned regulatory documents, such as G-306, *Severe Accident Management Programs for Nuclear Reactors*; RD-310, *Safety Analysis for Nuclear Power Plants*; and RD-337, *Design of New Nuclear Power Plants*, have not been re-evaluated and revised to account for the lessons learned following the Fukushima accident. There is currently no regulatory document giving specific requirements for accident management.
	Section 9 (#16) CNSC requirements for operational limits and conditions do not integrate into one structure the command and control needs during normal operation, the emergency operating procedures and severe accident management guidelines. Furthermore, there is currently no requirement for further guidance similar to the "extensive damage mitigation guidelines" used in the United States, which can be used when extensive damage has occurred across a site.
c) strengthening the suite of emergency preparedness regulatory documents	**Section 6.5.11 (#7)** The suite of emergency preparedness regulatory requirement documents, currently comprising guidance document G-225, *Emergency Planning at Class I Nuclear Facilities and Uranium Mines and Mills*, and regulatory document RD-353, *Testing the Implementation of Emergency Measures*, are lacking detailed and specific requirements needed to strengthen and standardize emergency preparedness and response in Canada.
d) reviewing applicable Canadian Standards Association standards	**Section 8.7 (#10)** Canadian Standards Association standards that apply to NPPs have not been reviewed by the CNSC staff as a result of lessons learned.
Recommendation 10	**Review finding(s)**
10. The CNSC should amend all power reactor operating licences to include specific licence conditions, requiring implementation of accident management provisions, severe accident management and public information.	**Section 6.4.7 (#6)** Current power reactor operating licences do not have specific licence conditions requiring implementation of accident management provisions, including those for severe accidents.
	Section 8.7 (#4) Existing licence conditions in power reactor operating licences do not explicitly address accident management, severe accident management and public information.
	Section 8.7 (#5) RD-99.3, *Requirements for Public Information and Disclosure* and its guide, GD-99.3, *Guide to the Requirements for Public Information and Disclosure*, have not been approved for publication, leaving a potential gap in regulatory requirements and guidance for licensees' public information programs.

10.3 Improving regulatory framework and processes	
	Section 8.7 (#11) Licence condition handbooks are lacking requirements and guidance needed to address lessons learned.
Recommendation 11	**Review finding(s)**
11. The CNSC should further enhance the regulatory oversight of nuclear power plants through implementation of a periodic safety review process.	**Section 8.7(#3)** Canada does not have a formal periodic safety review process. As demonstrated by international practice, regulatory oversight of nuclear power plants may be further enhanced through implementation of a periodic safety review process.
Recommendation 12	**Review finding(s)**
12. The CNSC should review memoranda of understanding with regulatory counterparts in countries with CANDU reactors to outline what support, if any, they would require from the CNSC during a nuclear emergency.	**Section 7.5 (#2)** The memoranda of understanding with regulatory counterparts in countries with CANDU reactors have not been reviewed to identify what support, if any, they would require from the CNSC during a nuclear emergency.
Recommendation 13	**Review finding(s)**
13. The CNSC should enhance cooperation with other nuclear regulators in addressing the lessons learned from the Fukushima accident and thus further strengthen the capability to respond efficiently to any nuclear emergency.	**Section 7.5 (#2)** The memoranda of understanding with regulatory counterparts in countries with CANDU reactors have not been reviewed to identify what support, if any, they would require from the CNSC during a nuclear emergency.

HERCA
Heads of the European Radiological protection Competent Authorities

Western European
WENRA
Nuclear Regulators' Association

HERCA-WENRA Approach for a better cross-border coordination of protective actions during the early phase of a nuclear accident

Stockholm, 22 October 2014

The HERCA-WENRA Approach is an incentive approach that comprises the necessary mechanisms for countries to exchange adequate information and to achieve practical and operational solutions on a voluntary basis during an emergency leading to a uniform way of dealing with any serious radiological emergency situation, regardless of national border line, hence allowing for coherent and coordinated protective actions.

The HERCA-WENRA Approach has the potential to improve the coherence of the response in case of a nuclear accident with impact on territories of other countries and to be used as guidance to implement Article 99.1[1] and 99.2[2] of the Euratom-BSS. It also fulfils recommendation N°12.7.b of the so-known ENCO study and it further addresses some of the other recommendations.

[1] 1 Art. 99.1. Member States shall cooperate with other Member States and with third countries in addressing possible emergencies on its territory which may affect other Member States or third countries, in order to facilitate the organisation of radiological protection in those Member States or third countries.

[2] [2] Art 99.2. Each Member State shall, in the event of an emergency occurring on its territory or likely to have radiological consequences on its territory, promptly establish contact with all other Member States and with third countries which may be involved or are likely to be affected with a view to sharing the assessment of the exposure situation and coordinating protective measures and public information by using, as appropriate, bilateral or international information exchange and coordination systems. These coordination activities shall not prevent or delay any necessary actions to be taken on a national level.

Content

General presentation of the HERCA WENRA Approach for a better cross-border coordination of protective actions during the early phase of a nuclear accident.

Part I.- HERCA-WENRA Approach for a better cross-border coordination of protective actions during the early phase of a nuclear accident.- General Mechanism.

Part II.- HERCA-WENRA Approach in case of a Severe Accident requiring Rapid Decisions for Protective Actions, while very little is known about the Situation.

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General Presentation of the HERCA-WENRA Approach for a better cross-border coordination of protective actions during the early phase of a nuclear accident

Stockholm, 22 October 2014

General presentation of the HERCA-WENRA Approach for a better cross-border coordination of protective actions during the early phase of a nuclear accident

The HERCA-WENRA Approach improves the response and cross-border coordination for all types of possible accident scenarios. It contains overarching principles based on radiation safety considerations and provides an incentive for joint actions between neighbouring countries. These principles need to be implemented at national level. Therefore additional conceptual work is needed, some of the principles need additional guidance, and other relevant stakeholders such as civil protection services need to be included.

HERCA and WENRA recognise that in European countries, efficient emergency preparedness and response (EP&R) arrangements have been established since many years and are tested and challenged regularly. They allow authorities to issue recommendations for effective public protective actions. In the development of such arrangements, each European state defines its own priorities and objectives in planning for nuclear emergencies directly affecting its own territory. The international and EU radiological protection frameworks leave large margins of freedom for setting national criteria for intervention. Emergency planning has evolved in all states over many years, mostly without giving great priority to cross-border issues. This has led to sometimes significant differences. Should a nuclear emergency occur in Europe, these differences can potentially have a significant effect, especially if the location of the emergency is close to a national border. Internationally, populations would feel unequally protected, depending on where they live. Agreeing or aligning protective actions along adjacent national borders is therefore highly desirable.

During the very early phase of any accident, the status of the reactor and the estimation of the amount of radioactivity released (the source term) are likely to be poorly understood. Thus, the uncertainties in terms of dose estimation and overall radiological impact are very large. The role of the decision-maker is to arrive at appropriate health protection measures possibly even without any dose estimation. This inevitably leaves room for flexibility in decisions, even where there is a rigid national framework. The HERCA-WENRA Approach makes use of this freedom for coordination between neighbouring countries in order to align early decisions across borders. As a result, the respective national arrangements do not necessarily need to be changed. Instead, the prevailing differences are respected and are taken into account, and the response is based on ‘compromise’ solutions which are understandable and explainable in each given situation.

HERCA and WENRA additionally consider that the possibility of a severe accident scenario (i.e. Fukushima-like) with no or insufficient information on the plant status cannot be completely ruled out. EP&R arrangements should therefore also cover such cases. However, in such cases, the recommendations of protective actions need to be formulated rapidly, leaving very limited time for cross border coordination during the first phase of the accident. Therefore, the HERCA-WENRA approach contains pre-defined simplified schemes for protective actions that may be applied in these cases, as improbable they might be.

The general mechanism of the HERCA-WENRA approach on EP&R for a better cross-border coordination of protective actions during the early phase of a nuclear accident is independent of the scenario of the accident.

The approach relies on the following principles: shared technical understanding, coordination and mutual trust. It does not propose a uniform cross border framework. The main strategy is to aim at an alignment of the response between neighbouring countries or neighbouring territories. This is supported by early information exchanges using existing dedicated bilateral and international arrangements as far as possible.

The HERCA-WENRA Approach is divided into 3 steps: the preparedness phase, the early phase and the later phase. The approach contains the main principles and leaves necessary margins of freedom for detailed implementation:

Step 1
In preparedness the aim is to achieve and maintain a shared understanding of the existing national emergency arrangements through the improvement of bilateral or multilateral arrangements, the testing of these arrangements and the implementation of improvements.

Step2
In the early phase of an accident, the proposed HERCA-WENRA Approach foresees rapid information exchanges by using existing dedicated bilateral and international arrangements, including the exchange of liaison officers as appropriate. If the response is thought consistent, the neighbouring countries can recommend to their governments to follow these recommendations, i.e. adopt the principle “We do the same as the accident country” in the first hours of the accident.

Step3
In the later phase a common situation report, accepted by all impacted countries, will further support coordinated protective actions.

The HERCA-WENRA Approach has been tested and validated against concrete and realistic accident scenarios in NPP’s that are close enough to national borders. A workshop in September 2013 showed that in case of a sufficient information exchange most countries would be able to recommend to their decision-makers that the advice of the accident country should be followed during the very early stages.

For the initial stage of a highly improbable severe accident (i.e. Fukushima-like), requiring rapid decisions for protective actions while very little is known about the situation, simplified schemes for protective actions are needed.

Fukushima has shown again that a severe nuclear accident anywhere in the world, including Europe, cannot be completely excluded. Considering the safety level of European nuclear power plants and their improvements resulting from the lessons learned from various events (including the Fukushima disaster), it is estimated that the probability of such a severe accident is very low. But, as improbable such an accident might be, EP&R arrangements must be prepared for such cases, too.

According to the current studies, international standards and methods used for emergency preparedness and response, an accident comparable to Fukushima would require protective actions such as evacuation to around 20 km and sheltering to around 100 km. These actions would be combined with the intake of stable iodine.

In this framework, HERCA and WENRA propose a methodology for a common European approach allowing to recommend urgent protective actions as well as a minimum common level of preparation for these actions.

HERCA and WENRA consider that in Europe:

- evacuation should be prepared up to 5 km around nuclear power plants, and sheltering and ITB up to 20 km;
- a general strategy should be defined in order to be able to extend evacuation up to 20 km, and sheltering and ITB up to 100 km;
- nuclear and radiation safety authorities in Europe should continue attempts to promote compatible response arrangements and protection strategies amongst the European countries.

The need for rapid decisions using the simplified schemes for protective actions will only apply during an initial phase. As soon as the accident country is in a position to present a more elaborate assessment of the plant status and the expected off-site impact, it shall take the necessary steps to align its decisions and cross-border coordination mechanisms accordingly.

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Part I.

HERCA-WENRA Approach for a better cross-border coordination of protective actions during the early phase of a nuclear accident.- General Mechanism

Stockholm, 22 October 2014

The HERCA-WENRA Approach (Part I) on emergencies was approved by the Board of HERCA on 12 June 2014 and later approved/endorsed by WENRA on 22 October 2014.

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Executive Summary

The Association of the Heads of the European Radiological protection Competent Authorities (HERCA) established its "Working Group on emergencies' (WGE) in June 2011. The mandate of the WGE covered all types of nuclear accidents. With regard to accidents originating from within the boundaries of the HERCA member countries the overall aim of the WGE was to come up with practical and operational solutions leading to a uniform way of dealing with any serious radiological emergency situation, regardless of national border lines. From December 2012 on, 42 experts (from 23 European countries) in nuclear safety, emergency preparedness and radiological protection of the WGE have worked aiming at fulfilling this mandate. As a result, they have proposed a response mechanism for the early phase of an accident for a better cross-border coordination of protective actions, called the "HERCA-Approach" which was approved by the Board of HERCA in June 2014. In developing the approach, the WGE started off by investigating what others had done or were doing, has taken advantage of this work and built on it. It has also acted in a complementary way to these activities, with the aim of reaching maximum mutual benefits. In this context, a representative of the European Commission has participated as observer in these activities and most recently an observer from the IAEA.

The HERCA-WENRA Approach recognises that in European countries, efficient emergency preparedness and response arrangements have been established for many years and are tested and challenged regularly. They allow authorities to issue recommendations for effective public protective actions. In the development of such arrangements, each European state defines its own priorities and objectives in planning for nuclear emergencies directly affecting its own territory, and the international and EU radiological protection frameworks leave large margins of freedom for setting national criteria for intervention. Emergency planning has evolved in all states over many years, mostly without giving great priority to cross-border issues. This has led to differences, sometimes significant. Should a nuclear emergency occur in Europe, these differences can potentially have a significant effect, especially if the location of the emergency is close to a national border. Internationally populations would feel unequally protected, depending on where they live. Aligning protective actions along adjacent national borders is therefore highly desirable.

In the early stages of an accident the uncertainties in terms of dose estimation and overall radiological impact are very large. The status of the reactor, the estimation of the amount and type of radioactivity released (the source term), and the dispersion conditions are very likely to be poorly understood in the first hours. The role of the decision-maker is to arrive at appropriate health protection measures taking into account these uncertainties. This inevitably leaves room for flexibility in decisions, even where there is a rigid national framework. The HERCA-WENRA Approach makes use of this freedom for coordination between neighbouring countries in order to align early decisions across borders. As a result, the respective national arrangements do not necessarily need to be changed. Instead, the prevailing differences are respected and are taken into account, and the response is based on 'compromise' solutions which are understandable and explainable in each given situation.

The HERCA-WENRA Approach on emergencies relies on the following principles: mutual understanding, coordination and mutual trust. It does not aim at proposing a uniform cross border framework to deal with such situations. The main strategy is to aim at an alignment of the response between neighbouring countries, or neighbouring territories. The HERCA-WENRA Approach comprises mechanisms of early information exchanges allowing neighbouring countries to align measures for protective actions by using as far as possible the existing dedicated bilateral and international arrangements. The HERCA-WENRA Approach is divided into 3 steps, the preparedness phase, the early phase and the later phase (development of a common situation report). The approach contains the main principles and leaves necessary margins of freedom for detailed implementation:

- In preparedness the aim is to achieve and maintain a shared understanding of the existing national emergency arrangements through the improvement of bilateral or multilateral arrangements, the testing of these arrangements and the implementation of improvements.
- In the early phase of an accident, the proposed HERCA-WENRA Approach foresees rapid information exchanges by using as far as possible the existing dedicated bilateral and international arrangements, including the exchange of liaison officers as appropriate. If the response is thought consistent, the neighbouring countries can recommend to their governments to follow these recommendations, i.e. adopt the principle that in the first hours, "we do the same as the accident country".
- In the later phase a common situation report, accepted by all impacted countries, will further support coordinated protective actions.

The HERCA-WENRA Approach has been tested and validated against concrete and realistic accident scenarios in NPP's that are close enough to national borders. Therefore a workshop was organized in September 2013. The workshop showed that in case of a sufficient information exchange most countries would be able to recommend to their decision-makers during the very early stages that the advice of the accident country should be followed. Other conclusions of the workshop will be taken into account when developing the guidelines for the implementation of the HERCA-WENRA Approach into the national arrangements.

The HERCA-WENRA Approach has the potential to improve the coherence of the response in case of a nuclear accident with impact on territories of other countries and to be used as guidance to implement Article 99.1[3] and 99.2[4] of the BSS Euratom. It also fulfils recommendation N°12.7.b of the ENCO study and it further addresses some of the other recommendations.

The HERCA-WENRA Approach is an incentive approach that comprises the necessary mechanisms for countries to exchange adequate information and to achieve compromise solutions on a voluntary basis during an emergency allowing for coherent and coordinated protective actions.

[3] Art. 99.1. Member States shall cooperate with other Member States and with third countries in addressing possible emergencies on its territory which may affect other Member States or third countries, in order to facilitate the organisation of radiological protection in those Member States or third countries.

[4] Art 99.2. Each Member State shall, in the event of an emergency occurring on its territory or likely to have radiological consequences on its territory, promptly establish contact with all other Member States and with third countries which may be involved or are likely to be affected with a view to sharing the assessment of the exposure situation and coordinating protective measures and public information by using, as appropriate, bilateral or international information exchange and coordination systems. These coordination activities shall not prevent or delay any necessary actions to be taken on a national level.

Part I. - HERCA-WENRA Approach for a better cross-border coordination of protective actions during the early phase of a nuclear accident - General Mechanism

1. Introduction

The Association of the Heads of the European Radiological protection Competent Authorities (HERCA) [1], identified as early as 2007 the need for an improved and harmonized cross-border approach in response to nuclear emergencies. A working group of HERCA was therefore established and issued a document on emergency preparedness "Practical Guidance – Practicability of Early Protective Actions" [2], which included the definition, aim and rationale of three early protective actions (sheltering, evacuation and thyroid prophylaxis), the planning phase, the intervention phase and the lifting of protective actions. Risk/benefit considerations and linked protective actions (e.g. food restrictions that need to be taken at the same time) were also discussed.

Subsequently the HERCA 'working group on emergencies' (WGE) concentrated its activities related to European nuclear emergency situations on mechanisms to improve the response to such an event. Key factors comprise the achieving of a more rapid exchange of information and the improvement of the coherence of national responses, including balancing radiation protection and social issues.

The present document deals with the development and testing of a response mechanism for the early phase of an accident, called the "HERCA-WENRA Approach". The testing of the approach during a dedicated workshop resulted in good progress, but also revealed several difficulties. The second part of this document presents and discusses those difficulties. Solutions for improvements are proposed, including concrete steps to be implemented through national, bilateral and multinational arrangements.

The HERCA-WENRA Approach on emergencies was approved by the Board of HERCA on 12 June 2014 and later approved/endorsed by WENRA on 22 October 2014.

2. Brief analyses of the given situation

Each European state defines its own priorities and objectives in planning for nuclear emergencies directly affecting its own territory, and the international and EU radiological protection frameworks leave large margins of freedom for setting national planning criteria for intervention. Emergency planning has evolved in all states over many years, mostly without giving great priority to cross-border issues. At the same time, the international framework for planning and response has changed.

This has led to differences, sometimes significant, in:

- Criteria for intervention levels for introducing protective actions (defined in terms of projected dose).
- Types of protective actions.
- Operational intervention levels (action levels based on measurements).
- Methods for assessing source terms.
- Methods for radiological impact assessment and dispersion modelling.
- Definitions of emergency planning zones.

In addition, there are differences between the concepts, e.g.:

- The implementation of protective actions can be based on assessments and calculations or triggers.
- The reference level and dose criteria are for planning purposes or also for response.
- The levels are legally binding or guidelines.
- There are national differences in the interpretation of international guidelines.

Should a nuclear emergency occur in Europe, these differences could potentially have a significant effect, especially if the location of the emergency is close to a national border. Figure 1 illustrates schematically how a particular protective action could be implemented when the decision is purely based on national considerations.

In each individual country, the decision is in line with the national plan and the legal framework, and it is well balanced and justified for the situation in the country given the national framework. However, internationally, populations would feel unequally protected, depending on where they live. An unbalanced cross-border implementation of one or more protective actions would lead to distrust in governmental decisions and potentially to panic. Attempts at explanation of the rational for such differences to the affected populations are not likely to be successful during the crisis. Aligning planning for protective actions along adjacent national borders is therefore highly desirable (see figure 1).

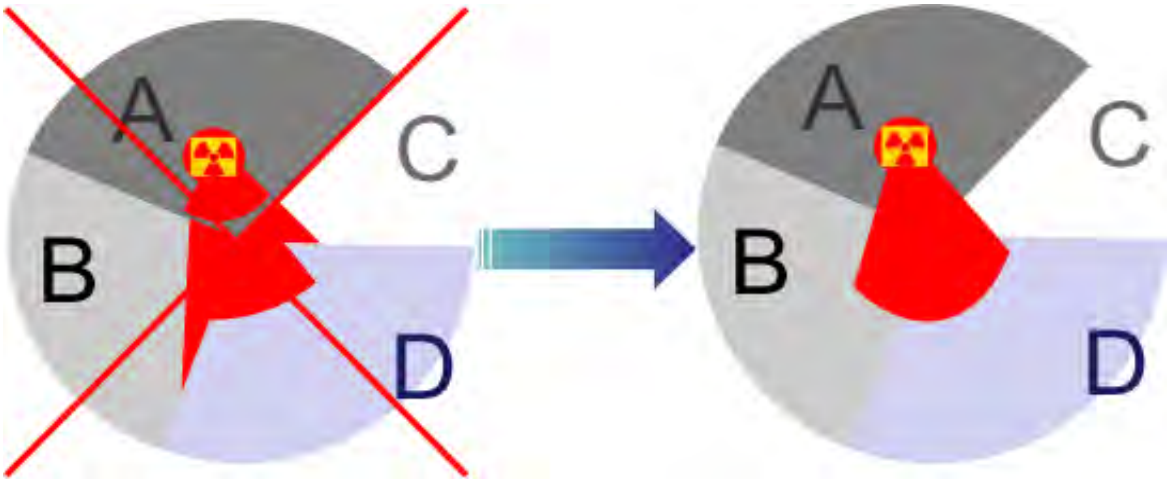


Figure 1: Country A has a nuclear emergency close to the borders of three others countries. All four countries are affected. Each country decides on a particular protective action individually. The protective action applies to the areas marked in red, for each country. The aim is to align protective actions.

3. The HERCA-WENRA Approach for the early phase

From December 2012, the WGE, in cooperation with members of WENRA, developed a new so-called "HERCA-Approach", relying on the following principles: mutual understanding, coordination, mutual trust and alignment of recommendations for decisions between neighbouring countries, or neighbouring territories, as the main strategy. The Board of HERCA had approved these principles on the occasion of its 10th meeting in Paris (30-31 October 2012). The basic aim is to develop mechanisms for implementing protective actions during an emergency in a consistent way along national borderlines but without – necessarily - changing the respective national arrangements. Instead, the prevailing differences are respected and are taken into account, and the response is based on 'compromise' solutions that are understandable and explainable in each given situation.

In the early stages of an accident the uncertainties in terms of the overall radiological impact are very large (see also figure 2).[5] The role of the decision-maker is to arrive at appropriate health protection measures despite this uncertainty. This inevitably leaves room for flexibility in decisions, even where a rigid national framework exists. The WGE believes that this freedom can be used for coordination between neighbouring countries in order to align early decisions across borders.

[5] WENRA and HERCA established the HERCA-WENRA taskforce that started in March 2014 to agree on common principles for advice in the early hours of a severe nuclear emergency. The difference between both approaches is that the general mechanism of the HERCA-WENRA Approach deals with accident scenarios with sufficient information for a technical assessment, whereas the HERCA-WENRA taskforce focuses on severe accidents where either no or not enough reliable information for a technical assessment is available or the rapid development of the accident does not leave sufficient time.

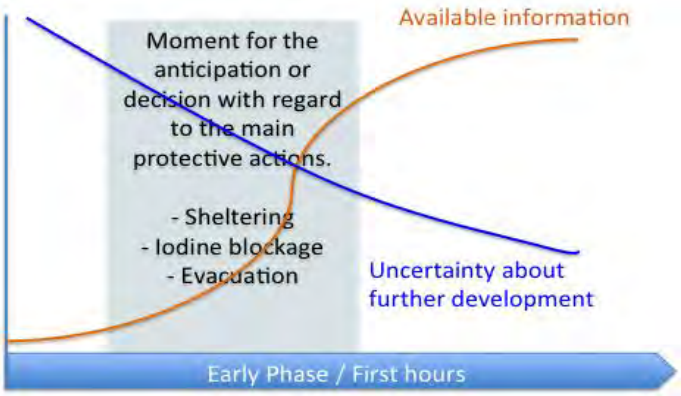


Figure 2: Factors influencing emergency decisions in the early phase of an accident.

For the early phase of an accident, the proposed HERCA- WENRA Approach comprises mechanisms of early information exchanges allowing neighbouring countries to align measures for protective actions by using as far as possible the existing dedicated bilateral and international arrangements.

This objective is in line with article 99 of EU-BSS calling for Member States to cooperate with other Member States and with third countries in addressing possible emergencies on their territory which may affect other Member States or third countries, in order to facilitate the organisation of radiological protection in those Member States or third countries.

The HERCA- WENRA Approach is divided into 3 steps, the preparedness phase, the early phase and the later phase (development of a common situation report). The approach contains the main principles and leaves necessary margins of freedom for detailed implementation. Compared to an earlier version, the approach below has been updated following the discussions at the workshop and the subsequent WGE meetings.

In preparedness

- Develop or improve already existing bilateral or multilateral arrangements, following a graded approach (i.e. the greatest priority is given to arrangements with the closest countries, and less urgent priority is given to countries at greater distances), with the goal of achieving and maintaining a shared understanding, taking into account the following:
    - National organizations:
        - General arrangements and information.
        - Stakeholders are involved in the emergency situations.
        - Facilities or reactors technologies.
    - National Emergency arrangements.
    - National strategies.
    - National expertise:
        - Assessment methods and tools (diagnosis, prognosis, environmental impact, etc.),
        - Information needed to understand correctly the products of national expertise (i.e. this may be available on restricted web pages – see below).
    - Arrangements regarding information exchange (what kind of information, ways to exchange it) during the accident and the deliverables (contents and frequency):

        - Forms, maps, technical and radiological data.
        - Information regarding countermeasures already implemented or planned to be.
        - Media information or press statements.
    - Trans border coordination mechanisms for protective measures in the response phase.
    - Communication policies to explain discrepancies in protection measures.
    - Joint public communication campaigns.
- Test arrangements and implement improvements.

Early phase / First hours

- The accident country should provide and update information required to the understanding of the situation and make available on-site and off-site assessments, using bilateral, multinational and international arrangements.
- Exchange of liaison officers and access to restricted websites may be arranged.
- Based on the information provided by the accident country and knowing the accident country's emergency arrangements, the neighbouring countries should be able to verify quickly if the response in the accident country is consistent with these arrangements.
- If the response is thought consistent, the neighbouring countries can recommend:
    - To their governments: if the accident country provides a recommendation for protective measures affecting part of the territory of the neighbouring country, to follow these recommendations i.e. adopt the principle that in the first hours, **"we do the same as the accident country".**
    - To their embassies: to protect their own nationals living in the accident country, by following the recommendations delivered by the authorities of the accident country.
- If the response is highly inconsistent, the neighbouring countries will urgently try to agree on an alternative position, which, together with their reasons, will be communicated to the accident country. The neighbouring countries should inform the competent authorities in the other European countries of their provisional position and the results of coordination.

Development of a common situation report

- The development of a common situation report is a major step towards more coordinated protective actions.
- Within the framework of the post-Fukushima action plan, the IAEA is currently developing mechanisms for an independent assessment and the production of a common situation report available for all Member States.
- The WGE will continue to analyse in more depth what has been proposed by the IAEA, and will then identify possible synergies and evaluate the potential for cooperation with the IAEA.

During its 12th meeting on 26-27 November 2013, the HERCA Board unanimously confirmed that the Approach fulfils the expectations of the Board in general terms.

4. Cologne WORKSHOP

4.1. Preparation of the workshop

As part of this work, the HERCA- WENRA Approach needs to be tested and validated against concrete examples, such as realistic accident scenarios in NPP's that are close enough to national borders. Therefore a first workshop was organized in September 2013. Some realistic accident scenarios in NPPs that are close to national borders were developed. The main goal was to explore whether the HERCA- WENRA Approach may potentially work, and also to identify difficulties.

Three scenarios with risks of considerable releases were prepared in advance, allowing participants some pre-preparation. The scenarios chosen were:

- NPP-Loviisa-1: The latest 8-countries exercise in Finland was used. STUK made its 15 situation reports available in English (USIE-format). The scenario was a real-time 12 hours exercise with 3 key moments, where decisions needed to be recommended or anticipated. In this scenario, no territory outside Finland was directly concerned with the main protective actions during the duration of the exercise. The main reason for providing this scenario for the Cologne workshop was to indicate how much information an accident country is able to provide in real time and in English.
- NPP Cattenom: IRSN had prepared a core melt scenario with risk of filtered venting. Detailed information was included in 5 IRSN and 3 ASN messages, the latter ones in the USIE format. The scenario contained two key moments, where decisions needed to be recommended or anticipated. In the earlier stage Germany and Luxembourg were concerned with protective sheltering and iodine blockage. The potentially large releases from a filtered venting threatened the territories of Luxembourg and Belgium where additionally evacuations needed to be considered.
- NPP Emsland: The BfS had prepared a short scenario concerning the NPP Emsland. It did not comprise elaborated technical details on the situation of the reactor, but contained key messages to be shared with the participants. The scenario was limited to the threat phase with a potential release along the border between Germany and the Netherlands (protective actions needed to be considered on both sides of the border). The two countries had agreed on the scenario beforehand.

4.2. Conduct of the workshop

The workshop took place on 24 September 2013 in Cologne at the GRS. 18 participants from 10 countries attended the workshop, during which participants responded to a predefined set of questions for each key moment of the 3 scenarios. The questions were:

1. Would we in reality have informed others that early?
2. Do we understand the information received from the accident country? If not, what is the issue?
3. Is the information consistent?
4. Is information missing? If yes, what?
5. As neighbouring country: Would we be able to align our recommendations with the protective action(s) as proposed by the accident country? If not what are the obstacles or concerns?

6. Would we be able to advice our citizens living in or visiting the accident country to follow the advice for protective actions of the accident country?
7. To those countries who are not a neighbouring country: If we were a very close neighbouring country (within the range of protective actions), would we be able to align our recommendations with the protective action(s) as proposed by the accident country?

Participants provided answers to those questions during the workshop as far as they were able to prepare themselves for the workshop and within the limits of a tight timescale. In particular WGE participants stressed the need for technical support from their national experts. Therefore, after the meeting, workshop participants and all other HERCA-WGE members had the opportunity to provide the missing answers in writing. In total, answers were received from 12 countries.

5. Main issues discussed at the workshop

The overall impression from all participants was very positive. The exercise of sitting together and having open and direct dialogues on concrete and relatively realistic accident scenarios was very useful. This gave raise to several interesting discussions.

Most participants thought that in the very early stages they would be able to recommend to their decision-makers that the advice of the accident country should be followed.

More discussion took place with regard to a possible alignment of recommendations for protective actions along national borders. However it has to be noted that the context of the discussion was somehow artificial. To imagine the coordination of protective actions between countries which do not share a common border is indeed difficult (see question 7). One key difficulty in such a discussion is clearly the missing knowledge of the arrangements in the accident country. Discussions concerned issues around the use of definitions and methodologies (for example, in dose calculations), the application of different decision criteria in the accident country and the extension of measures beyond EPZ's, to name only a few examples. Also societal particularities, such as the density of population, are potentially very different, for example between Nordic countries and West European countries.

The configuration of the workshop also permitted the accident country to provide missing information. With such additional explanations, most participants thought it would be possible to recommend to their own decision makers to 'do the same as the accident country'. This finding confirms the need for effective pre-emergency arrangements and shared understanding of these between all countries.

In a few countries, it seemed at the workshop, that the possibilities of adjusting recommendations during an emergency to favour coherent protective actions were very limited. These countries are obliged by law to do their own assessments and/or to recommend protective actions based on their own intervention levels. The workshop participants discussed several technical possibilities to overcome these difficulties. However no real solution emerged for these cases.

The WGE has undertaken more in-depth analyses of the workshop after having received all written answers. The main findings of this work are presented and discussed in the following chapter.

6. Main Findings of the workshop

6.1. Findings

The most important findings of the workshop were:

- Mutual knowledge of EPR arrangements is essential to make the HERCA-WENRA Approach work;
- Frequent updates by the accident country on the situation are essential for other countries to be able to verify the response in the accident country and are a pre-condition for them to be able to advise their decision-makers to follow the accident country;
- Most countries (not being neighbouring countries) were able to recommend their own citizens in the affected area to follow the advice given by the accident country based on the available information;
- The success of a harmonized approach between neighbouring countries is strongly influenced by bilateral agreements;
- Different values in decision criteria can result in a different advice than the one given by the accident country.

In the following paragraphs, the main elements of those findings are elaborated in more detail.

6.2. Information to be provided by the accident country through its first messages

A limited amount of information is available to be included in the first message. The type of information available for being included in the first message depends on the accident scenario. The present report does therefore not distinguish between the first message and the subsequent updates, but only refers to those in general terms as “Early Phase Messages (EPM)”. As a guiding principle, speed and accuracy are considered more important than quantity or completeness of information. Frequent updates are necessary.

Issue	Rational
(Conservative) evaluation of the potential hazard area.	Favours a common understanding and coherent communication internationally. Helps to give early assurance to populations outside this area.
Reports that contain maps, dispersion calculations and pictures.	Useful internationally for communication and similar purpose. Should be annexed to EMERCON forms.
Use of short message systems.	Essential to be used in case the situation changes rapidly (e.g.: update of emergency classification). It is recommended to the IEC to provide such a tool within USIE.
Include other operational measures, such as traffic restrictions, food restrictions, etc.	Important information for direct neighbouring countries (e.g.: hotlines). Helps deciding on travel advice. This possibility is included in the EMERCON forms, both for food and traffic. One may even add

Issue	Rational
	"other" measures
Clearly distinguish whether a protective action is, planned, recommended, decided (ordered) or implemented (taken).	The EMERCON form only asks to *"Describe protective actions that are planned, ordered, taken or withdrawn".* There is a need for clarity, in particular informing on recommendations for protective actions.
Prognosis for development, including a worsened case scenario (on a case by case basis).	This seems particularly useful in cases of a cliff edge effect (when consequences could dramatically worsen) or when failure of a further barrier is probable. In other situations such a scenario may be misleading and even favouring differences in decisions across national borders.
All responding countries enter information related to their decisions into USIE	This allows all countries, but in particularly the accident country, to reduce the burden on communication, i.e. the accident country may anticipate public discussions that may be stimulated by decisions taken elsewhere.

Table 1: Issues that are presently not considered by the EMERCON forms but that are worth exchanging through the EPM.

The WGE recommends that all countries should make full use of the USIE system and related EMERCON forms to inform the competent authorities of neighbouring countries and the international community. The workshop confirmed that the type of information foreseen to be exchanged by the EMERCON forms is vital in the early phase. In particular, the accident country should enter information on the classification of the emergency and its basis for declaration as early as available. For the provisional INES classification it should be borne in mind that the INES classification refers to the actual situation rather than to a possible degradation.

Besides, the workshop identified a couple of issues that are presently not considered by the EMERCON forms but that are worth for exchanging through the EPM. Those issues and their rational are given in Table 1.

Restricted websites exist in several countries with up-to-date information concerning the development of the accident. In some cases, authorities from neighbouring countries, the IEC and the EC have access to those sites during an emergency. In other countries, similar projects are under discussion. As a result of the workshop, it seems indeed a very good practice since the direct access to such a restricted website allows the technical expertise organizations in neighbouring countries to follow the situation in a timely manner as it develops. This permits anticipation and preparation for necessary developments and decisions. It also fosters a common understanding of the situation. As such, this finding confirms the HERCA-WENRA Approach as given in § 3.

A prerequisite for a successful implementation is a consistent mutual or bilateral agreement with the objective of co-ordinating activities in a wider area. A situation where neighbouring countries use the information provided to implement measures unilaterally has to be avoided. Finally, training will be needed before being able to understand the national expertise products.

6.3. Information to be exchanged in preparedness

The workshop demonstrated again how many differences in emergency preparedness arrangements actually exist. Harmonizing all those differences seems highly unrealistic. Therefore the aim of the HERCA-WENRA Approach to achieve from the beginning alignment of protective actions during the response, taking prevailing differences in preparedness into account, can be seen to be the correct approach.

As a minimum prerequisite, countries need to have sufficient knowledge of each other's arrangements. In this context, the workshop confirmed that good knowledge of the arrangements in the accident country helps to understand and to agree with decisions taken in that country. It further helps other countries in particular on the derivation of the accident country's recommendations for their own population. Indeed, neighbouring countries that, during the workshop, knew the arrangements in the accident country well enough could follow the HERCA-WENRA Approach more easily.

It also became clear that including this type of information in the first messages is not feasible, unless prepared and discussed beforehand. In that sense, although the HERCA- WENRA Approach is purely designed to improve coordination during response, pre-emergency arrangements are vital.

Otherwise the statements of the accident country will not be understood and will not be followed.

One possibility to effectively exchange this type of information would be the establishment of country factsheets. Those sheets should be short (approx. 2 pages), visual (to enable information to be found very quickly), factual and concise (i.e. key words rather than full sentences). The WGE should establish those factsheets and develop an appropriate solution for regular updates and dissemination.

6.4. Bilateral arrangements

The success of a harmonized approach between neighbouring countries is strongly influenced by bilateral arrangements (or multilateral if more than 1 country will be directly influenced by an accident within a certain NPP). This makes it easier to verify the assessment of the accident country and gives more understanding to the neighbouring countr(y)(ies). Understanding the response of the accident country is very important for advising decision-makers to harmonize their response with the accident country.

Additionally the arrangements shall contain provisions for coordinating the media response and for communicating well in advance about decisions and the reasoning behind those decisions, in particular in those cases when different decisions are unavoidable.

The WGE should develop guidelines for the establishment of these arrangements. Where an NPP is close to more than one other country, multilateral arrangements should be envisaged.

6.5. Key differences and potential obstacles for aligning recommendations for protective actions along national borderlines

Since emergency preparedness arrangements differ widely between European countries, it was to be expected that the verification of the HERCA-WENRA Approach against concrete accident scenarios would result in identifying situations where aligning recommendations for protective actions is not realistic. The workshop indeed revealed a few obstacles that may jeopardize the possible success of the HERCA-WENRA Approach. On the other hand, such obstacles cannot be generalized and depend largely on the situation and on the country concerned.

Table 2 gives an overview of the main difficulties that were identified. For most cases, it seems possible, nevertheless, to substantially reduce their impact through adapted solutions, as highlighted in the right column of the table.

Difficulties	Improvements to be implemented
Information not correctly understood (e.g.: definition, classification of the emergency different to IAEA, Basis for decisions, etc).	Increase knowledge of national arrangements and assumptions (country fact sheets, see § 6.3)
Information too late or too slow, not permitting other countries to prepare for necessary protective actions on the necessary timescale.	Improve quality of first messages (see § 6.1); Make use of single short messages to a specific subject or event between the regularly sent EMERCON forms; Grant access to restricted websites with the "national expertise product".
Different decision criteria, (e.g. action levels or triggers) used by the accident country, not used and/or not known by others.	Increase knowledge of national arrangements (country fact sheets, see § 6.3). The workshop has also shown that a good knowledge of the decision criteria used in the accident country helped most other countries to appreciate related decisions and to adapt their response, even if such criteria were otherwise not used.
Different values in decision criteria (e.g.: intervention levels). In a couple of countries intervention levels need to be used on a mandatory basis to trigger protective actions with only minor room for other considerations in issuing recommendations.	The new EU-BSS [3] has introduced the concept of "reference levels" for emergency and existing exposure situations. It allows for the protection of the individual as well as consideration of other societal criteria in the same way as dose limits and dose constraints for planned exposure situations. The obligation for the Member States to implement the new EU-BSS gives a unique chance for improved understanding and the implementation of adjustable criteria and the reduction of differences across Europe.
While appreciating different criteria, most authorities limit their considerations to their own territory. (the potential hazard	Need for systematic bilateral agreements that allow to look at the potential hazard area as a whole and to coordinate activities effectively during the

Difficulties	Improvements to be implemented
area is not regarded as a whole)	response between the involved bodies.
In a few countries, recommendations need by law to be based on own independent assessments following strict decision triggers.	There seem to be only a few countries concerned. However in those cases a successful implementation of the HERCA-WENRA Approach could be seriously jeopardized. The new EU-BSS may possibly help.
International requirements and recommendations are differently interpreted across Europe. This seems to be a major challenge.	More detailed work needed on listing the basis for each country, e.g. the use of reference levels, the legally binding criteria, the use of triggers. However, the new BSS present possibilities for further harmonisation, as above.
Extendibility of protective measures beyond EPZ's from an operational point of view.	Need for systematic bilateral agreements. It will be important to clearly define operational limitations (how far and how much can be extended) and how the responsibilities are assigned in each country. (In some countries the advisory body considers operational issues when issuing recommendations).
Advices on travel and traffic remain uncoordinated.	Implementation of the recommendations from the HERCA report "Practical proposals for further harmonisation of the reactions in European countries to any distant nuclear or radiological emergency" [4]

Table 2: Overview of the main difficulties that were identified.

7. Summary of the main findings

The workshop has enabled the WGE to clearly identify the following issues that need to be developed and implemented to allow best use of the HERCA-WENRA Approach:

- Implement nationally the guidelines included in chapter 6.1 for improving the effectiveness of the first messages.
- Development of country fact sheets;
- Development of a list of issues to be dealt with in bilateral or multilateral arrangements;
- Develop a common understanding of key elements of the new EU-BSS [3] and aim at reducing differences through a coordinated transposition and a better application of international recommendations. The EU-BSS does support such changes as they give the opportunity to review our basic principles of radiation protection in emergency situations.

Additionally, as a result from the workshop, the WGE makes the following recommendations:

- Make use of short message information exchange during the response;

- Countries should consider granting access to restricted websites and exchanging liaison officers;
- Always consider the whole affected area, independent of a national border, when making decisions.
- Aligning protective measures along borders should be a factor in decision-making.

8. Conclusions and further steps

The workshop has demonstrated that the HERCA-WENRA Approach has the potential to improve the coherence of the response in case of a nuclear accident with impact on territories of other countries. It was also shown that the approach allows for the assurance – sometimes deemed necessary - that things are done properly in the accident country. This permits in particular to recommend one's own citizens, who stay in the affected area, to follow the advice from the accident country.

A further positive result is the confirmation that the HERCA-WENRA Approach, as given in § 3, contains all necessary elements, ideas and principles needed.

While it may remain difficult to completely eliminate the occurrence of differences and inconsistencies in the response, the aim of the approach should be that this becomes the exception rather than the rule. In those cases where two countries take unavoidably different approaches, they shall coordinate their media response and communicate well in advance about their decisions and the reasoning behind those decisions. A systematic implementation of the findings of the present report (see summary in § 7) will certainly help to significantly improve towards the overall objective of the HERCA-WENRA Approach.

References

[1] HERCA the Association of the Heads of the European Radiological protection Competent Authorities; Radiation Regulator, Volume 1, Number 1.

[2] Emergency Preparedness. Practical Guidance – Practicability of Early Protective Actions; www.herca.org

[3] Council Directive 2013/59/EURATOM of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom.

[4] Practical proposals for further harmonisation of the reactions in European countries to any distant nuclear or radiological emergency; www.herca.org

Definitions

Accident country	The country where the nuclear or radiological emergency has taken place.
Affected countries	The countries that are not the accident country where protective actions need to be considered because of a transborder radiological contamination.
HERCA/WENRA countries	Each country represented through one or more authorities within HERCA/WENRA.
HERCA/WENRA members	Each authority who is a member of HERCA/WENRA.
Impacted countries	Countries that are not necessarily affected countries but which need to issue recommendations for their own citizens in the affected area, including travel arrangements.

List of acronyms

EMERCON: Emergency Convention

EP&R: Emergency Preparedness and Response

EPM: "Early Phase Messages" the first message and the subsequent updates distributed by the accident country in the early phase

EU-BSS: Council Directive 2013/59/EURATOM of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom.

HERCA: Association of the Heads of the European Radiological protection Competent Authorities

IAEA: International Atomic Energy Agency

IEC: Incident and Emergency Centre

MFA: Ministry of Foreign Affairs

NPP: Nuclear Power Plant

TSO: Technical Support Organisation

USIE: Unified System for Information Exchange on Incidents and Emergencies

WENRA: Western European Nuclear Regulators' Association

WGE: HERCA working group on emergencies

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ASN – Autorité de Sûreté Nucléaire; **BABS** - Bundesamt für Bevölkerungsschutz; **BfS** – Bundesamt für Strahlenschutz; **BMLFUW** - Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management; **BMU** – Bundesumweltministerium; **BNRA** – Nuclear Regulatory Agency; **CSN** - Consejo de Seguridad Nuclear; **DRP** – Division de la Radioprotection; **EC** – European Commission; **ENSI** - Swiss Federal Nuclear Safety Inspectorate; **FANC/AFCN** – Federal agency for nuclear control; **GR** - Icelandic Radiation Safety Authority; **GRS** – Gesellschaft für Reaktorsicherheit **ILT** - Inspectie Leefomgeving en Transport; **IRSN** - Institut de Radioprotection et de Sûreté Nucléaire; **Minez** - Ministerie van Economische Zaken; **NCRRP** - National Center of Radiobiology and Radiation Protection; **NRPA** – Norwegian Radiation Protection Authority; **OFSP** – Federal Office of Public Health; **ONR** - Office for Nuclear Regulation; **OSSKI** - National Research Institute for Radiobiology and Radiohygiene; **PHE** - Public Health England; **RPII** - Radiological Protection Institute of Ireland; **SNSA** - Slovenian Nuclear Safety Administration; **SSM** - Swedish Radiation Safety Authority; **STUK** - Radiation and Nuclear Safety Authority.

HERCA
Heads of the European Radiological protection Competent Authorities

Western European
WENRA
Nuclear Regulators' Association

Part II.-

HERCA-WENRA Approach in case of a Severe Accident requiring Rapid Decisions for Protective Actions, while very little is known about the Situation

Stockholm, 22 October 2014

The HERCA-WENRA Approach (Part II) on emergencies was approved by HERCA and WENRA on 22 October 2014.

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Executive summary

The HERCA-WENRA task force was established jointly by HERCA and WENRA. It included 21 experts in nuclear safety, emergency preparedness and radiological protection, belonging to 14 different countries. The HERCA-WENRA task force operated between March and September 2014. Its mission was to identify a common European approach addressing a severe accident affecting one or more nuclear power plant(s), and requiring rapid decisions for protective actions, while very little information is available. The HERCA-WENRA task force has built on existing European approaches, namely the NERDA, Nordic and HERCA approaches. IAEA developments and recommendations in emergency preparedness and response have also been considered.

HERCA and WENRA recognize that in European countries, efficient emergency preparedness and response arrangements have been established for many years and are tested and challenged regularly. They allow authorities to issue recommendations for effective public protective actions. In many cases, the current arrangements require exchange of a significant amount of information between the plant and the responsible authorities. However, past experience shows that the possibility of severe accidents without the information required by the current arrangements on the plant status in the initial stage cannot be completely ruled out. Such accidents could be as severe as the Fukushima one, affect more than one European country and require rapid protective actions in several of them.

HERCA and WENRA propose a general approach for dealing with the initial stage of such highly improbable cases. This approach, called the “HERCA-WENRA approach”, can serve as a basis to complement, when necessary, existing arrangements in the initial phase of an emergency situation and allow better coordination of protective actions between countries. The HERCA-WENRA approach proposes that, in case of a severe accident with great uncertainty about the situation, protective actions to be recommended to the decision makers be decided on the basis of the plant status and weather conditions. Three so-called Judgement Evaluation Factors (JEFs) are proposed: core melt risk, containment integrity and wind direction. The HERCA-WENRA approach assumes that a General Emergency (or an equivalent emergency class) is declared when a risk of core melt exists.

The JEFs have to be evaluated using expert judgement based on the nature of the event which has initiated the accident (e.g. earthquake, flooding, airplane crash), the information which can be obtained from the plant and the pre-existing knowledge of its behaviour under extreme conditions. As a first step of a general approach, HERCA and WENRA have only considered three direct protective actions: evacuation, sheltering and iodine thyroid blocking (ITB).

If the HERCA-WENRA approach has been initiated and core melt is judged possible, a precautionary approach is applied and the following actions shall be implemented: evacuation over a distance of 5 km, and sheltering and ITB over a distance of 20 km. However, if it is assessed that, additionally, containment integrity is lost, more serious actions would become necessary, such as evacuation up to 20 km, and sheltering and ITB up to 100 km. Depending upon the

prevailing and forecast wind conditions, protective actions are implemented either on a circular area around the plant or on a limited number of sectors of this circular area. The precise extension of the areas where protective actions are recommended is also adjusted as a function of demography, wind speed and stability.

It shall be noted that countries may have protection strategies more stringent than the conclusions of the HERCA-WENRA Task Force. Safety authorities in neighbouring countries should agree on consistent recommended protective actions.

Considering the safety level of European nuclear power plants and their improvements resulting from the lessons learned from the Fukushima disaster, HERCA and WENRA recognize that the probability of an accident comparable to Fukushima, which would require evacuation up to around 20 km and sheltering and ITB up to around 100 km, is very low.

Therefore, HERCA and WENRA consider that in Europe:

- **evacuation should be prepared up to 5 km around nuclear power plants, and sheltering and ITB up to 20 km;**
- **a general strategy should be defined in order to be able to extend evacuation up to 20 km and sheltering and ITB up to 100 km;**
- **nuclear and radiation safety authorities in Europe should continue attempts to promote compatible response arrangements and protection strategies amongst the European countries.**

Part II

HERCA-WENRA Approach in case of a Severe Accident requiring Rapid Decisions for Protective Actions, while very little is known about the Situation

1. Introduction

On January 15, 2014, a HERCA-WENRA extraordinary meeting held in Brussels established an Ad hoc High-Level Task force on emergencies. Its assigned task was to identify common European principles addressing nuclear emergency response decisions, in case of a severe accident affecting one or more nuclear power plant(s) and requiring rapid decisions for protective actions, while very little is known about the situation.

Between March and September 2014, the 21 high ranking members representing 14 countries met on four occasions. Coming from the fields of nuclear safety, emergency preparedness and radiological protection, they framed the HERCA-WENRA Approach, using the existing European approaches (NERDA, Nordic and HERCA) as a basis. IAEA developments and recommendations in emergency preparedness and response have also been considered. The following paper is the result of these discussions.

2. General Context

In European countries, emergency preparedness & response (EP&R) arrangements for nuclear power plants have been developed over many years. Nuclear and radiation safety authorities have established mechanisms with the nuclear power plants within their country to enable them, even under very difficult conditions, to have access to sufficient information and plant parameters for independently assessing the situation, both at the plant and concerning possible off-site consequences. This allows the authorities to issue recommendations for effective public protective actions, tailored to the possible or actual radiological exposure situation of the population. Drills are performed regularly through emergency exercises in order to train the teams and provide them with experience, which is in turn used to further improve the current arrangements.

However, in the case of the major nuclear accidents that have occurred in the past, namely Chernobyl and Fukushima, the situation was far less clear. Particularly for Fukushima, information was sparse during the early phase. At best only preliminary assumptions could be made on a

possible status of the plant, its evolution, and radiological consequences for the population and environment. In spite of the insufficient and unreliable information, it was necessary for the Japanese authorities to decide rapidly on protective actions for their population.

In Europe, both operators and authorities have sought to learn the main lessons from those accidents in order to strengthen their lines of defence. Should an accident occur, it is particularly vital to maintain functional communication channels between the plant(s) and the responsible authorities at all times, so that relevant and justified decisions can be made to attenuate the consequences of the situation.

Nevertheless, the possibility of a severe accident scenario with no or insufficient information on the plant status cannot be completely ruled out. Furthermore, the immediate effects of such a severe accident in Europe would most probably affect more than one country. This calls for the coordination of the approach to be followed in that case, to allow mutual understanding, consistent and fast decisions of countries affected by an extreme situation of this kind.

Independently of the root cause of the accident, several scenarios can be imagined where being able to use an assessment with projected doses to the populations as a basis for decision making is not realistic. This may be the case when:

- Little or no information from the plant is available (e.g. communication systems have failed such that nothing is known concerning the availability of any safety systems, the status of the reactor core and/or the primary circuit and/or the containment).
- The threat of a large/significant radiological release cannot be reliably estimated.

Since such a severe accident cannot be completely ruled out, the WENRA – HERCA extraordinary meeting of 15 January 2014 in Brussels decided to create an Ad hoc HERCA-WENRA High-Level European Task force in order to identify shared principles on how to address such an extreme situation.

In that context, the HERCA-WENRA Approach focuses explicitly on these extreme cases, producing a framework for European countries as guidance in formulating their detailed EP&R arrangements for an accident involving one or more nuclear power plant(s). Potentially affected countries would benefit from more detailed preparation specifically addressing the issues unique to these types of accidents.

Pre-existing agreement on the approach and actions to be taken in case of such extreme conditions would also significantly enhance the confidence of authorities in charge of protective actions. This is particularly the case for authorities of the countries neighbouring the country where the accident occurred.

It finally needs to be noted that past attempts to reduce differences between national EP&R arrangements were generally not very successful. Any success on agreeing upon common principles for these severe accident scenarios may improve mutual understanding and allow for better coordination of protective actions between countries, including coherence and consistency in early communications to the population across Europe.

Between March and September 2014, the HERCA-WENRA Task Force has developed a shared position for recommendations of generic protective actions for the early phase of those particular

nuclear emergency situations at nuclear power plants (NPPs) in operation when only information on the type of event, internal or external, the possibility of core melt and very little other information is available, including cases where the local operator no longer has the means to understand the situation or to communicate about the situation. At the present stage, the focus of the HERCA-WENRA Task Force lies on three direct protective actions: evacuation, sheltering and iodine thyroid blocking (ITB).

The present paper intends in no way to foreclose any national political decision as to whether or not to implement the proposed protective actions. The main intention is to give an outline on protective actions that may need to be considered. The aim of the HERCA-WENRA Task Force is to provide a common approach relevant to specific situations that can serve as a basis to complement, when necessary, existing arrangements in the initial phase of an emergency situation and allow better coordination of protective actions between countries.

It shall be noted that countries may have protection strategies more stringent than the conclusions of the HERCA-WENRA Task Force. Safety authorities in neighbouring countries should agree on consistent recommended protective actions.

3. Mechanisms for triggering decisions during an emergency situation

During the very early phase of any accident, the decision needs to be taken whether available information is sufficient to support a normal national assessment in a timely manner or whether the country faces an accident with great uncertainty about the situation. In the latter case, recommendations of protective actions have to be defined following a simplified scheme, hereafter referred to as the "HERCA-WENRA Approach". The normal national EP&R approach and the HERCA-WENRA Approach comprise as a whole the overall national approach. The different parts of the overall national approach, the normal approach and the HERCA-WENRA part, have to be compatible to ensure a smooth transition from one part to the other. The country where the accident occurs has the responsibility to judge which approach is appropriate and to organize if necessary the transition between the HERCA-WENRA Approach and the normal national approach.

It is therefore proposed that countries with operating nuclear power plants establish appropriate internal mechanisms, preferably within the competent regulatory authorities for nuclear safety and radiation protection (hereafter referred to as "safety authorities"), for triggering these decisions in a timely manner. The criteria to initiate the HERCA-WENRA Approach are any event, internal or external hazard, including a terrorist attack that might lead to large radioactive release in combination with a lack of the information necessary for applying the normal national EP&R arrangements.

Concerning the necessary decisions for protective actions in neighbouring countries, bilateral arrangements need to contain specific mechanisms for rapid exchange of relevant information between safety authorities. If the notification provided by the safety authority provides elements affecting parts of the territory of the neighbouring country, the neighbouring country should aim at doing the same as the "accident country"[6]. Such a mechanism would be in line with the principles of the general mechanism of HERCA-WENRA Approach.

[6] Country where the affected NPP is located

Generally, the need for simplified decisions using the HERCA-WENRA Approach will only apply during an initial phase. As soon as the accident country is in a position to present a more elaborate assessment of the plant status and the expected off-site impact, it shall take the necessary steps to align its decisions and cross-border coordination mechanisms accordingly.

It is finally emphasized that early information exchanges between neighbouring countries represent an essential element for a successful and coherent cross-border implementation of protective actions. The present paper shall nevertheless in no way provide a justification to neighbouring countries to unilaterally apply the HERCA-WENRA Approach.

4. Basic considerations of the HERCA-WENRA Approach

The HERCA-WENRA Approach is conceived as a general framework. It proposes a methodology for a common European approach allowing to recommend urgent protective actions as well as a minimum common level of preparation for these actions. Detailed implementation aspects will be provided in a second step, provided the methodology is accepted by HERCA and WENRA.

To initiate the HERCA-WENRA Approach (in case of any event, internal or external hazard, including a terrorist attack that might lead to a core melt and for which insufficient information is available to apply the national EP&R arrangements), the protective actions shall be based on the three so called Judgment Evaluation Factors (JEFs):

JEF	Description	Possible values of JEF		
1	Is there a risk of core melt?	Yes	No	Unknown
2	Is the containment integrity maintained?	Yes	No	Unknown
3	Is the wind direction:	Steady	Variable	Unknown

Table 1: Definition of JEFs

Note: If a General Emergency (or an equivalent emergency class) is declared, it is considered that a risk of core melt exists.

Initial containment integrity characterizes the overall structural state of the containment immediately after the initial event. Containment integrity could for example be considered lost after an airplane crash or if the initial event occurs while the containment is open. During the course of the accident, a small increase of containment leakage should not lead to an estimation of loss of containment integrity. However, if a drastic event like a violent internal explosion is expected, then containment integrity should be considered as lost (JEF 2 = No).

Wind direction should be considered, if known, in the period where large releases are expected.

5. Protective actions considered in the HERCA-WENRA Approach

The following protective actions have to be considered in the very early phase:

- **Evacuation**
  The rapid, temporary removal of people from an area to avoid or reduce short-term radiation exposure during emergency.

  It must be noted that there is a certain risk that evacuation will take place under the plume.

  The HERCA-WENRA position on this issue is detailed in § 8.4.

- **Sheltering**
  The use of a structure for protection from an airborne plume and/or deposited radionuclides.

- **Iodine Thyroid Blocking (ITB)**
  The administration of a compound of stable iodine to prevent or reduce the uptake of radioactive isotopes of iodine by the thyroid in the event of an accident involving radioactive iodine releases.

The protective action “Ban on harvesting and grazing” and actions like access control, which are part of the normal EP&R approach, are not considered by the HERCA-WENRA Approach at this stage.

Information to the public and the neighbouring countries as well as notification of and information to international organisations (IAEA and ECURIE) are of primary importance in any case.

6. Protective action zones considered in the HERCA-WENRA Approach

The protective actions should be planned up to distances of 5 km for evacuation and 20 km for sheltering and ITB. An extension to larger distances should also be considered for instance to take into account situations where containment integrity is lost (JEF 2 = No) (e.g. plane crash or large internal explosion) and large releases are expected.

It should be noted that existing planning zones such as the Precautionary Action Zone (PAZ) and the Urgent Protective Action Planning Zone (UPZ) should be used and adapted if already implemented in national emergency response plans. Local specificities (e.g. demographics and geography) should be taken into account to determine the exact shapes of the zones where the protective actions are implemented.

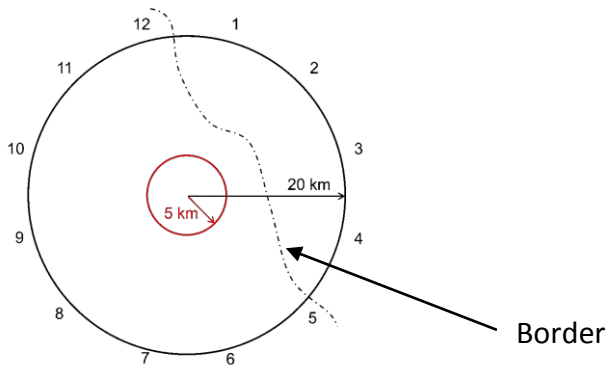


Figure 1: Distances where protective actions have to be planned.

7. Sectors considered in the HERCA-WENRA Approach

Depending on wind conditions forecast during the expected period of large release, these protective actions shall be implemented only in sectors potentially concerned rather than in the whole circular area. On the other hand, when complete circular areas are considered due to lack of wind, the extent of the area could be reduced to a shorter radius. HERCA and WENRA recommend the use of 30° sectors to cover the area concerned. However, other arrangements can also be used if already implemented in national emergency response plans (22.5° etc.). It should be noted that the variation of wind conditions might require adaptation with time of the sectors where protective actions are implemented. It has also been decided to always add an inner circle (keyhole approach) to the concerned sectors of at least 1 km (subject to adaptation to the local/field situation). Outside of the 20 km area, the radial sectors lead to large areas and therefore may not be appropriate and a more regional delimitation following municipality borders, rivers, etc. should be considered when more information on the radiological situation becomes available.

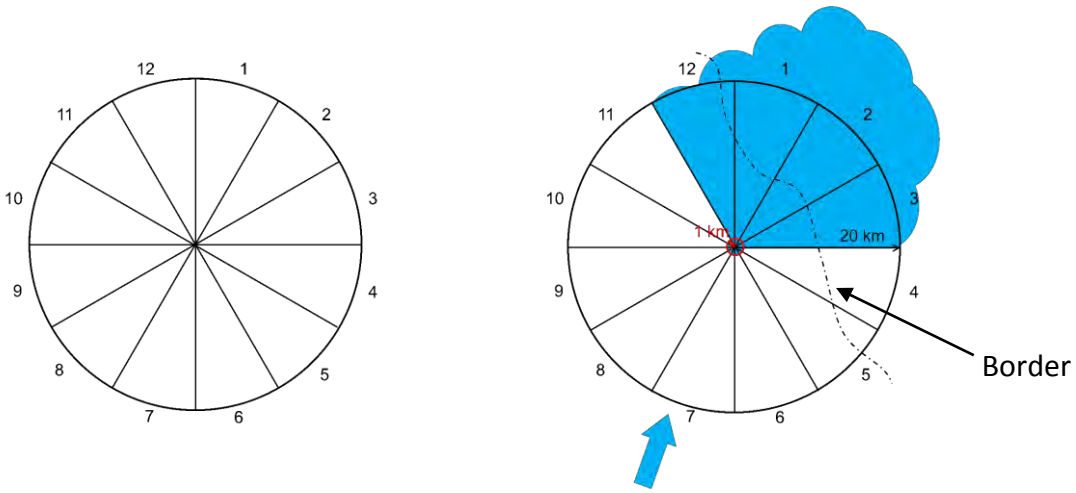


Figure 2: 30° sectors for the implementation of protective actions based on wind/weather conditions

8. Description of the HERCA-WENRA Approach

8.1. Estimation of time to release not available

Using the HERCA-WENRA Approach, a precautionary approach should be applied. Therefore, considering a situation that could lead to a core melt (JEF1 is Yes or unknown) and for which there is no indication of loss of containment integrity (JEF2 is Yes or unknown) and the time to radioactive release is not known, protective actions shall be implemented as follows:

Protective Action	Distance
Evacuation + ITB	up to 5 km
Sheltering + ITB	5 to 20 km

Table 2: Protective actions using the HERCA-WENRA Approach in case JEF1 is Yes or unknown, and for which there is no indication of loss of containment integrity (JEF2 is Yes or unknown) and time of release is unknown.

Note: If a General Emergency (or an equivalent emergency class) is declared it is considered that a risk of core melt exists.

8.2. Estimation of time to release available

Under the same situation and if the time to release ($t_{release}$) can be estimated, the evacuation of the population within a 5 km distance has to be evaluated on the basis of the time needed to evacuate (t_{evac}). If $t_{evac} > t_{release}$, sheltering is preferred over an evacuation under the plume.

The other protective actions are not considered critical because the implementation times for sheltering and ITB are comparably short if iodine tablets are already pre-distributed. Since sheltering cannot be implemented for a very long duration, it should be prepared immediately but only implemented a few hours before the time of release.

Protective Action	Distance	
	tevac > trelease	tevac < trelease
Evacuation + ITB	-	up to 5 km
Sheltering + ITB	up to 20 km	5 to 20 km

Table 3: Protective actions using the HERCA-WENRA Approach in the case JEF1 is yes or unknown, and for which there is no indication of loss of containment integrity (JEF2 is Yes or unknown) and time of release is known.

If containment integrity is lost due to the nature of the initiating event or the evolution of the accident (e.g., plane crash or large internal explosion) and core melt is expected, extended protective actions would become necessary, such as evacuation up to 20 km and sheltering and ITB up to 100 km. Additional ITB actions specific to children could also be necessary.

8.3. Weather Conditions

If the wind direction (JEF3) is known and steady, it can be used to determine in which adjacent basic (30°) sectors (cf. figure 2) protective actions are necessary. If the wind direction is unknown, protective actions have to be implemented in a zone of 360° around the installation and up to the specified distance.

8.4. Risk of evacuation under the plume

In the HERCA-WENRA Approach, sheltering and ITB are preferred to evacuation if it is predicted that the evacuation will actually occur under the plume. In all other cases, including unknown time to release, evacuation is preferred. Given the current state of knowledge, there are many uncertainties on this issue. Therefore, HERCA and WENRA recommend that additional studies be performed regarding the advantages and disadvantages of evacuating under a plume and considering a variety of factors including human behaviour, to provide a sound basis for such recommendations.

8.5. Organisation

The HERCA-WENRA Approach requires rapid assessment of the JEFs by experts, based on the available information. Timely interactions between the operator and the safety authorities will enhance the possibility to quickly assess the JEFs. Therefore, a national framework relying significantly, though not exclusively, on operators would facilitate the HERCA-WENRA Approach. Experts responsible for the necessary assessment should be designated. Robust communication

means should also be available between the key players involved in the evaluation of the situation and the production of recommendations for protective actions.

9. Harmonized preparation of protective actions in Europe

As shown by the Fukushima accident, a large nuclear catastrophe anywhere in the world, including in Europe, cannot be completely excluded. Emergency preparedness and response arrangements should therefore be prepared for such cases. According to the current studies, international standards and methods used for emergency preparedness and response, an accident comparable to the Fukushima one would require protective actions such as evacuation to around 20 km and sheltering to around 100 km. These actions would be combined with the intake of stable iodine.

However, considering the safety level of European nuclear power plants and their improvements resulting from the lessons learned from the Fukushima disaster, it is estimated that the probability of such a catastrophic accident is very low.

Therefore, HERCA and WENRA consider that in Europe:

- evacuation should be prepared up to 5 km around nuclear power plants, and sheltering and ITB up to 20 km;
- a general strategy should be defined in order to be able to extend evacuation up to 20 km and sheltering and ITB up to 100 km;
- nuclear and radiation safety authorities in Europe should continue attempts to promote compatible response arrangements and protection strategies amongst the European countries.

List of acronyms

EP&R: Emergency Preparedness & Response
HERCA: Heads of the European Radiation Protection Competent Authorities
ITB: iodine thyroid blocking
JEF: Judgment Evaluation Factor
WENRA: Western European Nuclear Regulators' Association

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ASN – Autorité de sûreté nucléaire; **BMU** – Bundesumweltministerium; **BNRA** – Nuclear Regulatory Agency; **Bel V** – FANC/AFCN TSO; **CSN** - Consejo de Seguridad Nuclear; **DRP** – Division de la Radioprotection; **EC** – European Commission; **ENSI** - Swiss Federal Nuclear Safety Inspectorate; **FANC/AFCN** – Federal agency for nuclear control; **FOCP** - Swiss Federal Office for Civil Protection ; **ILT** - Inspectie Leefomgeving en Transport ; **Minez** - Ministerie van Economische Zaken; **NCRRP** - National Center of Radiobiology and Radiation Protection; **NRPA** – Norwegian Radiation Protection Authority; **OFSP** – Federal Office of Public Health; **ONR** - Office for Nuclear Regulation; **OSSKI** - National Research Institute for Radiobiology and Radiohygiene; **PHE** - Public Health England; **RPII** - Radiological Protection Institute of Ireland; **SNSA** - Slovenian Nuclear Safety Administration; **SSM** - Swedish Radiation Safety Authority; **STUK** - Radiation and Nuclear Safety Authority; **SUJB** - State Office for Nuclear Safety ; **UJD SR** - Urad Jadroveho Dozoru Slovenskey Republiky;





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Other safety related IAEA publications are issued as **Radiological Assessment Reports**, the International Nuclear Safety Group's **INSAG Reports**, **Technical Reports** and **TECDOCs**. The IAEA also issues reports on radiological accidents, training manuals and practical manuals, and other special safety related publications. Security related publications are issued in the **IAEA Nuclear Security Series**.

ARRANGEMENTS FOR PREPAREDNESS FOR A NUCLEAR OR RADIOLOGICAL EMERGENCY

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IAEA SAFETY STANDARDS SERIES No. GS-G-2.1

ARRANGEMENTS FOR PREPAREDNESS FOR A NUCLEAR OR RADIOLOGICAL EMERGENCY

SAFETY GUIDE

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FOREWORD

by Mohamed ElBaradei
Director General

The IAEA's Statute authorizes the Agency to establish safety standards to protect health and minimize danger to life and property — standards which the IAEA must use in its own operations, and which a State can apply by means of its regulatory provisions for nuclear and radiation safety. A comprehensive body of safety standards under regular review, together with the IAEA's assistance in their application, has become a key element in a global safety regime.

In the mid-1990s, a major overhaul of the IAEA's safety standards programme was initiated, with a revised oversight committee structure and a systematic approach to updating the entire corpus of standards. The new standards that have resulted are of a high calibre and reflect best practices in Member States. With the assistance of the Commission on Safety Standards, the IAEA is working to promote the global acceptance and use of its safety standards.

Safety standards are only effective, however, if they are properly applied in practice. The IAEA's safety services — which range in scope from engineering safety, operational safety, and radiation, transport and waste safety to regulatory matters and safety culture in organizations — assist Member States in applying the standards and appraise their effectiveness. These safety services enable valuable insights to be shared and I continue to urge all Member States to make use of them.

Regulating nuclear and radiation safety is a national responsibility, and many Member States have decided to adopt the IAEA's safety standards for use in their national regulations. For the Contracting Parties to the various international safety conventions, IAEA standards provide a consistent, reliable means of ensuring the effective fulfilment of obligations under the conventions. The standards are also applied by designers, manufacturers and operators around the world to enhance nuclear and radiation safety in power generation, medicine, industry, agriculture, research and education.

The IAEA takes seriously the enduring challenge for users and regulators everywhere: that of ensuring a high level of safety in the use of nuclear materials and radiation sources around the world. Their continuing utilization for the benefit of humankind must be managed in a safe manner, and the IAEA safety standards are designed to facilitate the achievement of that goal.

PREFACE

In March 2002, the IAEA's Board of Governors approved a Safety Requirements publication, Preparedness and Response for a Nuclear or Radiological Emergency, jointly sponsored by seven international organizations, which established the requirements for an adequate level of preparedness for and for response to a nuclear or radiological emergency in any State. The IAEA General Conference, in resolution GC(46)/RES/9, encouraged Member States "to implement, if necessary, instruments for improving their own preparedness and response capabilities for nuclear and radiological incidents and accidents, including their arrangements for responding to acts involving the malicious use of nuclear or radioactive material and to threats of such acts", and has further encouraged them to "implement the Safety Requirements for Preparedness and Response to a Nuclear or Radiological Emergency".

The Convention on Early Notification of a Nuclear Accident ('Early Notification Convention') and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency ('Assistance Convention') adopted in 1986 place specific obligations on the Parties and on the IAEA. Under Article 5a (ii) of the Assistance Convention, one function of the IAEA is to collect and disseminate to States Parties and Member States information concerning methodologies, techniques and available results of research relating to response to such emergencies.

This Safety Guide is intended to assist Member States in the application of the Safety Requirements publication on Preparedness and Response for a Nuclear or Radiological Emergency, Safety Standards Series No. GS-R-2, and to help in fulfilling the IAEA's obligations under the Assistance Convention. In fulfilling its functions under the Assistance Convention and Early Notification Convention, the IAEA works together with other international organizations within an Inter-Agency Committee for Response to Nuclear Accidents (IACRNA). IACRNA has cooperated in the establishment of common requirements for preparedness and response for a nuclear or radiological emergency. Six members of IACRNA co-sponsored the development of Safety Standards Series No. GS-R-2. The Food and Agriculture Organization of the United Nations (FAO), the International Labour Office (ILO), the Pan American Health Organization (PAHO), the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) and the World Health Organization (WHO) are joint sponsors of this Safety Guide.

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1. INTRODUCTION

BACKGROUND

1.1. Under Article 5(a)(ii) of the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (the 'Assistance Convention') [1], one function of the IAEA is to collect and disseminate to States Parties and Member States information concerning methodologies, techniques and available results of research relating to response to such emergencies.

1.2. In March 2002, the IAEA's Board of Governors approved a Safety Requirements publication, Preparedness and Response for a Nuclear or Radiological Emergency, issued as Safety Standards Series No. GS-R-2 [2], jointly sponsored by seven international organizations, which established the requirements for an adequate level of preparedness for and for response to a nuclear or radiological emergency in any State. The IAEA General Conference in resolution GC(46)/RES/9 encouraged Member States "to implement, if necessary, instruments for improving their own preparedness and response capabilities for nuclear and radiological incidents and accidents, including their arrangements for responding to acts involving the malicious use of nuclear or radioactive material and to threats of such acts" and has further encouraged them to "implement the Safety Requirements for Preparedness and Response to a Nuclear or Radiological Emergency".

This Safety Guide is not a standalone text. It should be used in conjunction with Ref. [2], referred to in this text as 'the Requirements'.

OBJECTIVE

1.3. The primary objectives of this Safety Guide are:

- To provide guidance on those selected elements of the Requirements [2] for which guidance has been requested by Member States and for which there is an international consensus on the means to meet these requirements;
- To describe appropriate responses to a range of emergencies;
- To provide background information, where appropriate, on the past experience that provided a basis for the Requirements, thus helping the

user to better implement arrangements that address the underlying issues.

SCOPE

1.4. The guidance presented in this Safety Guide concerns emergency preparedness for a nuclear or radiological emergency. The range of possible nuclear or radiological emergencies of concern is enormous, extending from a general emergency at a nuclear power plant to emergencies involving lost, stolen or found radioactive material. The guidance presented in this Safety Guide is applicable to the entire range of emergencies, concentrated on the general aspects of emergency preparedness.

1.5. Clearly, this Safety Guide cannot take all State specific, site specific or emergency specific factors into account. Planners should remain flexible in their use of the guidance and should adapt it to take account of local sociopolitical, economic and other factors.

1.6. This Safety Guide does not provide detailed guidance on all the arrangements or operational criteria necessary to respond effectively to a nuclear or radiological emergency. The IAEA has published more detailed information on developing and maintaining an effective emergency response capability. Reference [3] provides an overview of this information. Guidance on preparing for emergency response to transport accidents involving radioactive material is provided in Ref. [4].

1.7. This Safety Guide does not provide guidance on the tactical or investigative response to terrorist or other criminal acts. It does address the coordination of such a response with the response to deal with actual or to anticipate potential radiological consequences.

STRUCTURE

1.8. This Safety Guide is divided into six sections. Section 2 provides guidance on basic concepts that must be understood to apply the guidance. Sections 3, 4 and 5 provide guidance on how to meet the requirements in the corresponding sections of the Requirements [2]. Section 6 discusses the concept of operations, describing in general terms how the response should proceed for different types of emergency. The Safety Guide also contains eight

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appendices and an annex which provide further elaboration and clarification. Recommendations expressed as 'should' statements carry the implication that it is necessary to take the measures recommended or equivalent alternative measures to comply with the Requirements. Requirements quoted directly from Ref. [2] are expressed as 'shall' statements.

2. BASIC CONCEPTS

TYPES OF EMERGENCY

2.1. The approaches for developing the capability to respond to a nuclear or radiological emergency differ depending on the characteristics of the emergency. Consequently, it is convenient to divide the guidance for emergency preparedness and response into two classes:

(a) Nuclear emergencies. These are categorized in threat category I, II or III[1], depending on their on-site and off-site threats. Nuclear emergencies may occur at:

- Large irradiation facilities (e.g. industrial irradiators);
- Nuclear reactors (research reactors, ship reactors and power reactors);
- Storage facilities for large quantities of spent fuel or liquid or gaseous radioactive material;
- Fuel cycle facilities (e.g. fuel processing plants);
- Industrial facilities (e.g. facilities for manufacturing radiopharmaceuticals);
- Research or medical facilities with large fixed sources (e.g. teletherapy facilities).

(b) Radiological emergencies. These are categorized in threat category IV. They can occur anywhere and so this guidance is applicable to all States. Radiological emergencies include:

[1] The threat categories are discussed in paras 2.19 and 2.20.

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— Uncontrolled (abandoned, lost, stolen or found) dangerous sources;[2]
— Misuse of industrial and medical dangerous sources (e.g. of those used in radiography);
— Public exposures and contamination from unknown origins;
— Re-entry of a satellite containing radioactive material;
— Serious overexposures;[3]
— Malicious threats and/or acts;
— Transport emergencies.

RADIATION INDUCED HEALTH EFFECTS

2.2. The Requirements [2] (para. 2.3) present the following practical goals of emergency response in relation to radiation induced health effects:

"— To prevent the occurrence of [severe] deterministic health effects[4] in workers and the public;
— To render first aid and to manage the treatment of radiation injuries;
— To prevent, to the extent practicable, the occurrence of stochastic health effects in the population."

2.3. This section reviews the important aspects of radiation induced health effects that may result from a nuclear or radiological emergency. Reference [5] provides a further discussion of these health effects.

Deterministic effects

2.4. One of the primary objectives of the response to an emergency is to prevent the occurrence of deterministic effects. A deterministic effect of radiation is one for which generally a threshold level of dose exists, below which there is no effect and above which the severity of the effect increases

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[2] A dangerous source is a source that could, if not under control, give rise to exposure sufficient to cause severe deterministic health effects. This categorization is used for determining the need for emergency response arrangements and is not to be confused with categorizations of sources for other purposes. Dangerous sources are discussed further in Appendix III.

[3] A serious overexposure is one that can result in severe deterministic health effects.

[4] 'Severe deterministic effect' is defined in the Glossary under 'deterministic effect'.

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with the dose received. The threshold differs for different organs and for different effects. A deterministic effect is described as 'severe' if it is fatal or life threatening or results in a permanent injury that reduces quality of life. The thresholds for severe deterministic effects are — except for doses to the foetus — one or more grays (Gy) from radiation at high dose rates (thousands to millions of times the normal radiation doses due to background levels of radiation) delivered over a short period of time. Keeping the doses below these thresholds will prevent deterministic effects.

2.5. Radiological emergencies in the past have resulted in severe deterministic effects, including fatalities and very serious injuries, among the public [6–12]. Severe deterministic effects have also occurred in patients owing to accidental medical overexposure [13, 14].

2.6. Severe deterministic effects have occurred among workers and responders in emergencies at facilities in threat categories I, II and III [15–18]. Severe deterministic effects could also result off a site owing to a release of large amounts of radioactive material from facilities in threat category I. This threat is most probably limited to large reactors[5] and facilities where there are large quantities of volatile radioactive material, such as facilities for reprocessing fuel waste.

Stochastic effects

2.7. For a stochastic health effect of radiation, the probability of its occurrence increases with increasing dose, and the severity of the effect (if it occurs) is independent of dose. Stochastic effects are assumed to occur without a threshold level of dose and they include cancers (e.g. thyroid cancer and leukaemia) and hereditary effects.

2.8. Only the exposure of many tens of thousands of people to whole body doses in the range of 100–200 mSv [15] or of many tens of thousands of children to thyroid doses of the order of 50 mSv [19] (i.e. at dose rates thousands of times higher than those due to background levels of radiation) could result in a detectable increase in the incidence of cancer among those population groups

[5] In the Chernobyl accident, dose rates off the site were higher than 1 Gy/h from the deposition of radioactive material, which is sufficient to cause severe deterministic health effects within a few hours [15]. Fortunately, these dose rates occurred only in uninhabited areas.

exposed. Even emergencies that have led to the exposure of very large groups of people (e.g. the Chernobyl accident) who received doses well above those due to background levels of radiation have not resulted in a detectable increase in the incidence of solid cancers among those exposed.[6]

2.9. Typically, following a nuclear or radiological emergency a number of people (not all of whom may be experts) will make estimates of a radiation induced increase to be expected in the incidence of cancers and other effects (e.g. birth defects) that may appear among those population groups who were exposed to radiation as a result of the emergency. Such stochastic health effects would not be individually attributable to radiation exposure (as they could not be distinguished from health effects with other causes). Estimates of consequences for a population may be made on the basis of the collective radiation dose (i.e. the sum total of all individual doses in an exposed population, expressed in man-sieverts) and levels of radiation health risks derived from observations made on exposed population groups who received high radiation doses (e.g. survivors of the atomic bombing in Japan). However, health consequences to be expected are generally estimated for people who have received only low radiation doses. In estimating such health consequences certain assumptions have to be made because of scientific uncertainties concerning the biological effects of radiation exposure at low doses and low dose rates. For the purposes of the system of radiation protection the assumption is made that there is no threshold level of radiation dose below which there is no associated radiation risk. This is only an assumption, however; data on radiation health risks that are yielded by studying the effects of exposure at high doses are not directly applicable for low dose exposure. Moreover, the very small projected increases in the incidence of cancers among those people exposed with such low levels of dose would in any case be undetectable epidemiologically against the fluctuations in the spontaneous incidence. Incautious estimates of the health effects of low dose exposures have

[6] As of 2000 no excess solid cancers had been observed among the approximately 200 000 people who performed recovery operations within the 30 km zone in 1986–1987 where the highest doses were received following the Chernobyl accident [15]. However, a major increase was detected in the incidence of thyroid cancer among those persons who had received radiation doses as a foetus or child following the Chernobyl accident. This detectable increase in incidence in this population group was due to a very large release of radioiodine, resulting in high thyroid doses in hundreds of thousands of children (primarily due to the consumption of contaminated milk and leafy vegetables). This radiation induced rise in cancer incidence was easily detected epidemiologically because of the very low spontaneous rate of thyroid cancers among the children.

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led to what many consider is an exaggerated view on the part of the public of the risks associated with radiation, and consequently in inappropriate and, in some cases, counterproductive and harmful 'protective' actions being taken by the public and by officials. Risks of stochastic effects occurring as a result of low radiation doses (e.g. lower than 100 mSv) that are quantified for the purposes of radiation protection should therefore be interpreted for and communicated to the public with great caution, if at all. Any such quantification should be accompanied by a plain language explanation that makes it clear that, for such low doses, any radiation induced increase in the incidence of health effects in a population would be inherently very difficult, if not impossible, to detect. This plain language explanation should also discuss the risks and consequences of any actions taken to reduce the risks associated with exposure. If others (e.g. official or unofficial parties within or outside the State) make such estimates, consideration should be given to providing a clear explanation that puts these estimates in perspective.

2.10. One of the important goals of emergency preparedness is to prevent, to the extent practicable, the occurrence of stochastic effects. Since it is assumed that any dose, no matter how small, can increase the risk of occurrence of a stochastic effect, it would be impracticable and probably harmful to attempt to reduce the dose, and thus its associated risk, resulting from an emergency to near zero. In fact, some actions taken to reduce the risk of stochastic effects (e.g. relocation from an area with insignificant levels of contamination) may do more harm than good. The difficulty lies in determining what is practicable and reasonable. To address this issue, international standards provide generic intervention and action levels at which various protective measures would be justified on radiation protection grounds [2]. Taking protective action at levels significantly below these levels could do more harm than good.

Special concern

2.11. One special concern is radiation exposure of the embryo or foetus (exposure in utero). The health effects of radiation exposure in utero may include both deterministic effects (e.g. a reduction in average intelligence quotient among an exposed group) and stochastic effects expressed in the child after birth (e.g. radiation induced cancers). As with the general population, only the exposure of a large number of pregnant women to doses many times those due to normal background levels of radiation could possibly give rise to a detectable increase in stochastic effects among children exposed in utero.[6] During the period of 8–25 weeks after conception, foetal doses in excess of about 100 mGy may result in a verifiable decrease of intelligence quotient [20].

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This would correspond to dose rates a thousand or more times those due to normal background levels. However, doses sufficient to result in deterministic effects in a child born following in utero exposure, as a consequence of a nuclear or radiological emergency, have not been reported.[7]

EXPOSURE PATHWAYS

2.12. The ways in which people can be exposed to radiation are referred to as exposure pathways and include:

- External exposure from contact with or being in proximity to a source of radiation (e.g. a source, a plume containing radioactive material or ground contamination);
- Ingestion (e.g. of contaminated food, milk or water, inadvertent ingestion of contamination on hands);
- Inhalation from a plume or due to the resuspension of deposited radioactive material;
- Contamination of skin and clothing.

2.13. For radiological emergencies that have involved uncontrolled dangerous sources in the public domain, historically the most important pathways of exposure have been external exposure and inadvertent ingestion. Severe deterministic effects have resulted from unshielded dangerous sources being carried (e.g. by hand or in pockets) or taken home [9–12, 21].[8] In one instance, individuals who were not aware of the hazard removed a dangerous amount of radioactive material from its container and scattered this material. This led to the contamination of large and complex areas in a city, and at least one victim inadvertently ingested an amount of this material with fatal consequences [6]. In these emergencies, the most important means of movement of the radioactive material was human activity.

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[7] Studies on adverse consequences relating to the Chernobyl accident have been performed in those areas close to the plant where the doses were highest. "So far, no increase in birth defects, congenital malformations, stillbirths, or premature births could be linked to radiation exposure caused by the [Chernobyl] accident" [15].

[8] In one emergency, a family member picked up a tiny, shiny cylinder (a lost radiography source) and took it home. This resulted in the deaths of eight family members and relatives in the following three months [21].

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2.14. Workers in irradiation facilities (threat category III) have received lethal exposures from being near extremely dangerous unshielded sources[9] [16, 17], in one case for less than a minute [22]. Workers have also received fatal doses almost instantaneously from being near an accidental criticality event in a fuel cycle facility [18].

2.15. For radiological emergencies an airborne release of radioactive material is of concern primarily if a dangerous source containing dispersible material is in a fire or explosion. The distance at which such a release is hazardous is typically limited to less than a few hundred metres, but this depends on many factors such as the size of the source, the amount of material dispersed into the air, its dilution, the movement of the plume and the size and nature of the particles.[10] It may be that none of these factors is known with any certainty during an emergency.

2.16. For airborne releases from facilities the significant pathways of exposure for the public are mainly:

— External gamma radiation from the plume, called cloud shine;
— External gamma radiation from radioactive material deposited on the ground, called ground shine;
— Inhalation of radioactive material contained in the plume;[11]
— Ingestion of contaminated food, milk or water;
— To a lesser extent, deposition of radioactive material on the skin.

2.17. The pattern of the radioactive material deposited following an airborne radioactive release is very complex, as was seen following the Chernobyl [15, 23] and Tomsk [24] accidents. For facilities in threat category I, airborne releases have been postulated (e.g. for large reactors [25]) or have actually occurred (i.e. in the Chernobyl accident [15]) that would result or have resulted in doses sufficient to cause severe or even fatal deterministic effects within a few hours to persons off the site. For some facilities in threat categories I and II, airborne releases have been postulated or have actually occurred [25, 26] that would result or have resulted in doses over several days sufficient to warrant

[9] See Table 9 for the D values of different radionuclides.

[10] Appendix III provides a plain language explanation of the possible impacts of emergencies involving dangerous sources.

[11] Resuspension could be an important pathway of exposure if the deposited material contains significant amounts of alpha emitters (e.g. Pu).

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the implementation of urgent protective measures to prevent severe deterministic effects or reasonably to reduce the risk of stochastic effects.

2.18. There may also be emergencies at some threat category II facilities that involve unshielded criticalities and that would result in off-site doses (without a significant airborne release[12]) sufficient to warrant the implementation of urgent protective actions within a distance of several hundred metres.

THREAT CATEGORIES

2.19. The Requirements [2] and the guidance in this publication are often specified for the threat categories summarized in Table 1. Threat categories I, II and III represent decreasing levels of threat at major facilities and therefore correspond to decreasing stringency of requirements for emergency preparedness and response. Facilities in threat categories I and II warrant extensive on-site and off-site arrangements for emergency preparedness. For facilities in threat category III the radiation related threat is limited to the site or to areas on the site (e.g. treatment rooms or laboratories), but arrangements to inform and reassure the public in the event of an emergency are still warranted.

2.20. Threat category IV includes radiological emergencies that could occur anywhere unexpectedly and applies always in all jurisdictions, possibly together with other threat categories. Threat category IV includes emergencies involving the types of event listed in Table 2.

2.21. These threat categories apply both to facilities or practices and to governmental jurisdictions for which various levels of preparedness are warranted. Section 3 provides guidance on determining threat categories and Appendix I gives examples of threat categories for different practices.

[12] Criticality accidents cannot produce sufficient amounts of fission products to result in a significant airborne radioactive release; however, the energy produced could result in an airborne release of other hazardous material that may be present at the time of the criticality.

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TABLE 1. FIVE CATEGORIES OF NUCLEAR AND RADIATION RELATED THREATS FOR THE PURPOSES OF THE REQUIREMENTS (taken directly from Ref. [2])

Threat category	Description
I	Facilities, such as nuclear power plants, for which on-site events[a] (including very low probability events) are postulated that could give rise to severe deterministic health effects[b] off the site, or for which such events have occurred in similar facilities.
II	Facilities, such as some types of research reactors, for which on-site events[a] are postulated that could give rise to doses to people off the site that warrant urgent protective action in accordance with international standards[c], or for which such events have occurred in similar facilities. Threat category II (as opposed to threat category I) does not include facilities for which on-site events (including very low probability events) are postulated that could give rise to severe deterministic health effects off the site, or for which such events have occurred in similar facilities.
III	Facilities, such as industrial irradiation facilities, for which on-site events are postulated that could give rise to doses that warrant or contamination that warrants urgent protective action on the site, or for which such events have occurred in similar facilities. Threat category III (as opposed to threat category II) does not include facilities for which events are postulated that could warrant urgent protective action off the site, or for which such events have occurred in similar facilities.
IV	Activities that could give rise to a nuclear or radiological emergency that could warrant urgent protective action in an unforeseeable location. These include non-authorized activities such as activities relating to dangerous sources obtained illicitly. They also include transport and authorized activities involving mobile dangerous sources such as industrial radiography[d] sources, nuclear powered satellites or radiothermal generators. Threat category IV represents the minimum level of threat, which is assumed to apply for all States and jurisdictions.

TABLE 1. FIVE CATEGORIES OF NUCLEAR AND RADIATION RELATED THREATS FOR THE PURPOSES OF THE REQUIREMENTS (taken directly from Ref. [2]) (cont.)

Threat category	Description
V	Activities not normally involving sources of ionizing radiation, but which yield products with a significant likelihood[e] of becoming contaminated, as a result of events at facilities in threat category I or II, including such facilities in other States, to levels necessitating prompt restrictions on products in accordance with international standards.

[a] Such on-site events would be events involving an atmospheric or aquatic release of radioactive material or external exposure (e.g. due to a loss of shielding or a criticality event) that originates from a location on the site.

[b] Doses in excess of those for which intervention is expected to be undertaken under any circumstances (Refs [2, 5]). See the Glossary under 'deterministic effect'.

[c] See Annex III of Ref. [2].

[d] For the purposes of this Safety Guide a mobile source is a source, such as a radiography camera, that is authorized to be used under the control of the operator at any location.

[e] Contingent on the occurrence of a significant release of radioactive material from a facility in threat category I or II.

AREAS AND ZONES

2.22. The Requirements [2] establish numerous requirements relating to generic areas: on the site (on-site) and off the site (off-site). In addition, the Requirements [2] establish requirements (para. 4.48) for two off-site emergency zones: the precautionary action zone (PAZ) and the urgent protective action planning zone (UPZ). Finally, the Requirements [2] establish requirements (para. 4.89) for areas in threat category V.

On-site area

2.23. The on-site area is the area under the control of the operator or first responders.

2.24. For facilities in threat category I, II or III, the on-site area is the area surrounding the facility within the security perimeter, fence or other designated property marker that is under the immediate control of the facility operator.

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TABLE 2. TYPES OF EVENT ASSOCIATED WITH RADIOLOGICAL EMERGENCIES

— Detection of medical symptoms of radiation exposure due to unknown sources
— Lost dangerous source
— Theft of a dangerous source
— Found dangerous source
— Recovery of an uncontrolled dangerous source
— Radiography: disconnected or damaged source
— Radiography: source in a fire
— Damage to a fixed dangerous sealed source (e.g. as used in gauges)
— Public contamination and/or exposure (including that caused intentionally)
— Re-entry of a satellite containing radioactive material
— Accident with a nuclear weapon
— Transport emergency
— Emergency in radiology or nuclear medicine
— Emergency in radiotherapy
— A serious overexposure
— Credible or confirmed terrorist threats
— Non-credible terrorist threats
— An explosive radiological dispersal device
— Intentional contamination of water supply
— Intentional contamination of food and/or other products
— Detection of elevated radiation levels (in air, water, food or other products)
— Notification of a transnational emergency by the IAEA or any State

2.25. For licensed practices using radiography sources or other dangerous sources in threat category IV this is the area under the control of the operator.

2.26. For radiological emergencies involving transport, uncontrolled sources or localized contamination the first responders should establish a security perimeter containing the inner and outer cordoned areas to define the on-site area [27]. This is shown in Fig. 1. Appendix II provides suggested sizes for the inner cordoned area for various radiological emergencies.

Off-site area

2.27. The off-site area is the area beyond that area under the control of the facility, operator or first responders.

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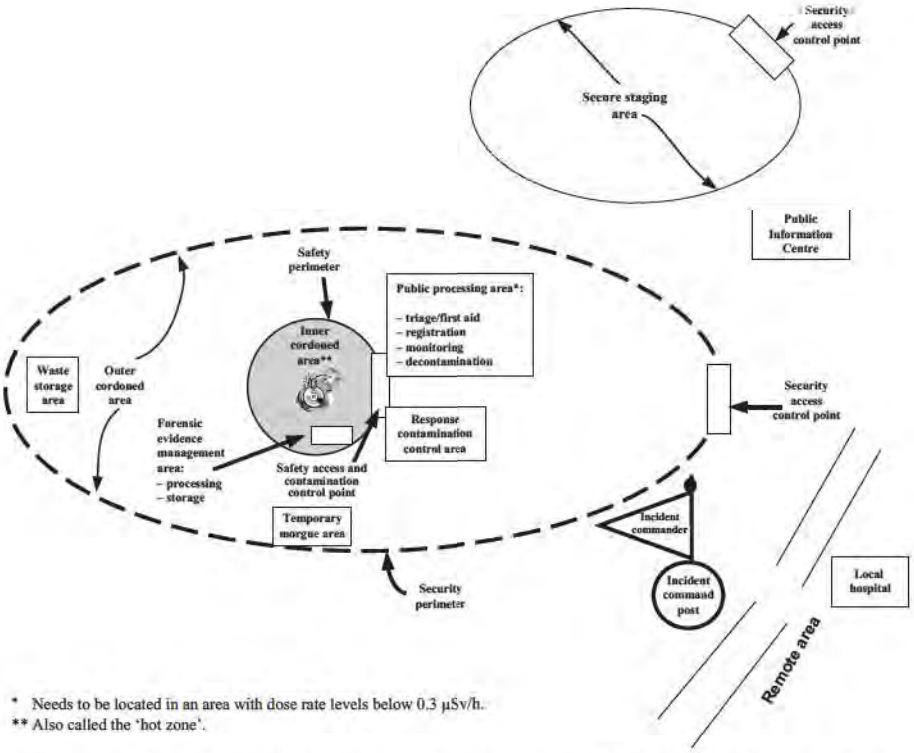


FIG. 1. Areas established by first responders (Appendix VIII provides a description of some of the facilities and locations shown).

2.28. The Requirements [2] (para. 4.48) require that, for facilities in threat category I or II, arrangements be made for effectively making and implementing decisions on urgent protective actions to be taken off the site within:

"(i) A precautionary action zone, for facilities in threat category I, for which arrangements shall be made with the goal of taking precautionary urgent protective action, before a release of radioactive material occurs or shortly after a release of radioactive material begins, on the basis of conditions at the facility (such as the emergency classification) in order to reduce substantially the risk of severe deterministic health effects.

"(ii) An urgent protective action planning zone, for facilities in threat category I or II, for which arrangements shall be made for urgent

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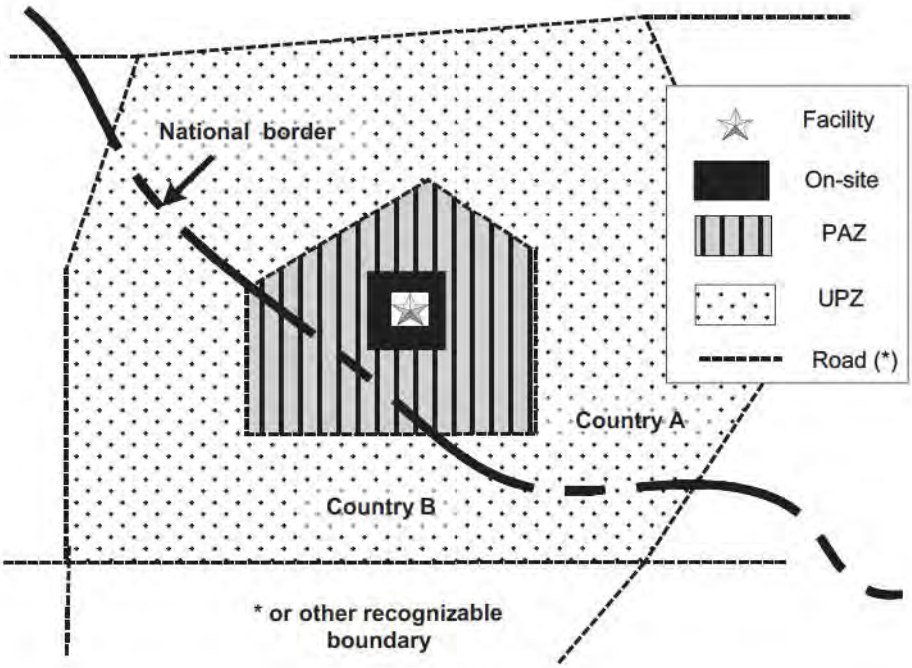


FIG. 2. Emergency zones.

protective action to be taken promptly, in order to avert dose off the site in accordance with international standards."

2.29. The PAZ and UPZ should be roughly circular areas around the facility, and their boundaries should be defined, where appropriate, by local landmarks (e.g. roads or rivers) to allow easy identification during a response, as illustrated in Fig. 2. It should be noted that the zones should not stop at national borders. The size of the PAZ and the UPZ should be in accordance with the guidance provided in Appendix II.

2.30. The Requirements [2] (para. 4.89) establish requirements for areas with activities in threat category V. Threat category V includes activities that might yield products with a significant likelihood of becoming contaminated, as a result of events at facilities in threat category I or II, to levels necessitating prompt restrictions on products in accordance with international standards.

3. GENERAL REQUIREMENTS

BASIC RESPONSIBILITIES

3.1. The Requirements [2] require (para. 3.3) that legislation be adopted to clearly allocate responsibilities for preparedness and response for a nuclear or radiological emergency and for meeting the Requirements.

3.2. Responsibilities for emergency preparedness and response are typically assigned at three levels: operator, off-site and international. Table 3 summarizes the emergency preparedness arrangements that should be the responsibility of the operator and off-site officials.

Operator level

3.3. The operator may be:

- The staff and operating organization of a facility in threat category I, II or III;
- A designated and qualified individual who is authorized to operate equipment containing dangerous sources (threat category IV); such devices are found in:
  - Radiotherapy [28];
  - Industrial radiography;
  - Well logging;
- Those responsible for the on-scene operation of a facility where uncontrolled dangerous sources may be encountered; such facilities include:
  - Border crossings, airports and seaports;
  - Scrap metal dealers and processors.

3.4. The assignment of responsibilities for response to emergencies in transport is discussed in Ref. [4].

3.5. The operator should be responsible, as appropriate, for:

- Identifying and/or detecting an emergency or hazard (e.g. dangerous sources);
- Taking immediate action to mitigate the consequences of the emergency;

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TABLE 3. EMERGENCY PREPAREDNESS ARRANGEMENTS BY THREAT CATEGORY

Threat categories I and II	
Operator	Off-site officials responsible for response within the emergency zones
Arrangements to promptly: classify an emergency; protect those on the site and on-site emergency workers; mitigate the consequences of the emergency; notify and recommend protective actions for the public to off-site officials; obtain off-site assistance; conduct environmental monitoring near the facility; and assist off-site officials in keeping the public informed.	Arrangements to promptly: implement urgent protective action within the emergency zones; conduct environmental monitoring; control consumption of contaminated food; provide emergency services to the facility; provide medical treatment for individuals who have been contaminated or overexposed and register them for long term medical follow-up on the basis of predetermined criteria; tell the public and media in plain language of the risks and of the actions they should take; respond to inappropriate public reactions; report transnational emergencies to the IAEA; respond to IAEA notifications; and request IAEA assistance when needed.
Threat category III	
Operator	Off-site officials (near the facility)
Arrangements to promptly: classify an emergency; protect those on the site and on-site emergency workers; inform off-site officials; obtain off-site assistance; ensure that there are no off-site risks; and assist off-site officials in keeping the public informed.	Arrangements to promptly: provide emergency services; protect emergency workers; provide medical treatment to those contaminated or overexposed and register them for long term medical follow-up on the basis of predetermined criteria; confirm there are no off-site impacts; inform the public and media in plain language of the risks and of the actions they should take; respond to inappropriate public reactions; report transnational emergencies to the IAEA; respond to IAEA notifications; and request IAEA assistance when needed.

TABLE 3. EMERGENCY PREPAREDNESS ARRANGEMENTS BY THREAT CATEGORY (cont.)

Threat category IV	
Operator (dangerous source)	Off-site officials (national level)
Arrangements to promptly: recognize an emergency; take action to protect people nearby; mitigate the consequences of the emergency; inform off-site officials of the risks; and provide technical assistance to off-site officials if needed.	Arrangements to: inform as part of an ongoing programme medical practitioners, scrap metal dealers and border crossing officials of the recognition and response to a radiological emergency; promptly make decisions on protective actions in accordance with international standards; provide local officials with assistance in assessing and responding to radiological conditions; provide medical treatment to those contaminated or overexposed and register them for long term medical follow-up on the basis of predetermined criteria; inform the public and media in plain language of the risks and of the actions they should take; respond to inappropriate public reactions; report transnational emergencies to the IAEA; respond to IAEA notifications; and request IAEA assistance when needed.
Threat category V	
Farmers and food production processors	Off-site officials
Arrangements to respond promptly to official instructions to protect food and water supplies and to control potentially contaminated food and water.	Arrangements to issue instructions to protect food and water supplies and to control potentially contaminated food and water and products, in accordance with international standards.

— Protecting individuals on the site and within the area controlled by the operator;
— Declaring the class of the emergency (if appropriate);
— Notifying off-site officials and possibly providing them with recommendations on protective actions and technical assistance;
— Establishing ongoing communication with off-site officials;

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— Assisting the off-site officials in keeping the public informed and countering incorrect information and inappropriate public reactions;
— Providing, if possible, initial radiological monitoring and technical advice.

Off-site level

3.6. The off-site level consists of organizations that will perform the response actions carried out off the site, and should include:

— Local officials.

  • For facilities in threat category I, II or III, local officials are the government and support agencies responsible for providing immediate support to the operator and prompt protection of the public in the emergency zones;
  • For a radiological emergency in the public domain, local officials are the emergency services responding at the scene. These include the police, firefighting and civil emergency services or medical personnel, and they may be the first to learn of an emergency.

— Medical practitioners. They should be able to recognize radiation induced injuries and notify the appropriate officials.
— National and regional officials. These are the governmental agencies responsible for planning and response at the national (or regional) level and also non-governmental organizations (NGOs). These agencies should be responsible for providing technical assistance to local responders and for implementing protective actions and other actions that do not need to be implemented urgently to be effective. At the national level, preparations should be made to respond to radiological emergencies that can occur anywhere unexpectedly. These preparations should be designed to support local officials in dealing with these emergencies.
— Officials in all States should be responsible for the implementation of protective actions within the emergency zones of a facility in threat category I or II.

International level

3.7. The international level consists of organizations responsible for providing international assistance as described in the Joint Radiation Emergency Management Plan of the International Organizations [29]. It includes:

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— IAEA implementation of the Convention on Early Notification of a Nuclear Accident ('Notification Convention') and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency ('Assistance Convention') [1], and para. 4.15 of the Requirements [2]. The Parties to the Notification Convention commit themselves to informing forthwith those States that may be affected by a significant transboundary release and the IAEA and to meeting the international requirements [2]. States adopting the Conventions must notify States and the IAEA of a transnational emergency. These notifications can be made directly or through the IAEA. However, areas in States with territory within the emergency zones should be notified promptly and directly and not through the IAEA. Under the Assistance Convention, States commit themselves to facilitating prompt assistance in the event of an accident. The IAEA, with the help of Member States and other international organizations, has provided assistance in emergencies under the Assistance Convention, including conducting environmental monitoring, making aerial surveys, providing medical consultation and treatment, assisting with source recovery and assisting with media relations.
— Organizations, such as the United Nations Office for the Coordination of Humanitarian Affairs (OCHA), the World Health Organization (WHO) and the Food and Agriculture Organization of the United Nations (FAO), that can provide technical, humanitarian or medical assistance in the event of an emergency.

National coordinating authority

3.8. The Requirements [2] require (para. 3.4) that an existing governmental body or organization be established or identified to act as a national coordinating authority whose function, among others, is to coordinate the threat assessment[13] for threats within the State and to ensure that the functions and responsibilities of operators and response organizations are clearly assigned and are understood by all response organizations.

3.9. The national coordinating authority should be an existing ministry or a standing committee with representatives of all national organizations that play a major part in the response to a nuclear or radiological emergency. This

[13] The term 'threat assessment' does not imply that any threat, in the sense of an intention and capability to cause harm, has been made in relation to such facilities, activities or sources.

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authority should have the ability to coordinate the response preparations for all the national organizations with roles in preparation for, or response to, nuclear or radiological emergencies, conventional emergencies or criminal activities (e.g. terrorist attacks or threats).

3.10. The national coordinating authority should ensure that a threat assessment (see paras 3.24–3.31) is conducted periodically to identify any new practice or event that could necessitate an emergency response. This should include the exchange of information with nearby States.

3.11. The national coordinating authority should determine which tasks each organization plans to perform during an emergency, whether it is actually responsible for them and whether it has adequate resources and capabilities to perform them. The findings should then be assessed at the national and local levels to identify gaps, overlaps and conflicts. The national coordinating authority should resolve any conflicts and incompatible arrangements between the various participating organizations.

3.12. The national coordinating authority should ensure that organizations that perform tasks (conventional, radiological or law enforcement) that are critical to a successful response have agreed to their assigned responsibilities as defined in the concept of operations (see Section 6). Reference [3] provides a list of tasks that are critical for a successful response.

3.13. The national coordinating authority should coordinate the development of the national all-hazards response plan or the national radiation emergency plan and should foster the implementation by other States of measures designed to fulfil the relevant international obligations[14] in accordance with the Requirements [2] (para. 3.5). (In this context, a 'radiation emergency' means the same as a 'nuclear or radiological emergency'.)

3.14. The individual groups to which roles and responsibilities are assigned should make a commitment to develop the necessary response capability.

3.15. Within the national coordinating body, a single overall national radiation emergency planning coordinator should be designated to guide the preparedness process.

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[14] For example, to notify promptly those States with territory within the emergency zones in the event of a general emergency.

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3.16. The coordinator should have in-depth technical and operational knowledge of emergency preparedness and response issues and should have sufficient decision making authority to ensure an effective coordination process. The coordinator should be provided with sufficient staff and resources for the long term to develop and maintain the response capability once it has been established. This should include a multi-year budget.

Integrated planning (all hazards approach)

3.17. A nuclear or radiological emergency may be caused by or may involve different types of hazards, including natural (e.g. storms), technological (e.g. nuclear power generation) or criminal and malicious activity (e.g. theft, sabotage, terrorist attacks). The response to each of these hazards would probably involve different response organizations with their own response terminology, cultures and plans.

3.18. Consequently, the Requirements [2] (para. 3.11) require that the national coordinating authority and the response organizations ensure that the arrangements for response to a nuclear or radiological emergency are coordinated with the arrangements for response to conventional emergencies.

3.19. The planning and preparations for response to a nuclear or radiological emergency should be integrated with the planning for response to hazards of all types and should fully involve the national or local organizations responsible for response to conventional emergencies such as those due to fires, floods, earthquakes, tsunamis or storms. Since an emergency may involve criminal activity such as terrorism or theft, preparations should also involve law enforcement agencies.

3.20. Consequently, the Requirements [2] (para. 3.12) require that "All organizations that may be involved in the response to a nuclear or radiological emergency shall ensure that appropriate management arrangements are adopted to meet the timescales for response throughout the emergency. Where appropriate, the management system shall be consistent with that used by other response organizations in order to ensure a timely, effective and coordinated response."

3.21. The preparation (planning) for response to all hazards should be structured into a coherent and interlocking system (Fig. 3). At the top level

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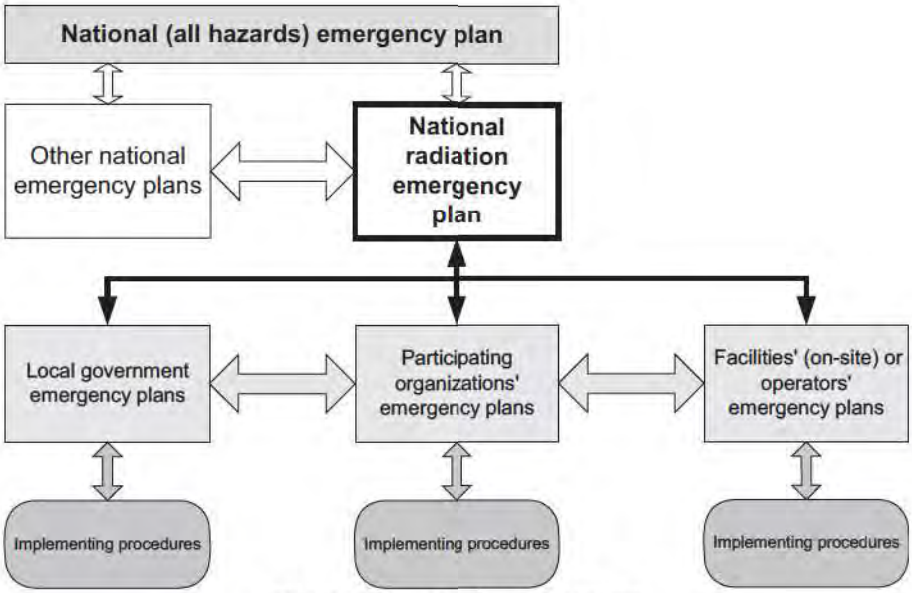


FIG. 3. Integrated planning concept.

should be a national emergency plan for an integrated response to any combination of hazards. The national radiation emergency plan may be a part of this all hazards plan. If there is no national all hazards plan, the national radiation emergency plan should provide for integration with the responses of other organizations during emergencies involving a combination of actual and perceived radiation hazards. The national radiation emergency plan should describe the concepts of operations, and roles and responsibilities of all the responding organizations, and their relationships with each other, summarizing more detailed plans and ensuring that all the other planning is integrated and compatible. In particular, the national radiation emergency plan should provide sufficient detail to ensure that the plans for the functional areas that are performed by personnel drawn from different ministries or organizations can function effectively. This could be accomplished by attaching to the national radiation emergency plan detailed functional plans for operations such as incident command, radiological monitoring and assessment, medical response and public affairs.

3.22. The next level should contain the plans developed by individual agencies, governmental jurisdictions and facilities or operators. The final level should represent the procedures (e.g. implementing instructions and operating procedures) and resources that will be used during an emergency to carry out the plans. Reference [3] outlines the various levels of plans and procedures.

3.23. To optimize the use of resources and the effectiveness of the response, response plans should be highly coordinated and consolidated. Planning should not be done by one organization or agency without consultation with the others. Responsibilities should be assigned jointly with the participation of all concerned parties.

THREAT ASSESSMENTS

3.24. The Requirements [2] (paras 3.13–3.20) require that operators, the national coordinating authority and other appropriate organizations periodically conduct a threat assessment for the threats posed by facilities, sources, practices, on-site areas, off-site areas and locations to determine which threat categories apply. Moreover, these bodies are required to identify facilities, sources, practices, on-site areas, off-site areas or locations for which nuclear or radiological emergencies[15] could warrant (Ref. [2], para. 3.17):

- "Precautionary urgent protective action to prevent severe deterministic health effects by keeping doses below those for which intervention would be expected to be undertaken under any circumstances;[16]
- "Urgent protective action to prevent stochastic effects to the extent practicable by averting doses, in accordance with international standards;[17]
- "Agricultural countermeasures, countermeasures to ingestion and longer term protective measures, in compliance with international standards[17]; or
- "Protection for the workers responding (undertaking an intervention), in accordance with international standards.[18]"

3.25. The threat assessment should include the exchange of information with any nearby States whose territory may fall within the PAZ or UPZ (see paras 2.28–2.30 and Appendix II) of a facility located within the territory of the State performing the threat assessment.

3.26. The threat assessment should also identify:

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[15] Including events with a very low estimated probability of occurrence.
[16] Annex II of Ref. [2].
[17] Annex III of Ref. [2].
[18] Annex I of Ref. [2].

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— Significant non-radiation-related threats (e.g. UF_6 or other hazardous chemical releases) to individuals on and off the site who are associated with the facility;
— The operators of dangerous sources (threat category IV in Tables 1 and 4);
— The threat category of the jurisdictions within the State, on the basis of Table 5.

3.27. Operators of facilities in threat categories I, II and III and operators using dangerous sources should perform threat assessments to identify emergencies that could warrant the implementation of protective actions on or off the site. This threat assessment should be reviewed and revised periodically to take into account emergencies in similar facilities, in particular if there have been changes to on-site operations or off-site conditions that could have an impact on the preparations for emergency response.

3.28. A minimum level of threat (threat category IV in Table 1) should be assumed to exist for all jurisdictions. States should therefore assess their vulnerability to emergencies that can occur anywhere. This threat assessment should include:

— Types of shipments of radioactive material that have passed through the State and their main routes and focal points (e.g. distribution centres);
— Uses of dangerous sources (e.g. medical or industrial);
— Locations where spent and/or recovered dangerous sources are stored;
— Locations at which there is a significant probability of encountering an uncontrolled dangerous source that has been stored, lost, abandoned, stolen or illicitly transported. These should include scrap metal processing facilities, national border crossing points, seaports and airports.

3.29. Appendix I provides the typical threat categories for practices and Appendix III provides a method for determining whether a quantity of radioactive material should be considered a dangerous source.

3.30. The threat category of off-site jurisdictions should be consistent with their responsibilities in the response to an emergency, as shown in Table 5 and as illustrated in Fig. 4. Different threat categories may be applicable for a governmental jurisdiction (local or national): while typically only one threat

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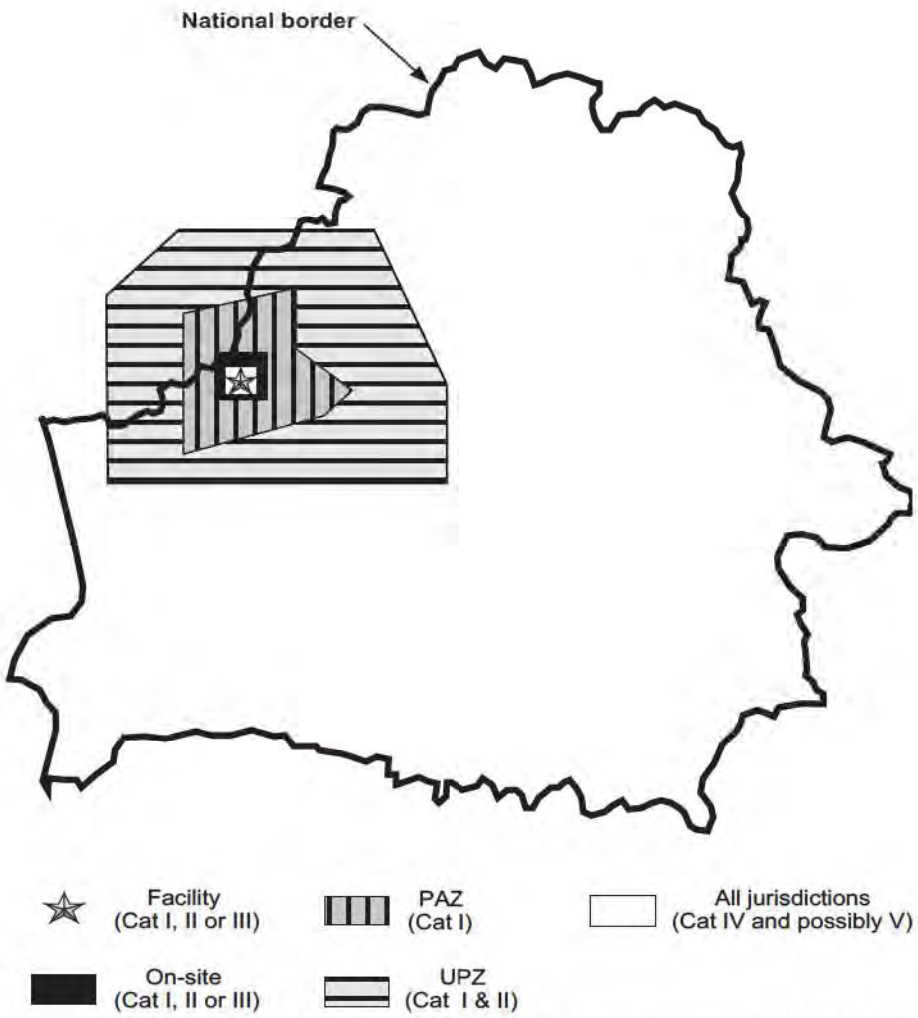


FIG. 4. Emergency zones and areas, and application of threat categories (this figure is not to scale).

category can apply to a facility and on-site area, all jurisdictions, as a minimum, fall within threat category IV.

3.31. The results of this analysis should be documented and included in the national all hazards plan or national radiation emergency plan (see paras 3.21–3.23) with a list and a map that show the threat categories of the facilities and their local jurisdictions. The results of the threat analysis should be used to implement a graded approach to emergency preparedness arrangements commensurate with the potential magnitude and the nature of the hazard.

TABLE 4. SUGGESTED CRITERIA FOR DETERMINING EMERGENCY THREAT CATEGORIES FOR FACILITIES AND PRACTICES

Threat category	Criteria[a]
I	Facilities for which emergencies have been postulated that could result in severe deterministic health effects off the site, including: • Reactors with power levels greater than 100 MW(th) (power, nuclear ship and research reactors);[b] • Facilities and/or locations containing recently discharged irradiated reactor fuel with a total of more than about 0.1 EBq of ^{137}Cs (equivalent to the inventory in a 3000 MW(th) reactor core); • Facilities with inventories of dispersible radioactive material sufficient to result in severe deterministic effects off the site.[c]
II	Facilities for which emergencies have been postulated that could result in doses warranting urgent protective action being taken off the site, including: • Reactors with power levels greater than 2 MW(th) and less than or equal to 100 MW(th) (power reactors, nuclear ship and research reactors); • Facilities and/or locations containing recently discharged irradiated reactor fuel requiring active cooling; • Facilities with potential for an uncontrolled criticality within 0.5 km of the off-site boundary; • Facilities with inventories of dispersible radioactive material sufficient to result in doses warranting urgent protective action being taken off the site.[d]
III	Facilities for which emergencies have been postulated that could result in doses warranting urgent protective action being taken on the site, including: • Facilities with the potential, if shielding is lost, for causing direct external dose rates of more than 100 mGy/h at 1 m; • Facilities with potential for an uncontrolled criticality more than 0.5 km from the off-site boundary; • Reactors with power levels of less than or equal to 2 MW(th); • Facilities with inventories of radioactive material sufficient to result in doses warranting urgent protective action being taken on the site.[e]

TABLE 4. SUGGESTED CRITERIA FOR DETERMINING EMERGENCY THREAT CATEGORIES FOR FACILITIES AND PRACTICES (cont.)

Threat category	Criteria[a]
IV	Practices involving mobile dangerous sources, including: • A mobile source with: (i) potential, if shielding is lost, for causing direct external (shine) dose rates of more than 1 mGy/h at 1 m, or (ii) dangerous sources according to Appendix III; • Satellites containing dangerous sources according to Appendix III; • Transport of quantities of radioactive material that would be dangerous sources according to Appendix III if not controlled. Facilities/locations at which there is a significant probability of encountering an uncontrolled dangerous source, such as: • Large scrap metal processing facilities; • National border crossing points, seaports and airports.

[a] Site specific analysis can be performed to determine the appropriate threat category.

[b] This is on the assumption that the reactor has been operating at this power level sufficiently long to build up the ^{131}I inventory close to 10 PBq/MW(th). For research reactors, owing to the great variety in their design and operation, a facility specific analysis should be performed to determine whether there could be sufficient inventory and energy to result in a significant airborne release off the site.

[c] Inventories 10 000 times the A/D_2 value calculated in Appendix III may place a facility in threat category I if it is assumed that 10% of the inventory could be released to the atmosphere in a single event.

[d] Inventories 100 times the A/D_2 value calculated in Appendix III may place a facility in threat category II if it is assumed that 10% of the inventory could be released to the atmosphere in a single event.

[e] Inventories 0.01 times the A/D_2 value calculated in Appendix III may place a facility in threat category III if it is assumed that 10% of the inventory could be released in a single event into a room from which people can be evacuated within a few minutes.

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TABLE 5. EMERGENCY THREAT CATEGORIES FOR GOVERNMENT JURISDICTIONS

Threat category	Local preparedness is warranted for jurisdictions	National preparedness is warranted for States
I	With responsibility for urgent protective actions within the PAZ and UPZ of a threat category I facility	With territory within the PAZ or UPZ of a threat category I facility
II	With responsibility for urgent protective actions within the UPZ of a threat category II facility	With territory within the UPZ of a threat category II facility
III	With responsibility for providing emergency services to a threat category III facility, including firefighting, police and medical services	Containing a threat category III facility
IV	Applies to all jurisdictions	Applies to all jurisdictions
V	With farming or food production processing facilities and/or responsibility for taking local action for agricultural and ingestion control	With territory that may warrant control of potentially contaminated food and/or water and products in the event of an emergency at a threat category I or II facility, including those located in other States

4. FUNCTIONAL REQUIREMENTS

IDENTIFYING, NOTIFYING AND ACTIVATING

4.1. The severity of nuclear emergencies has not always been initially recognized or comprehended by facility operators even when there were indisputable indications of the severity of the event [18, 30]. In some nuclear emergencies it has taken considerable time (hours to days) to select and implement various response actions, including urgent protective action for the public. In addition, in several emergencies it took considerable time to coordinate the response and this, in many cases, severely degraded the effectiveness of the on-site and off-site response. These failures have been attributed to the following: (1) emergency arrangements that did not address the full range of postulated emergencies; (2) procedures that lacked

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predetermined criteria as a basis for determining the severity of the event and making decisions about the response; (3) an absence of emergency arrangements (e.g. provision for prompt decision making) that could enable a coordinated response on and off the site within minutes to hours.

4.2. Consequently, the Requirements [2] (para. 4.19) require the operator of a facility or practice in threat category I, II, III or IV to make arrangements for the prompt identification of an actual or potential nuclear or radiological emergency and determination of the appropriate level of response. Furthermore, the Requirements [2] (para. 4.20) require that the criteria for classification be "predefined emergency action levels (EALs) that relate to abnormal conditions for the facility or practice concerned, security related concerns, releases of radioactive material, environmental measurements and other observable indications." The Requirements [2] (para. 4.25) also require that declaration of a particular class of emergency "shall promptly initiate the appropriate level of co-ordinated and preplanned emergency response on and off the site. The responsibilities and initial response actions of all response organizations shall be defined for each class of emergency."

4.3. The classification system and the immediate actions that should be taken by on-site and off-site response organizations immediately upon declaration of the level of emergency should be in accordance with the guidance in Appendix IV.

4.4. The emergency action levels should be based on the consideration of the full range of postulated emergencies, including those of very low estimated probability of occurrence (see para. 3.15 of Ref. [2]).

4.5. The emergency action levels should include, to the extent possible, symptomatic thresholds that will allow the operator, on the basis of information readily available during the emergency, promptly to declare, with a minimum of effort, the appropriate levels of emergency. The emergency action levels for reactor emergencies should be in accordance with Ref. [31].

4.6. Standardized national guidance on the response at the local (first responders) and national level that encompasses the types of radiological emergency listed in Table 2 should be developed and made available, with training, to the appropriate response organizations. This guidance should be consistent with the concepts of operation discussed in Section 6. The action guides in Ref. [3] (Appendix 7) could provide a basis for the response actions

for most of the types of emergency listed in Table 2; Ref. [4] should be used for emergencies involving transport.

International Nuclear Event Scale (INES)

4.7. The Requirements [2] (footnote 27) point out that the emergency response classification system should not be confused with the International Nuclear Event Scale (INES). The INES is used for communicating to the public the severity or estimated severity of an event and cannot be used as the basis for emergency response actions.

4.8. The Requirements [2] require (para. 4.20) that "It shall be ensured that the process of rating the event on the joint IAEA and OECD/NEA International Nuclear Event Scale (INES) does not delay classification or other response actions."

4.9. Experience has shown that in the early phase of an emergency its nature and its potential consequences may not be fully understood. Any INES rating made during this phase may be subject to change as more information becomes available. While an emergency is developing, no final rating should be assigned. Early announcement of the rating may help the public to understand the significance of the event only if the situation is clear and a provisional INES rating can genuinely be established.

4.10. If an INES rating is requested and sufficient information is available, the best estimate for a provisional rating should be given. If there is insufficient information to define a rating plus or minus one level, it should be stated in a broader communication on the emergency that there is not yet enough information available to provide an INES rating.

TAKING URGENT PROTECTIVE ACTIONS AND ASSESSING THE INITIAL PHASE

4.11. The Requirements [2] require (para. 4.42) that "Urgent protective action, in accordance with international standards[19], shall be taken to prevent to the extent practicable the occurrence of severe deterministic health effects and to avert doses."

[19] See Annexes II and III of Ref. [2].

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4.12. The Requirements [2] define an urgent protective action as "A protective action in the event of an emergency which must be taken promptly (normally within hours) in order to be effective, and the effectiveness of which will be markedly reduced if it is delayed."

4.13. The urgent protective actions and countermeasures should include the following, which are further described in Appendix V:

- For radiological emergencies, isolation of a contaminated area or radioactive source;
- Prevention of inadvertent ingestion;
- Evacuation;
- Sheltering;
- Respiratory protection and protection of skin and eyes;
- Decontamination of individuals;
- Prophylaxis with stable iodine;
- Protection of the food supply and prevention of the consumption of significantly contaminated foodstuffs and water;
- Management of the medical response;
- Protection of international trade.

4.14. International standards[20] have been established for determining whether and when evacuation, shelter, relocation and food restrictions are justified. However, these standards cannot be used directly during an emergency since they are not specified in terms of quantities that are directly measurable in a facility or in the environment.

4.15. Consequently, the Requirements [2] (para. 4.71) require that "arrangements shall be made for promptly assessing the results of environmental monitoring and monitoring for contamination on people in order to decide on or to adapt urgent protective actions to protect workers and the public, including the application of operational intervention levels (OILs) with arrangements to revise the OILs as appropriate to take into account the conditions prevailing during the emergency."

[20] For facilities it may be possible for the criteria for decisions on protective actions to be established at the time of the emergency, provided that there is a high degree of assurance that they can be established and implemented immediately upon the receipt of field monitoring results.

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4.16. All States should develop default OILs (see footnote 20) in advance, as part of the preparedness process, for determining whether and when exposure rates or contamination levels warrant taking protective action and other countermeasures in the event of a nuclear or radiological emergency. OILs should be developed for:

- The isolation of a contaminated area or dangerous source;
- Evacuation or substantial shelter;
- Stable iodine prophylaxis;
- Decontamination of people;
- Decontamination or control of vital equipment, vehicles and personal property;
- Immediate medical treatment;
- Long term medical monitoring;
- Countermeasures against excessive doses from ingestion;
- Control of international trade, goods and products.

4.17. OILs should be developed for radioactive releases and/or direct exposures resulting from emergencies involving facilities in threat categories I, II and III and for radiological emergencies, by using realistic assumptions and including arrangements to revise the OILs as appropriate to take into account the conditions prevailing during the emergency.

4.18. The default OILs for the dose rates from deposition resulting from a nuclear reactor emergency, which are used to make decisions concerning evacuation and substantial shelter, and the arrangements for their revision, should be consistent with Ref. [31].

4.19. The OILs for the isolation of a contaminated area or dangerous source should be consistent with Appendix II, Table 7.

4.20. For most radiological emergencies, first responders should initiate the initial urgent protective action. Often, the first responders will not have radiological monitoring equipment and they may have misconceptions about the risks, which may compromise the initial response.[21]

[21] For example, in some emergencies first responders have been reluctant to perform life saving actions or to treat victims because of indications that radioactive material was present.

4.21. Consequently, the Requirements [2] (para. 4.47) require that "First responders shall be informed that, in the event of an immediate threat to life (such as a fire), they should not delay any action to save human life or prevent serious injury for the reason that signs or placards indicate the possible presence of radioactive material."

4.22. For the emergencies listed in Table 2, the initial actions to be taken by first responders should be predetermined and communicated to the first responders. In general, the actions should be initiated on the basis of information and conditions that are observable by the first responder at the scene.

4.23. Emergencies have been postulated or have occurred at facilities in threat category I for which urgent protective measures should be taken off the site within the PAZ before or shortly after a radioactive release if they are to be effective. The effectiveness of protective actions in these cases can best be ensured by taking the actions upon the detection of dangerous conditions in the facility and not awaiting a release or environmental monitoring results. Emergencies have also been postulated or have occurred at facilities in threat categories I and II for which urgent protective measures should be promptly taken within the UPZ on the basis of the results of radiological monitoring off the site.

4.24. During general emergencies at facilities in threat categories I and II it has taken many hours or days to decide on and to implement urgent protective actions for the public.[22] Subsequent analysis showed that, even with the delays, inappropriate protective action had been taken. This occurred because no arrangements for making decisions promptly were in place[23] for these low probability emergencies.

4.25. Consequently, the Requirements [2] (para. 4.48) require that "For facilities in threat category I or II arrangements shall be made for effectively

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[22] After the Chernobyl accident, imposition of restrictions on the consumption of contaminated milk was delayed for several days. This delay probably resulted in several thousand avoidable cases of thyroid cancer among children.

[23] In most cases, a meeting was held to decide what to do and who should do it. In addition, the decision makers were untrained (often they were too busy to attend training courses or exercises). In one case, a regulatory body interfered in the process for making decisions on protective actions even though it had no designated role in this area.

making and implementing decisions on urgent protective actions to be taken off the site. This capability shall make use of existing public infrastructure[24] to limit the occurrence of severe deterministic health effects and to avert doses, in accordance with international standards (Ref. [2], Annexes II and III), for the full range of possible emergencies[25] at those facilities."

4.26. For facilities in threat categories I and II these arrangements should include provisions for promptly taking urgent protective actions off the site upon the declaration of an emergency, in accordance with Appendix VII and based on OILs for environmental measurements. The arrangements should be based on site specific analysis to best ensure that severe deterministic effects will be prevented and that other justified actions taken will be in accordance with international standards. These arrangements should be established with the goal of meeting the time objectives in Appendix VI.

4.27. The decision support systems, including those using computer models, may not be able to predict the size and timing of a radioactive release (the source term), the movements of plumes, deposition levels or resulting doses sufficiently quickly or accurately during an emergency that they could provide the sole basis for deciding on initial urgent protective actions. This is particularly true for emergencies for which protective actions must be initiated before or shortly after a release to be effective or for which a release is by an unmonitored pathway. Consequently, for such emergencies, immediate protective actions should be implemented out to a predetermined distance from the facility in all directions when severe conditions are detected in the facility. The protective actions and the distance should be determined in advance and should be consistent with Appendix II, or should be determined on the basis of site specific analysis.

4.28. Emergencies have occurred in facilities in threat categories I, II and III that have resulted in hazardous conditions on the site.

4.29. Consequently, the Requirements [2] (para. 4.51) require that, for these facilities, specific arrangements be in place to effectively implement urgent protective action for the people on the site. These arrangements should apply to all people in areas controlled by the operator, such as visitors or others (e.g. construction workers, fishermen).

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[24] Such infrastructure includes, for example, buildings and transport networks.

[25] The full range of possible emergencies includes those of very low probability.

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4.30. In an emergency, public officials will make recommendations with regard to what protective actions the public should take. It may be that neither these officials nor the public understand the principles or terminology of radiation protection. The arrangements for taking protective action should therefore include a plain language explanation of how the protective actions would ensure the safety of the public.

4.31. Inconsistencies between measures taken by different States may be difficult to explain and may possibly result in a loss of trust in officials on the part of the public. Consequently, the arrangements should include a means to ensure that the recommended countermeasures or actions are coherent among States or that any differences can readily be explained to the public to allow the public and decision makers to make informed decisions.

KEEPING THE PUBLIC INFORMED

4.32. It has often been stated that the public panicked during a nuclear or radiological emergency when they expressed concern or did not follow official recommendations. However, subsequent investigations have found that in some emergencies the public received, apparently from official sources, the news media and other people, confusing and inconsistent information concerning the risks of exposure and the appropriate actions to be taken to reduce the risks. In many cases the confusion was partly the result of attempts by local officials, national officials and the operator, without prior coordination, to address the news media from different locations (e.g. the national capital, the regional capital, the location of the emergency) [32]. Under these circumstances, the public did what they felt was appropriate to protect themselves, their families and their interests. This often resulted in the public taking actions that did not appear to follow official recommendations or that were later found to be inappropriate and, in some cases, harmful (see para. 4.52), and which resulted in severe adverse economic and psychological consequences.

4.33. The severity of the non-radiological effects may depend in part on how well the following questions from the public are answered:

— Is the situation safe?
— How do I keep my family and myself safe and how do I protect my interests?

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4.34. It may be impossible to answer these questions simply and effectively without preparation. Officials are not experienced in responding to these questions since a nuclear or radiological emergency is a very rare occurrence and even professionals (e.g. medical practitioners or radiation professionals) may have misconceptions (often assumed to be well established truths) concerning the risks associated with radiation and how to reduce them.

4.35. Consequently, the Requirements [2] (para. 4.83) require that "Arrangements shall be made for: providing useful, timely, truthful, consistent and appropriate information to the public in the event of a nuclear or radiological emergency….".

4.36. These arrangements should include provision:

- To designate an individual within each organization with the role, during the response, of coordinating the provision of information to the news media.
- To arrange to coordinate the provision of information to the public by national officials, local officials and the operator. This could include the establishment, as soon as possible, of a public information centre, as described in Appendix VIII, to serve as the single source of information.[26] For facilities in threat category I, the public information centre should be at a pre-established location.
- To give plain language answers to typical questions, descriptions of the risks involved and appropriate actions that the public can take to reduce the risks.
- To identify and correct misleading and harmful information.

MANAGING THE MEDICAL RESPONSE

4.37. Many emergencies resulting from lost or uncontrolled radioactive sources are first discovered through reports by physicians who have observed medical symptoms that they suspect to be radiation induced injuries [6, 12]. Local physicians are inexperienced in the diagnosis of radiation induced injuries. There have been several emergencies in which people suffering from radiation

[26] During the Three Mile Island emergency in the USA in 1979, the President of the USA directed that all official information should come from one place in order to prevent the confusion that resulted from providing information from several places [32].

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induced injuries made several visits to medical professionals before radiation exposure was suspected. In each of these cases, other information (e.g. that the patient remembered seeing the radiation trefoil) prompted doctors to consider radiation exposure as a possible cause of the symptoms.

4.38. Consequently, the Requirements [2] (para. 4.77) require that "Arrangements shall be made for medical personnel, both general practitioners and emergency staff, to be made aware of the medical symptoms of radiation exposure and of the appropriate notification procedures and other immediate actions warranted if a nuclear or radiological emergency is suspected."

4.39. Experience also shows [6–14, 33] that emergencies that result in a wide range of radiation induced injuries and personal contamination requiring specialized treatment are possible in any State and that local medical practitioners and hospitals may not have a good understanding of how to treat overexposed or contaminated patients. Medical personnel without training in radiological response have in some cases been reluctant to treat potentially contaminated victims for fear of contaminating themselves. There are only a few medical centres around the world with significant experience in the diagnosis and specialized treatment of radiation induced injuries. However, radiation induced injures have been effectively treated in national hospitals in cases in which doctors benefited from international consultations with specialists.[27]

4.40. In emergencies involving actual or possible personal contamination (e.g. the terrorist attack with sarin nerve gas in the Tokyo subway in 1995), local hospitals may be confronted with individuals seeking treatment, many of whom may have travelled individually to nearby medical facilities. Such individuals would most probably not have been monitored for contamination and the medical staff would not know the kind of contamination (if any) to which they had been exposed. The hospitals would therefore need to implement procedures that are appropriate for all possible types of contamination (by radiological, chemical or biological agents).

[27] The IAEA and WHO have, under the terms of the Assistance Convention [1], arranged for consultations with or treatment at international specialized centres in numerous emergencies.

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4.41. Consequently, the Requirements [2] (para. 4.80) require that "Arrangements shall be made at the national level to treat people who have been exposed or contaminated." These arrangements should include:

- A limited national capability to provide initial treatment of contaminated and/or severely overexposed patients;
- Arrangements to provide advice and expertise to local hospitals;
- Guidelines for local medical facilities on the response to possible emergencies, involving all possible types of contamination (by radiological, chemical or biological agents);
- National and international arrangements to provide highly specialized treatment for exposed people, which include arrangements to consult specialists with significant experience in the diagnosis and specialized treatment of radiation induced injuries (this could include the use of specialized drugs such as 'Prussian blue' (iron(III)-hexacyanoferrate(II)) and chelating agents). Such a consultation could be obtained under the Assistance Convention through the IAEA or WHO [1].

4.42. It is possible that during a nuclear or radiological emergency individuals might receive radiation doses that lead to high individual risks of incurring radiation induced cancers. It is also possible — although unlikely (see footnote 6) — that there may be a detectable increase in the incidence of cancers among the exposed population group owing to the extra radiation induced cases. However, in past emergencies there were no pre-established criteria for determining who should receive long term medical follow-up with the purpose of detecting the disease early, and hence treating it more effectively. Furthermore, criteria established after emergencies were often set at a low level of received dose or were not based on radiation dose criteria at all. This led to the designation of groups for follow-up in which it was impossible to detect any increase due to extra radiation induced cases in the incidence of cancers because of the inherent limitations on epidemiological studies given the relatively small effects. This resulted in an exaggerated perception of radiation risks on the part of the public and consequently in an unjustified and inefficient use of resources.

4.43. Consequently, the Requirements [2] (para. 4.81) require that "Arrangements shall be made for the identification, [tracking,] long term health monitoring and treatment of people in those groups that are at risk of sustaining detectable increases in the incidence of cancers [and other health effects] as a result of radiation exposure due to a nuclear or radiological emergency." Inclusion of people in a long term monitoring programme should

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be on the basis of criteria that provide an opportunity to detect an increase in the incidence of cancers among the exposed population group due to radiation induced cases and to treat cancers more effectively at an early stage.

4.44. Emergencies resulting in severe deterministic effects among on-site personnel and on-site responders have been postulated or have occurred in facilities in threat categories I, II and III. Facilities in threat category I could also potentially give rise to emergencies that result in severe deterministic effects among the public.

4.45. Consequently, the Requirements [2] (para. 4.78) require that "Facilities in threat category I, II or III shall make arrangements to treat a limited number of contaminated or overexposed workers, including arrangements for first aid, the estimation of doses, medical transport and the initial medical treatment of contaminated or highly exposed individuals in local medical facilities." These arrangements should include capabilities:

- To admit a limited number of personnel from these facilities;
- To treat and decontaminate exposed or contaminated patients;
- To identify persons needing specialized treatment following radiation exposures;
- To control the spread of contamination and to prepare patients for transport to a referral hospital (see Appendix VIII) that can treat persons having received severe overexposures in accordance with Refs [34–36].

4.46. In addition, there should be a referral hospital designated outside the UPZ that can provide highly specialized treatment for a limited number of exposed and/or contaminated persons, as well as for persons with combined injuries as a result of the emergency.

TAKING AGRICULTURAL COUNTERMEASURES, COUNTERMEASURES AGAINST INGESTION AND LONGER TERM PROTECTIVE ACTIONS

4.47. The Requirements [2] (para. 4.85) require that "Agricultural countermeasures and longer term protective actions in accordance with international standards[28] shall be taken to avert doses."

[28] See the guidelines reproduced in Annex III of Ref. [2].

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4.48. Agricultural countermeasures and longer term protective actions are countermeasures and protective actions that do not need to be implemented promptly to be effective, and include:

— Relocation;
— Longer term agricultural[29] countermeasures and remedial actions;
— Longer term countermeasures relating to international trade;
— Medical follow-up;
— Decontamination of areas and their return to normal use.

4.49. These actions are intended to avert doses delivered over long periods (months to years) or to anticipate and detect medical conditions that may only appear years later. A limited delay in their implementation, while measurements are taken and the situation is assessed, would therefore appear to be justified. However, the emergencies at Chernobyl in 1986 and in Goiânia in 1987 showed that at the time of the emergency the development of criteria for taking longer term protective actions was driven by public mistrust and political pressure, resulting in criteria that were not in accordance with generally accepted radiation protection principles.

4.50. Consequently, the Requirements [2] (para. 4.89) require that "For areas with activities in threat category V arrangements shall be made for taking effective agricultural countermeasures, including restriction of the consumption, distribution and sale of locally produced foods and agricultural produce following a release of radioactive material." These arrangements should include default OILs and they should be in place for all activities in threat category V.

4.51. The Requirements [2] (para. 4.90) require that "In the urgent protective action planning zone and beyond, where relocation may be necessary as a result of a major release of radioactive material from a facility in threat category I or II, arrangements shall be made for effective temporary relocation. These arrangements shall include: OILs for dose rates due to deposition and deposition densities; the means to revise the OILs; timely monitoring for ground contamination; the means for accomplishing relocation; and arrangements for assisting those persons who have been relocated."

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[29] This includes measures relating to livestock, food production, gardens, forest products, fishing and water supplies.

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MITIGATING THE NON-RADIOLOGICAL CONSEQUENCES OF THE EMERGENCY AND RESPONSE

4.52. Virtually all nuclear and radiological emergencies have resulted in members of the public taking inappropriate actions[30], which can result in significant adverse psychological and economic effects. Even emergencies with few or no radiological consequences off the site [18, 30] have resulted in significant non-radiological consequences among the off-site population. This has included possibly thousands of abortions that were undergone in Europe after the Chernobyl accident owing to misplaced fears of radiation induced health effects in babies [37]. This effect occurred even though doses due to the Chernobyl accident were well below levels at which deterministic health effects could be induced in the embryo or foetus [37]. Other examples include spontaneous evacuation, interference with the funerals of people who had previously been contaminated, boycotting of products from areas where emergencies had occurred, refusal to sell airline tickets to people from areas where emergencies had occurred, and refusal to provide medical treatment to contaminated victims.

4.53. Consequently, the Requirements [2] (para. 4.96) require that "Arrangements shall be made for responding to public concern in an actual or potential nuclear or radiological emergency" and for "monitoring for and responding to any related health effects and preventing inappropriate actions on the part of workers and the public."

OTHER ACTIONS

4.54. All States should make arrangements to protect their interests in the event of an emergency. These arrangements should take account of:

— Citizens in the affected State(s);
— Embassies in the affected State(s);
— Travellers to the affected State(s);
— Travellers from the affected State(s);
— Transport and trade with the affected State(s);

[30] Inappropriate actions include, for example, discrimination against possibly exposed persons, spontaneous evacuation, the hoarding of food and unwarranted terminations of pregnancy.

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— Any installation or activity in the State similar to that involved in the emergency.

5. REQUIREMENTS FOR INFRASTRUCTURE

5.1. The Requirements [2] (Section 5) establish the requirements for infrastructural elements that are essential for providing an adequate response capability. These infrastructural elements are:

— Authority;
— Organization;
— Coordination of emergency response;
— Plans and procedures;
— Logistical support and facilities;
— Training, drills and exercises;
— A quality assurance programme.

5.2. Inadequate responses to emergencies can often be traced back to an inadequacy in one or more of these infrastructural elements. The following gives some examples:

— Authority: There have been cases where the operator delayed notifying off-site authorities while conferring with management or attempting to solve a problem. This occurred because there was not a person on the site at all times with the authority and responsibility for promptly classifying the emergency and notifying off-site authorities.
— Coordination: There have been radiological emergencies in which different responding organizations were unaware of or did not recognize the responsibilities of the other response organizations; this resulted in delay and confusion, especially when dealing with local officials. Also there have been cases of agencies or ministries that believed incorrectly that they had a role in the response to an emergency because the public or senior officials thought so; this too had hindered the emergency response since they actually had no defined role and had not, therefore, been included in the planning process. There have also been cases of further emergencies arising during the initial emergency, where the simultaneous

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implementation of uncoordinated plans (e.g. the security plan and the emergency plan) interfered with the emergency response.[31]

— Procedures and training: As discussed earlier, during the Three Mile Island and Chernobyl emergencies the on-site and off-site response staff did not initially recognize or comprehend the severity of the event or initiate the appropriate response. It was said that the staff at the Chernobyl nuclear power plant when the accident happened in April 1986 were very brave but they did not know what to do early in the emergency [38]. Such failures have been attributed to training that did not address severe accidents and to procedures that lacked predetermined criteria on the basis of which to classify events and to make decisions in response. Major emergencies were not addressed if their occurrence was considered to be not credible, i.e. so improbable they did not need to be given serious consideration. Another common problem is that those who occupy senior positions (e.g. leaders of the national or local government) in the response organization in many cases do not attend training or exercises and thus are not sure what to do when called on under stressful response conditions.
— Facilities and logistics: Equipment and facilities used under normal conditions are not adequate during emergencies. As an example, overloading and sometimes breakdown of public telephone networks (land line and mobile networks) in the vicinity of an emergency often occur shortly after the public becomes aware of events that they perceive as significant — not necessarily always emergencies.[32] This occurs when people telephone to offer assistance and to enquire about the safety of family and friends. Other common problems are that items of communications equipment used by response personnel are not compatible and therefore response organizations cannot communicate with each other, and that available equipment (e.g. monitoring instruments) is unsuitable for emergency use (e.g. their ranges are not sufficient or they are not suitable for the working conditions).
— Quality assurance programme: Failure to have a system in place to ensure that the emergency arrangements made are maintained at an adequate

[31] In one case, the response to an intruder included essentially locking all the doors in a nuclear power plant, which interfered with activation of the emergency centres, off-site communications and notifications.

[32] This occurred in the USA following the attacks on 11 September 2001, earthquakes and the Three Mile Island emergency in 1979 and, in at least one case, by people telephoning for tickets for a rock music concert.

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state of readiness has resulted in many problems. In some emergencies, equipment, supplies and facilities required for the response were not available or were inadequate because they: (a) had not been procured in advance; (b) were not located near to where they were needed; (c) had been taken and not returned to the emergency stores or replaced; (d) were not operational when needed; (e) were not properly maintained or calibrated; (f) had exceeded their recommended life; (g) did not have the necessary fuel, lubricant, power supply, food and water supplies or other expendable supplies for long term operation; or (h) were not suitable for use under the conditions prevailing during the emergency (e.g. rain, high temperatures, high dose rates). Experience also shows that outdated call lists, procedures and other documentation have hindered emergency response. This is primarily because emergencies are rare events so equipment, facilities and resources designated solely for emergency response are not normally used and frequently there is no adequate programme to ensure that these resources are maintained.

5.3. Consequently, Section 5 of the Requirements [2] establishes requirements for infrastructural elements that are essential to providing the capability of fulfilling the functional requirements.

5.4. In developing the infrastructure needed in an emergency, the following characteristics of emergencies should be considered:

- Emergencies are rare and in many cases result from events that were considered improbable;
- Responders will have little or no experience in dealing with emergencies;
- The functions that must be performed and the conditions under which they would have to be be performed can be considerably different from those associated with the normal jobs of the responders;
- The response may be carried out under highly stressful and possibly dangerous conditions;
- Actions may need to be performed immediately.

5.5. Emergency facilities should be provided that are in accordance with Appendix VIII.

5.6. Examples of emergency response organizations and plans and procedures are provided in Ref. [3]. The reader should review Ref. [3] for a comprehensive discussion of the factors that should be considered when preparing to make the necessary arrangements to develop and maintain these infrastructural elements.

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6. CONCEPT OF OPERATIONS

GENERAL

6.1. The Requirements [2] (paras 5.13–5.14) require each response organization to prepare an emergency plan for coordinating and performing their assigned response functions. As defined in the IAEA Safety Glossary, an emergency plan should contain a concept of operations.

6.2. The concept of operations should be a brief description of the ideal response to an emergency. It should be developed at the beginning of the preparedness process to ensure that all those involved in the development of a response capability share a common vision. This section provides a summary of the threats posed by a nuclear or radiological emergency and an example of a concept of operations for dealing with any such emergency.

6.3. There are two operational concepts that apply in responding to any emergency. First, the response should operate under a system similar to the integrated incident command system as described in Ref. [3]. The most important characteristic of an incident command system is that there should be a single incident commander responsible for directing the response of all the organizations responding to the emergency (response to radiological hazards, response to conventional hazards, and law enforcement). This responsibility should be assigned to an individual in the organization that has the primary role in each phase of the response. As the emergency progresses, the primary role will typically pass from the operator or the first responders to a local official and finally to a national official, or to a command group (composed of representatives of the facility and other principal response organizations) for events involving several jurisdictions or ministries. The incident commander should direct the response from an incident command post (see Appendix VIII) located near the scene of the emergency if appropriate.[33]

6.4. The second general operational concept is that arrangements should be made to promptly provide useful and coordinated information to the public via the news media. This should include arrangements to ensure that the public statements of the operator, local officials and national officials all provide a

[33] There may be emergencies, such as transnational emergencies, for which it is not reasonable for the command post to be located near the scene of the emergency.

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consistent message to the public. While this could be accomplished by other means, in this concept of operations it is accomplished by establishing, as soon as possible, a single location as the public information centre (see Appendix VIII). In addition, in all cases the public should be provided with a plain language explanation of the risks to them, the actions they can take to reduce the risks and the actions being taken to ensure that people are safe and their interests are being protected. It should be recognized that this applies to any event perceived as an emergency by the public or the media.

6.5. The arrangements for facilities in threat categories I, II and III should be established with the goal of meeting the time objectives given in Appendix VI.

6.6. Programmes to deal with the longer term impact of an emergency should be carefully developed according to internationally accepted criteria, and social, psychological and economic factors should be considered. Methods for compensation (if any) should be carefully considered and targeted at compensating for the tangible consequences of the emergency. Recovery operations should be conducted subject to the full system of detailed requirements in respect of occupational exposure.

THREAT CATEGORIES I AND II

Threat description

6.7. For reactors and facilities with large amounts of spent fuel or dispersible radioactive material, the primary risk arises from airborne releases of radioactive material. For the biggest releases (general emergencies, see Appendix IV) postulated at facilities in threat category I, the risk of severe deterministic effects off the site can only be substantially reduced by taking urgent protective action in the PAZ (see Appendix II) before or shortly after a release. This can best be ensured by the implementation of this action upon the detection and classification of dangerous conditions in the facility, and not by awaiting a release or the results of environmental monitoring. For facilities in threat categories I and II, airborne releases have also occurred or been postulated that result or that would result in doses from exposure to ground shine over several days that warrant taking urgent protective measures to prevent severe deterministic effects or reasonably to reduce the risk of stochastic effects. There could also be emergencies at facilities in threat category II involving unshielded criticalities that result in off-site doses

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(without a significant airborne radioactive release[34]) sufficient to warrant the implementation of urgent protective action within several hundred metres. Prompt monitoring to locate and evacuate hot spots or areas with high dose rates due to shine from the facility can prevent the majority of these doses and their associated effects. Deposition from major releases that warrant relocation and the imposition of restrictions on food consumption may occur at a considerable distance.

6.8. Off-site releases or doses arising from criticalities at facilities in threat categories I and II are not predictable with any accuracy and a release could result in a very complex pattern of deposition and doses off the site. However, in most cases emergency action levels can be identified in advance and these will indicate serious conditions in time to classify the emergency and to initiate a response before a significant release or significant exposure occurs.

6.9. On-site dose rates during an emergency at facilities in threat categories I, II and III may be very high (e.g. >10 Gy/h), and there is a risk of contamination by beta emitters and other hazardous conditions (e.g. emission of steam) in areas where staff action may be needed to mitigate the consequences of the emergency. People responding on the site should therefore be provided with appropriate protective equipment and training.

6.10. The actions taken to respond to the long term consequences of these emergencies may result in serious detrimental social, psychological and economic impacts on the public if they are not based on internationally accepted criteria and if their long term social, psychological and economic impacts are not considered.

Concept of operations

6.11. Before or shortly after a radioactive release or a criticality, the operator (facility staff) should declare a general emergency on the basis of predetermined emergency action levels. Upon the declaration of an emergency, the facility staff should notify the jurisdictions within the PAZ, the UPZ and

[34] Criticalities cannot produce sufficient amounts of fission products to result in an airborne radioactive release that would warrant the implementation of urgent protective actions off the site. Nonetheless, it is likely that the energy produced by a criticality would result in the release of other hazardous materials that may be present.

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the area where agricultural countermeasures may be warranted (including jurisdictions within other States).

6.12. Within about 15 minutes of the declaration of an emergency the facility staff should recommend to off-site officials that they perform the protective actions specified in Appendix VII. The facility staff should take all possible actions to prevent or mitigate the release or the exposure and should perform all other immediate actions specified in Appendix IV. Local officials should provide police and firefighting services and medical assistance to the site, if requested, and should decide on the protective actions to recommend to the public. They should warn the populations in the PAZ and the UPZ (e.g. with sirens) and should inform them (e.g. via radio or television messages) within 30 minutes of being notified of the general emergency. The public, having been instructed in advance, should promptly take the actions recommended. National officials should notify the IAEA and all States that may be affected (e.g. where food restrictions are warranted). The facility staff should promptly monitor the PAZ and UPZ to determine whether additional protective actions are needed and should continue until relieved by off-site officials. Following a radioactive release or a criticality default OILs should be used by officials to immediately assess environmental data and determine whether additional protective actions are warranted. A radiological monitoring and assessment centre should be established at which all environmental monitoring, sampling and assessment is coordinated. The facility operator should ensure that the people on the site or those responding from off the site are protected from all possible hazards. People coming from the site who have been contaminated or exposed above predetermined criteria should be taken to local hospitals and treated in accordance with procedures. Physicians treating exposed individuals should consult doctors with experience in dealing with overexposures. Local officials, supported by national officials, should assist in obtaining specialized treatment for exposed individuals, through the IAEA if necessary. Triage centres should be established within 24 hours outside the evacuated area to screen casualties and to determine the level of treatment for any overexposed members of the public and on-site personnel. People who have been contaminated or exposed above predetermined criteria should be assigned to predetermined and prepared hospitals located outside the affected area. National officials should support local officials, should conduct monitoring away from the site and should coordinate longer term protective actions. Soon after the public is warned (e.g. by means of sirens), the news media should be briefed by a single government spokesperson. Joint press briefings should be given periodically (at a joint public information centre) with participation by the operator and local and national officials.

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6.13. The personal data of people who have incurred exposures due to an emergency at a level high enough to give rise to a high individual risk of developing radiation induced cancer, or to lead to a detectable increase due to radiation exposure in the incidence of health effects among the population exposed, should be recorded in a registry. Those individuals listed in the registry should be provided with information on their individual risks and should be considered for long term medical follow-up to be able to detect early and treat effectively any radiation induced cancers or other radiation induced injuries.

THREAT CATEGORY III

Threat description

6.14. Emergencies at facilities in threat category III may occur with little warning and could result in significant exposure in areas on the site (e.g. a radiotherapy treatment room). However, for most emergencies, emergency action levels for classifying emergencies (see Appendix IV) that ensure a prompt, effective on-site response can be developed for the facility.

6.15. In most cases, emergencies involve industrial or radiotherapy sources in an exposed position, or the dispersal of radioactive material and contamination of people, places or things (e.g. products) at industrial, research or educational facilities as a result of a source being melted, ruptured or spilled. In most cases only a limited area (e.g. a treatment room) of the facility is involved. Such emergencies should be detected promptly by the operator and should be limited to an area under administrative control. The source of the contamination and the potentially exposed or contaminated persons and items should be promptly identified, and the cause and scope of the emergency should be promptly determined.

6.16. Depending on the facility concerned there may be high dose rates, contamination by beta emitters or other hazardous conditions in areas where action by the staff is required to mitigate the consequences of the emergency. People responding on the site should therefore be provided with appropriate protective equipment and training.

6.17. Threat category III has no credible emergencies postulated for which urgent off-site protective action is warranted. Emergencies at facilities in threat category III may, however, cause considerable concern and lead to unnecessary

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actions being taken among the population and by off-site officials. Emergencies at such facilities can result in significant adverse psychological and economic consequences if the public or off-site officials are not aware that the emergencies do not in themselves pose any risk off the site. However, there may be a risk that contaminated persons, products, packages or equipment leave the site.

Concept of operations

6.18. The facility staff should declare a facility emergency (see Appendix IV) on the basis of predetermined emergency action levels, should take any necessary life saving action, and should evacuate and secure potentially hazardous areas and notify local off-site officials. These officials should provide police and firefighting services and medical assistance to the site if requested. The operator should ensure that all people on the site (including those responding from off the site) are provided with appropriate protection. Access to the potentially hazardous area should be restricted until authorized by the radiation protection officer (or radiological assessor) but should be allowed for the purpose of saving lives. If there is a potential for contamination or contaminated individuals or products to be leaving the facility or area, off-site officials should be promptly notified and advised on the action to be taken. Monitoring and technical assistance should be provided to off-site officials if needed. If there are serious overexposures, the facility staff should gather information concerning the circumstances and any other information that would be helpful for reconstructing doses. Highly contaminated or severely overexposed persons should be identified on the basis of predetermined criteria and should be taken to local hospitals (if appropriate) and treated there in accordance with advanced training and procedures. Physicians treating exposed individuals should consult doctors with experience in dealing with overexposures. Local officials, supported by national officials, should assist in obtaining specialized treatment for exposed persons, through the IAEA if necessary. The facility staff should promptly conduct monitoring to confirm, on the basis of default OILs, that no protective actions are necessary elsewhere on the site. Local officials, with the assistance of the facility staff, should promptly conduct monitoring to confirm, on the basis of default OILs, that no protective actions are needed off the site and that no persons and objects leaving the facility are contaminated. Local and national officials should promptly inform the public and the news media of the emergency. Soon after the public is notified, the news media should be briefed by a single government spokesperson. Joint press briefings should be given periodically (at a joint public information centre) with participation by the operator and local and

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national officials. Recovery operations should be conducted subject to the full system of detailed requirements for occupational exposure.

6.19. The personal data of people who have incurred exposures due to an emergency at a level high enough to give rise to a high individual risk of developing radiation induced cancer, or to lead to a detectable increase due to radiation exposure in the incidence of health effects among the population exposed, should be recorded in a registry. Those individuals listed in the registry should be provided with information on their individual risks and should be considered for long term medical follow-up to be able to detect early and treat effectively any radiation induced cancers or other radiation induced injuries.

THREAT CATEGORY IV (RADIOLOGICAL EMERGENCIES)

Threat description

6.20. Planning for emergencies in threat category IV applies everywhere and represents the minimum level of preparedness appropriate for all States. In general, this applies to emergencies involving:

— Dangerous sources;
— Transport of radioactive or fissile material;
— Severe overexposure.

6.21. Appendix III provides plain language statements of the risks arising from uncontrolled dangerous sources. Reference [3] provides 'action guides' that summarize the threat and the necessary response to a range of radiological emergencies.

Dangerous source related emergency

6.22. In this Safety Guide, the term 'source emergency' applies to emergencies involving:

— Medical symptoms of radiation exposure;
— Lost or stolen dangerous sources;
— Mobile dangerous sources;
— Public exposure and/or contamination;
— Nuclear weapons;
— Re-entry of satellites containing radioactive material.

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6.23. Many, if not most emergencies with uncontrolled sources are first discovered by physicians treating people reporting medical symptoms of radiation exposure.

6.24. There are typically several fatalities among the public around the world each year resulting from someone who is unaware of the hazard of handling a lost or stolen dangerous source. There have been several cases in which prompt announcements alerting the public of a hazard, following the loss or theft of a source, have resulted in prompt recovery of the source and thus the prevention of serious consequences.

6.25. Among the most common types of mobile dangerous sources are radiography cameras. The operator generally handles these sources with limited or no assistance. However, there have been emergencies that have resulted in serious exposure of the operator and other workers owing to an inadequate response by the operator or a loss of control over the source by the operator.

6.26. Emergencies with contamination and/or exposure of the public may involve the spread of contamination for a long period before its detection. There have been cases where contamination was not detected for several years. Such emergencies can result from the rupture or dispersal of uncontrolled (lost or stolen) radioactive material in the public domain. In several cases, a member of the public has unknowingly ruptured a sealed source, and other members of the public have unknowingly spread the radioactive material. These emergencies can have very serious consequences. For example, the Goiânia emergency [6] resulted in four deaths and a volume of 5000 m^3 of radioactive waste. Emergencies involving contamination of members of the public may also result from the undetected dispersal of controlled material. The undetected melting of gauges into metal products is an example. The most important feature of such emergencies is that the source and the scope of the emergency are unknown at the time of detection. These emergencies are often detected through the diagnosis of radiation induced injuries by physicians or during routine checks, such as monitoring at borders or entrances to facilities that detects contamination of people, vehicles, packages or products. In some cases, contamination has been detected in imports, leading to transnational emergencies. By the time contamination is detected the area contaminated and the number of people exposed can be very large. Emergencies such as these, understandably, often receive intense public and media attention.

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6.27. Accidents with nuclear weapons are very rare and such an accident would probably involve a vehicle or aircraft crash. The primary risk may arise from the inhalation of toxic materials such as plutonium, enriched uranium or beryllium. The most important feature of an emergency involving a nuclear weapon is that commonly available monitoring instruments and radiological assessment teams may not be able to identify the cause (e.g. Pu) of dangerous levels of airborne contamination and deposition. To respond adequately to such an emergency, specially trained and equipped radiological assessment teams are required. The owner of the nuclear weapon involved should be responsible for providing these radiological assessment teams. Consequently, first responders should be made aware of the potential hazards and of the precautions to take until specialized assistance arrives.

6.28. On several occasions satellites carrying dangerous amounts of radioactive material have re-entered the atmosphere. In most cases, the State responsible for the satellite provides, often through the IAEA or another UN system organization, an estimated time and location for the re-entry. However, these estimates have often been inaccurate. Typically, the radioactive components — less than one cubic metre in volume — shatter upon re-entry and the debris impacts over an area of 100 000 km^2 or more. Thus, in most cases it would be virtually impossible to identify the area of impact with sufficient accuracy to allow effective precautionary protective actions to be taken. For emergencies involving satellites, the risk is very low and consists principally in someone finding and handling radioactive debris. None of the satellite re-entries to date have resulted in a known case of significant exposure or the contamination of water or food. Nevertheless, these emergencies often receive intense attention from the international news media.

Transport emergency

6.29. A transport emergency could result in a release of radioactive material, a loss of shielding or a loss of criticality control. In the event of an emergency, firefighters are generally well equipped with standard protective clothing and equipment for respiratory protection. This equipment should provide good protection against radioactive contamination and inhalation of airborne radioactive material, but it does not provide protection against penetrating radiation. By following basic principles to limit inhalation, inadvertent ingestion and external exposure (e.g. limiting the time spent near the possible source of exposure), emergency services should be able to respond safely and effectively until radiation specialists arrive. Historically, there have been no

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reported transport emergencies involving radioactive material that have had serious radiological consequences [4].

Emergency involving severe overexposure

6.30. Severe overexposures can result from controlled sources such as radiotherapy devices or from uncontrolled sources. In some cases, equipment, software or human factors (e.g. confusion over the procedures provided by the manufacturer) were contributing causes. Other users (nationally and internationally) of similar devices should therefore be promptly alerted to the circumstances of any such emergency. However, there have been cases in which the investigation of the cause of such an overexposure was delayed, resulting in the loss of important information and in substantial delays (months) in warning other users of the devices. In other cases, a failure to alert other users of similar devices and techniques of the occurrence of emergencies may have allowed further overexposures to occur.

6.31. Once diagnosed, severe overexposures have in some cases been inadequately treated owing to the inexperience of the local medical staff, resulting in considerable unnecessary suffering. There are several medical centres around the world with the necessary experience to develop treatment strategies for radiation injuries. Advice from these centres and other assistance may be obtained through the IAEA or the WHO under the Assistance Convention [1].

Concept of operations

6.32. Emergencies may result from natural phenomena, accidents or deliberate acts (e.g. criminal activities); however, the necessary emergency response will be essentially the same regardless of the cause of the emergency. For major emergencies, preparations at the local level should be aimed at being able to recognize a possible radiological emergency (e.g. recognizing labels for radioactive material and recognizing the clinical symptoms of radiation exposure), being familiar with basic precautions and knowing who should be called on to provide further assistance. Local officials will most probably need assistance from officials at the national level in dealing with the radiological aspects of the emergency. If there is public or media interest, the news media should be promptly briefed by a single official spokesperson. Preparedness at the national level should include adopting operational criteria and having the capability to promptly advise (e.g. over the telephone) and support local

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officials if necessary in controlling a limited radiological emergency, with provision to ask for international assistance if this capability is overwhelmed.

6.33. The response organization for a nuclear or radiological emergency may be composed of elements drawn from the national or local organizations responsible for the first response to an emergency involving hazardous material (e.g. radioactive material), conventional hazards (e.g. fire) or criminal activities (e.g. theft or terrorism). All of these elements should form a single coordinated response organization that is structured to take into account the concerns of the various elements in the response, such as the need for the collection of evidence, while also ensuring the safety of the responders.

6.34. If additional radiological assistance is needed, national officials should request it through the IAEA under the Assistance Convention [1]. The IAEA would arrange for additional radiological support and consultation with physicians experienced in treating severe overexposure.

Dangerous source related emergencies

6.35. First responders or physicians should be able to promptly recognize the medical symptoms of a radiological emergency. Even if radiation or contamination is suspected, the first responders or physicians should promptly implement life saving actions (e.g. rescuing persons from a fire) and should provide first aid for serious injuries without delay and without waiting for the results of radiological monitoring. They should also isolate the possible source of exposure and then notify local officials. If an emergency involves a source that should be under the control of the operator, the operator should implement immediate actions, including measures to protect people nearby, and should report any uncontrolled sources. The operator should also notify and provide technical assistance to off-site officials. When local officials are notified of a potential hazard they should take immediate precautions to confine radioactive material and to protect people in the vicinity. National officials should provide advice to local officials and should dispatch personnel and radiological assessment teams to assist with monitoring, decontamination, media relations and medical treatment. National support radiological assessment teams and personnel should be mobilized using pre-identified experienced personnel from throughout the State. Off-site officials should brief the local news media collectively shortly after monitoring activities or protective actions have been initiated.

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6.36. In the case of a lost or stolen dangerous source the operator should report the loss to the appropriate officials and provide a description of the device and of the threat to the public. The operator should also conduct a search for the source and provide technical support to off-site officials. Off-site officials should make a timely public announcement describing the source (providing an illustration if possible) and emphasizing the hazard. If theft is suspected, the operator should protect the scene and any records that may be important to an investigation and should coordinate any additional action with law enforcement officials. If a lost or stolen dangerous source may have originated from another State or may have been taken across a border, the potentially affected States and the IAEA should be notified. Officials should conduct an investigation to determine the reason why the source was not properly controlled and whether further sources may have been lost or stolen.

6.37. In an emergency involving a radiography camera (a mobile dangerous source) under the control of an operator, the operator: should carry out a radiation survey; should cordon off the area in accordance with Appendix II; should set up barricades as required; should verify the location of the source; should seek advice from the radiation protection officer (radiological assessor); and should notify the local authorities. A recovery plan should be developed to minimize the exposure of workers. The recovery operation should be carried out with the use of suitable tools and without exceeding occupational dose limits. During the recovery operation, the location of the source and the doses to the workers should be continuously monitored and controlled. The recovered source should be stored in a properly shielded and secure container.

6.38. In an emergency involving public exposure and/or contamination, local officials should notify national officials and should isolate, on the basis of preliminary information, potentially contaminated people and areas. A consolidated incident command post should be established in the vicinity. Monitoring and interviews should be conducted to identify the source and to isolate significant contamination in accordance with Appendix II. A radiological monitoring and assessment centre should be established at which all environmental monitoring, sampling and assessment is coordinated. Default OILs should be used to determine whether protective actions are warranted. The local media should be briefed before or shortly after monitoring is commenced or protective actions are initiated in public areas. Medical facilities at which exposed or contaminated patients can be treated should be identified and their staff should be briefed on the treatments being used and the possible risks to the staff. An experienced radiological assessor should be assigned to the hospital. The public should be evacuated from significantly contaminated areas

and should be kept informed of the status of the situation and actions they should take, any health risks and any consequences for their families and property. Field monitoring centres should be established in the vicinity for triage, management and decontamination of potentially contaminated individuals and for isolated temporary storage of contaminated items. The affected population should be monitored in accordance with predetermined criteria, decontaminated and admitted to hospital if appropriate. Preparations should be made to monitor those who are concerned about possible contamination (the 'worried well'). If necessary, additional expertise and equipment should be promptly requested through the IAEA under the Assistance Convention [1]. A system should be established to ensure that products and people leaving the area are not contaminated above predetermined criteria. Before recovery efforts begin, a long term plan should be developed with objectives and criteria that are in accordance with international standards. Decontamination and other methods of remediation should be tested before their long term application. Methods of compensation should be carefully considered and should be targeted at the consequences of the emergency. The personal data of people who have incurred exposures due to an emergency at a level high enough to give rise to a high individual risk of developing radiation induced cancer, or to lead to a detectable increase due to radiation exposure in the incidence of health effects among the population exposed, should be recorded in a registry. Those individuals listed in the registry should be provided with information on their individual risks and should be considered for long term medical follow-up to be able to detect early and treat effectively any radiation induced cancers or other radiation induced injuries. Joint press briefings should be given (at a joint public information centre) periodically with participation by the operator and local and national officials.

6.39. For emergencies involving contaminated products, monitoring and interviews should be conducted to identify and isolate the source of contamination. If the contaminated products may have originated from another State or may have been taken across a border, the potentially affected States and the IAEA should be notified in accordance with the Requirements [2]. An analysis should be performed to determine the risks and the criteria — on the basis of international standards — for clearance. The national news media should be briefed before or shortly after the initiation of monitoring or protective actions in public areas. A system should be established to ensure that products leaving and entering the areas are not contaminated in excess of predetermined criteria.

6.40. In response to an accident involving a nuclear weapon, the first responders should take initial life saving action, should isolate the area in accordance with Appendix II and should notify national officials. Specially trained and equipped personnel should be provided by the State responsible for the nuclear weapon to assist in monitoring, recovery and other follow-up actions.

6.41. In response to the re-entry of a satellite containing dangerous amounts of radioactive material, the State responsible for the satellite should notify the IAEA of the estimated time and location of re-entry and should provide an analysis of the risks. The IAEA should inform the potentially affected States. These States should inform the public of the limited nature of the hazard. If, following re-entry, the area of concern can be bounded (e.g. through sightings), the public should be instructed to report and to avoid possible debris from a crash. Monitoring should be conducted to locate radioactive debris if the search area can be reasonably limited. Ground based monitoring should be used to investigate reported possible debris or areas first identified by airborne monitoring. Airborne monitoring should be initiated, possibly through the IAEA, if a limited area of concern has been identified.

Transport emergency

6.42. The carrier should immediately take initial life saving and first aid actions without concern for the risk associated with radioactive material, and should isolate the source and notify local emergency response services. First responders should take the initial actions appropriate for the UN number or labels affixed to the item being shipped [3, 4]. Typically, this involves isolating the accident scene, taking the names of people who may have been in the area (for possible follow-up) and requesting radiological assistance from regional or national officials. National officials should send a radiological assessment team to conduct monitoring and cleanup if necessary. Reference [4] provides a detailed discussion of the response to transport emergencies.

Emergency involving serious overexposure

6.43. In a case of serious overexposure[35], interviews should be conducted, photographs should be taken and the information necessary to estimate doses should be gathered at the scene. Medical examinations and blood tests should

[35] A serious overexposure is one that could result in severe deterministic health effects.

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be promptly performed to assist in estimating doses. The IAEA may be contacted to arrange for consultation with physicians with expertise in treating overexposures. A course of treatment, based on the estimated doses received, should be established in consultation with experts. Decisions on treatment should take into consideration both the physical and the psychological suffering of patients.

6.44. The operator should conduct an investigation to determine the cause of the overexposure, and should take actions to prevent further overexposures and to preserve information that may be important in the investigation of the cause. National officials should promptly identify the causes of the overexposures that could give rise to similar overexposures in other States and should report them to the IAEA. The IAEA should inform other States of relevant information that warrants their attention.

THREAT CATEGORY V

Threat description

6.45. Preparedness for events in threat category V is intended for providing prompt restrictions on food, water or products in accordance with international standards. The Chernobyl accident in 1986 resulted in contamination exceeding the international standards for food restrictions more than 1000 km from the plant site.

6.46. The staff of an affected facility in threat categories I or II should declare a general emergency (see Appendix IV) and notify the IAEA or the affected States before a radioactive plume arrives. However, the first indication of an emergency may be the detection of airborne contamination. For some States, the entire territory could be contaminated at levels warranting restrictions on foodstuffs and agricultural products. The patterns and levels of contamination will be complex, varying both temporally and spatially. OILs for gross gamma dose rates due to ground deposition can be used to identify areas where food contamination can be expected to be well above the international criteria warranting restrictions. However, laboratory analysis of food samples should be used to confirm that the concentrations warrant such restrictions.

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Concept of operations

6.47. The State where an emergency occurs is required to notify potentially affected States and the IAEA of a possible significant transboundary release (general emergency). The IAEA, in accordance with the Notification Convention [1], also transmits the notification to potentially affected States. Upon receiving notification of an emergency potentially affecting their State, national officials should provide instructions to the public, farmers, and processors and distributors of foodstuffs on measures to take to protect the food supply. They should also conduct monitoring and sampling to determine what actions are required for the control of foodstuffs. OILs should be used as input in making decisions on imposing restrictions on foodstuffs. These OILs should be determined in advance, with local conditions (e.g. a limited supply of food) taken into consideration. In no case should the consumption of food be allowed that would result in doses approaching levels at which they could result in severe deterministic effects. The criteria used should be in accordance with international standards and should be coordinated with neighbouring States. OILs for gross gamma dose rates due to ground deposition should be used to identify areas to which access should be restricted until laboratory analysis of food samples can be conducted. Programmes for dealing with the long term impact of a nuclear or radiological emergency in threat category V should be carefully developed according to internationally accepted criteria, and the long term sociological, psychological and economic impacts should be considered.

6.48. If a State detects contamination at significant levels that is suspected to have originated in another State, national officials should promptly alert the IAEA of the possible occurrence of a transnational emergency.

Appendix I

TYPICAL THREAT CATEGORIES

I.1. Table 6 provides a summary of the typical threats and associated threat categories of selected practices and events.

TABLE 6. TYPICAL THREAT CATEGORIES OF PRACTICES

Practice	Threat summary	Typical threat category[a]
	Facilities manufacturing or using radioisotopes for industry, medical purposes or scientific research	
Radiopharmaceutical manufacturing	Off-site: No potential for deterministic effects. A small potential for a release in excess of urgent generic intervention levels (GILs) near the facility. Major fires at facilities and loading dock fires appear to represent the greatest potential for a release in excess of urgent GILs. The threat will be a function of inventory and volatility. Explosions, tornadoes, spills and leaks represent small risks.	Limited[b] or III
	On-site: Severe deterministic effects very unlikely on the site, but doses in excess of occupational limits are possible.	
Radiopharmacies	Off-site: No potential for a release in excess of urgent GILs.	Limited[b]
	On-site: No potential for exceeding urgent GILs on the site. Very small potential for exposures above occupational dose limits.	
Hospitals	Off-site: No potential for a release in excess of urgent GILs.	III or IV
	On-site: Severe deterministic effects possible for staff if sealed sources (e.g. brachytherapy sources or radiation beams) are misused or are not controlled and secured. In addition, radioactive medication and diagnostic drugs can represent a hazard if not properly controlled and administered.	

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TABLE 6. TYPICAL THREAT CATEGORIES OF PRACTICES (cont.)

Practice	Threat summary	Typical threat category[a]
Sealed source manufacturing	Off-site: No potential for deterministic effects. A small potential for a release in excess of urgent GILs near the facility. A major facility fire appears to represent the greatest potential for a release in excess of urgent GILs. The release will be a function of inventory and volatility. Explosions, tornadoes, spills and leaks represent small risks. On-site: Severe deterministic effects possible for staff during the manufacturing process due to loss of shielding, ingestion or inhalation.	III
Research laboratories	Off-site: Unless large quantities of radioactive or fissile material are stored or used in a single location, there is no potential for exposures in excess of urgent GILs. On-site: Potential for severe deterministic effects. This will be site specific.	Limited[b] or III
Warehousing and burial of low level waste	Off-site: No potential for exceeding urgent GILs for burial operations for low level waste. On-site: No potential for exceeding urgent GILs on the site. Small potential that, if the waste contains radioiodine, a major fire involving waste in a warehouse may result in a release leading to occupational dose limits being exceeded.	Limited[b]
Depleted uranium products	Off-site: No potential for exceeding urgent GILs. Potential for deaths following a UF_6 release due to chemical toxicity of HF (product of a UF_6 release). The potential is a function of the UF_6 inventory. Greatest risk appears to be ruptures of heated tanks containing many tonnes. On-site: No potential for exceeding urgent GILs.	Limited[b]

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TABLE 6. TYPICAL THREAT CATEGORIES OF PRACTICES (cont.)

Practice	Threat summary	Typical threat category[a]
	Source	
— Sterilization irradiators — Industrial radiography — Teletherapy — High and medium dose rate brachytherapy — Category 1 and 2 sources in Ref. [39]	Off-site: If controlled, no potential for exceeding urgent GILs; if uncontrolled (lost or stolen), potential for fatal exposure in minutes if unshielded and for severe tissue damage if held. On-site: Localized exposure sufficient for fatal doses in minutes if source unshielded.	III or IV[c]
— Gauges — Well logging — Category 3 sources in Ref. [39]	Off-site: If uncontrolled (lost or stolen), potential for fatal exposure if unshielded and for severe tissue damage if held. On-site: Potential for fatal exposure if unshielded.	IV[c]
— Moisture density gauge — Static eliminator — Tritium exit signs — Pu pacemaker — Consumer products — Category 4 and 5 sources in Ref. [39]	Off-site: Little or no potential for exceeding urgent GILs. On-site: Little or no potential for exceeding urgent GILs.	Limited[b]
	Fuel cycle	
Uranium milling and mining	Off-site: No potential for a release in excess of urgent GILs. Contamination warranting intervention (e.g. water contamination) could result from failures of tailing ponds. On-site: No potential for exceeding urgent GILs.	Limited[b]
Yellow cake processing	Same as uranium mining and processing.	Limited[b]

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TABLE 6. TYPICAL THREAT CATEGORIES OF PRACTICES (cont.)

Practice	Threat summary	Typical threat category[a]
UF_6 conversion plants	Off-site: Potential for deaths following a UF_6 release due to chemical toxicity of HF (product of a UF_6 release). The potential is a function of the UF_6 inventory. Greatest risk appears to be ruptures of heated tanks containing many tonnes.	Limited[b, d]
	On-site: Same as off-site.	
Enrichment plants	Off-site: Same as UF_6 conversion plants.	Limited[b]
	On-site: Same as UF_6 conversion plants.	
Fuel fabrication using uranium	Off-site: Risk for UF_6 same as for UF_6 conversion plants. Potential for doses in excess of urgent GILs from criticality accidents if the fissile material is processed in an unshielded location within 200–500 m of the site boundary.	II or III
	On-site: Risk for UF_6 same as for UF_6 conversion plants. Potential for deterministic effects and doses in excess of urgent GILs on the site from criticality accidents.	
Fuel fabrication using plutonium	Off-site: Potential for doses in excess of urgent GILs from criticality accidents if the fissile material is processed in an unshielded location within 200–500 m of the site boundary. Large fires or explosions could result in doses off the site in excess of urgent GILs near the facility. This will be a function of the inventory.	II or III
	On-site: Potential for deterministic effects and doses in excess of urgent GILs from criticality accidents. Fires and explosions could result in doses in excess of urgent GILs from inhalation.	
Fresh fuel (not irradiated)	Off-site: No potential for doses in excess of urgent GILs.	Limited[b]
	On-site: No potential for doses in excess of urgent GILs.	

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TABLE 6. TYPICAL THREAT CATEGORIES OF PRACTICES (cont.)

Practice	Threat summary	Typical threat category[a]
Spent fuel, pool storage	Off-site: For damage to fuel in a pool (underwater), no potential for doses in excess of urgent GILs. If the fuel in the pool is totally uncovered, doses in excess of urgent GILs may be possible. Distance of concern depends on inventory. If a pool containing fuel discharged from a reactor core within the past few months is drained, severe deterministic effects are possible. The potential and the distances of concern depend on quantities and pool design.	I, II or III
	On-site: For damage to fuel in a pool (underwater), doses from ^{85}Kr could exceed urgent GILs in the pool area. For a drained pool, the dose from the direct shine from the pool could be several sieverts per hour near the pool. If fuel is uncovered, the dose near the pool could result in severe deterministic effects.	
Spent fuel, dry cask storage	Off-site: No potential for doses in excess of urgent GILs.	III
	On-site: No potential for doses in excess of urgent GILs from inhalation. If shielding is lost, direct shine dose could exceed urgent GILs.	

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TABLE 6. TYPICAL THREAT CATEGORIES OF PRACTICES (cont.)

Practice	Threat summary	Typical threat category[a]
Reprocessing of spent fuel	Off-site: Small potential for doses in excess of urgent GILs from criticality accidents (depending on location of criticality). Large fires or explosions could result in doses in excess of urgent GILs several kilometres from the facility, depending on the inventory and the volatility of the radionuclides. Ruptures of large liquid storage tanks could result in contamination that would warrant extensive intervention. This will be a function of inventory and volatility. On-site: Potential for severe deterministic effects and doses in excess of urgent GILs from criticality accidents. Fires and explosions could result in inhalation doses in excess of urgent GILs and could result in severe deterministic effects. If shielding is lost, direct shine dose could exceed urgent GILs or could result in severe deterministic effects.	I or II or III
	Reactors (power, ship, research)	
Reactors >100 MW(th)	Off-site: Emergencies involving severe core damage have the potential to cause severe and even fatal deterministic effects. Doses in excess of urgent GILs are possible more than 5 km from the facility. Deposition resulting in doses in excess of relocation GILs and ingestion generic action levels is possible at great distances from the facility. An emergency not involving core damage has only a small potential for exceeding urgent GILs. On-site: For emergencies involving core damage, doses sufficient to result in severe and even fatal deterministic effects are possible.	I or II

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TABLE 6. TYPICAL THREAT CATEGORIES OF PRACTICES (cont.)

Practice	Threat summary	Typical threat category[a]
Reactors 2–100 MW(th)	Off-site: Doses due to inhalation of short lived iodine in excess of urgent GILs are possible if cooling of the core is lost (core melt).[e]	II or III
	On-site: Potential for doses in excess of urgent GILs if fuel cooling is lost. If shielding is lost, direct shine dose could exceed urgent GILs or could result in severe deterministic effects.	
Reactors <2 MW(th)	Off-site: No potential for doses in excess of urgent GILs.	III
	On-site: Potential for doses in excess of urgent GILs from inhalation (depending on design) if fuel cooling is lost. If shielding is lost, direct shine dose could exceed urgent GILs or could result in severe deterministic effects.	
	Transport	
Excepted packages UN 2910 UN 2911 UN 2909 UN 2908	These shipments contain only minor amounts of radioactive material. There is no risk of any radiological consequences requiring special protective actions. Ground contamination resulting from the emergency may require decontamination.	None
Industrial packages UN 2912 UN 3321 UN 3322 UN 2913	These packages contain only qualified 'low specific activity' materials or qualified 'surface contaminated objects'. Urgent GILs may be exceeded, however, in the vicinity of a damaged package, since industrial packages are not designed to survive accidents and the only external radiation limit on the unshielded but qualified contents is 10 mSv/h at a distance of 3 m. Ground contamination resulting from the emergency may require decontamination.	None

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TABLE 6. TYPICAL THREAT CATEGORIES OF PRACTICES (cont.)

Practice	Threat summary	Typical threat category[a]
Type A packages UN 2915 UN 3332	The activity allowed for Type A packages limits the radiological hazard. Doses in excess of urgent GILs are possible beyond the immediate vicinity of the package. Ground contamination resulting from the emergency would require decontamination.	IV[f]
Type B packages [B(U) and B(M)] UN 2916 UN 2917	Type B packages normally contain large amounts of radioactive material. Type B packages have been designed to withstand all credible land and sea transport accidents. The radioactive content of a Type B package shipped by air is restricted. For 'low dispersible radioactive material', the limit is as authorized by the competent authority for the package design. For other material: if it is special form, the restriction is 3000 A_1 or 100 000 A_2, whichever is lower; if it is other than special form, 3000 A_2 [40]. For all other radioactive material, the restriction is 3000 A_2. Doses in excess of urgent GILs are considered possible in an air accident but not credible in land or surface mode transport. However, in the event of an emergency, this should be confirmed by monitoring.	IV[f]
Type C packages UN 3323	Type C packages normally contain large amounts of radioactive material. Type C packages have been designed to withstand all credible land and sea accidents and most credible air transport accidents. Doses in excess of the urgent GILs are not considered credible. However, in the event of an emergency, this should be confirmed by monitoring.	IV[f]

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TABLE 6. TYPICAL THREAT CATEGORIES OF PRACTICES (cont.)

Practice	Threat summary	Typical threat category[a]
Special arrangements UN 2919	Shipments of non-fissile or fissile excepted radioactive material transported under special arrangements require seven days prior notification to the competent authorities of each State involved. In an emergency, urgent GILs may be exceeded. Ground contamination resulting from the emergency may require decontamination.	Limited or IV[f]
Packages containing fissile material UN 2977 UN 3324 UN 3325 UN 3326 UN 3327 UN 3328 UN 3329 UN 3330 UN 3331	Industrial, Type A, Type B and Type C packages may all contain fissile material. Such packages containing fissile material are designed with the contents limited, so as to maintain subcriticality during both normal and accident conditions of transport. The risk summary is therefore the same as that for the relevant Industrial, Type A, Type B or Type C package. Type IF, Type AF, Type B(U)F or Type B(M)F packages that are involved in an air accident and contain only fissile UF_6 may release UF_6 with its associated chemical hazard. However, packages containing only UF_6 have no risk of any radiological consequences requiring special protective actions. Ground contamination resulting from the emergency may require decontamination.	Limited or IV[f]
Packages containing UF_6 UN 2978	Packages containing non-fissile or fissile excepted quantities of UF_6 that are involved in an air accident may release UF_6 with its associated chemical hazard. There is no risk of any radiological consequences requiring special protective actions. Ground contamination resulting from the emergency may require decontamination.	Limited[d]

TABLE 6. TYPICAL THREAT CATEGORIES OF PRACTICES (cont.)

Practice	Threat summary	Typical threat category[a]
	Other	
Nuclear weapon accident (Pu dispersal)	If there is a fire or explosion resulting in dispersal of Pu from a nuclear weapon, deterministic effects are possible from inhalation of the plume or resuspension of deposited material within about 1 km. The area of significant contamination could be of the order of a square kilometre. It may not be possible to detect dangerous levels of airborne contamination with common radiation survey instruments.	IV
Lost/stolen dangerous source	Lethal doses are possible for persons handling an unshielded dangerous source (see Glossary and Appendix III). Lethal doses and considerable contamination resulting in doses above urgent GILs are possible from a ruptured source. A considerable area may be contaminated owing to dispersal by human activities.	IV
Contamination from a significant transboundary release	Deposition leading to doses in excess of the relocation GILs and ingestion generic action levels is possible at great distances from a facility in threat category I or II.	V
Re-entry of a nuclear powered satellite	The risk is very small and it would be virtually impossible to limit the area of concern so that protective action could reasonably be taken. The handling of debris could result in deterministic effects.	IV

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TABLE 6. TYPICAL THREAT CATEGORIES OF PRACTICES (cont.)

Practice	Threat summary	Typical threat category[a]
Import of contaminated food or material	Off-site: Uncontrolled (unknowing) use of contaminated steel and other products could result in doses in excess of the occupational dose limits (very small risk) but it is very unlikely that urgent protection action GILs can be exceeded. Food contamination could exceed the generic action level for food protection. On-site: The risk would arise from unknowingly bringing radioactive material or sources onto the site of a practice. The facility of the practice may be the first to identify the hazard.	V

[a] The method described in Section 3 should be used for determining the threat category.

[b] No special emergency preparations are required for the radiological hazard other than those needed for any normal radiation protection programme. However, emergency preparations may be warranted to address perceived concerns and normal industrial and workplace safety for hazards associated with chemical toxicity and other non-radiological hazards associated with the practice.

[c] Threat category IV: mobile dangerous source.

[d] The chemical toxicity due to a UF_6 release is far more important than the radiation dose, even for highly enriched uranium. A lethal concentration of HF (due to chemical toxicity) may be possible off the site.

[e] For research reactors, because of the great variations in the design and operation of the installations, a site specific analysis should be performed to determine whether there is sufficient inventory and energy to result in a significant airborne release off the site.

[f] Transport packages that comply with international regulations [40] are not considered dangerous sources owing to their design and content limits, provided that they are properly controlled and only removed from their packaging under properly supervised conditions. However, if they are lost, stolen or inadvertently removed from their packaging (in an uncontrolled way), they may be considered a dangerous source (see Appendix III).

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Appendix II

AREA AND ZONE SIZES

RADIOLOGICAL EMERGENCIES

II.1. Table 7 provides suggestions for the approximate radius of the inner cordoned area (see safe distances in Fig. 1) in a radiological emergency. Appendix VII discusses the protective actions that are justified within these areas.

FACILITIES IN THREAT CATEGORIES I AND II

II.2. Table 8 provides suggestions for the approximate radii of the emergency zones for facilities in threat categories I and II. The distances in Table 8 are suggested with due recognition of the great uncertainties involved and they should be revised by a factor of up to two during their application if necessary to meet local conditions. The choice of the suggested radii represents a judgement of the distance from the site of the emergency for which it is reasonable to make advanced arrangements to ensure an effective response. In a particular emergency, protective actions may be warranted only in a small part of the zones. For the most serious emergencies, protective actions might need to be taken beyond the radii suggested.

II.3. The radii shown in Table 8 are suggestions on the basis of a general analysis. Each State may carry out an independent analysis to determine its own zone sizes that are appropriate in view of the specifics of the State, provided that the analysis: (a) addresses the full range of possible emergencies, including those of low probability, as required by the Requirements (Ref. [2], para. 4.48); and (b) is carried out with the goal of meeting the requirements for establishing these zones as established in the Requirements (Ref. [2], para. 4.48).

II.4. The sizes of the zones are shown in terms of the radius of a circle centred at the source of a potential release or criticality. However, the actual boundary of the zones should not be a circle but should be established to conform to physical and geographical features such as roads or rivers or to political boundaries, as illustrated in Figs 2 and 3. A discussion of the philosophy for establishing the zone size follows Table 8.

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TABLE 7. SUGGESTED RADIUS OF THE INNER CORDONED AREA (SAFETY PERIMETER) IN A RADIOLOGICAL EMERGENCY

Situation	Initial inner cordoned area (safety perimeter)
Initial — outside	
Unshielded or damaged potentially dangerous source[a]	Spill area (if a spill occurs) plus 30 m around
Major spill from a potentially dangerous source	Spill area plus 100 m around
Fire, explosion or fumes involving a potentially dangerous source	300 m radius
Suspected bomb (potential radiological dispersal device), exploded or unexploded	400 m radius or more to protect against an explosion
Initial — inside a building	
Damage, loss of shielding or spill involving a potentially dangerous source	The room affected and adjacent areas (including floors above and below)
Fire, suspected radiological dispersal device or other event involving a potentially dangerous source that can spread materials in the building (e.g. internal dispersion through the ventilation system)	Entire building and appropriate outside distance as indicated above
Based on OILs — following the initial determination	
— Ambient dose rate of 100 μSv/h[b] — 1000 Bq/cm^2 beta and/or gamma deposition[c,d] — 100 Bq/cm^2 alpha deposition[d]	Wherever these levels are measured

[a] See Appendix III.
[b] The ambient dose rate is measured at 1 m above ground level for strong gamma emitters.
[c] These levels are not directly measured in the field and therefore OILs must be developed for the instruments to be used to determine if these levels of deposition are present.
[d] Deposition levels can only be assessed by a qualified radiological assessor.

Precautionary action zone (PAZ)

II.5. The PAZ, which only applies to facilities in threat category I, is the area within which arrangements should be made to implement precautionary urgent protective actions before or shortly after a major release with the aim of preventing or reducing the occurrence of severe deterministic effects.

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TABLE 8. SUGGESTED EMERGENCY ZONES AND AREA SIZES[a]

Facilities	Precautionary action zone (PAZ) radius[b,c]	Urgent protective action planning zone (UPZ) radius[d]
Threat category I facilities		
Reactors >1000 MW(th)	3–5 km	5–30 km[e]
Reactors 100–1000 MW(th)	0.5–3 km	5–30 km[e]
A/D_2 from Appendix III is $\geq 10^5$ [f]	3–5 km	5–30 km[e]
A/D_2 from Appendix III is $\geq 10^4$–10^5 [f]	0.5–3 km	5–30 km[e]
Threat category II facilities		
Reactors 10–100 MW(th)	None	0.5–5 km
Reactors 2–10 MW(th)	None	0.5 km
A/D_2 from Appendix III is $\geq 10^3$–10^4 [f]	None	0.5–5 km
A/D_2 from Appendix III is $\geq 10^2$–10^3 [f]	None	0.5 km
Fissionable mass is possible within 500 m of site boundary[g]	None	0.5–1 km

[a] The radius is the approximate default distance from the facility at which the boundary of the zone should be established. Variation by a factor of two or more during application is reasonable. A different distance should be used when this is substantiated by a detailed safety analysis.

[b] The suggested radii are the approximate distances for which the acute (2 day) dose to the bone marrow or lung could (with a very low probability) approach levels that are life threatening (i.e. exceed the values in Annex II of Ref. [2]). A maximum radius of 5 km is recommended, as discussed elsewhere in this appendix. The source term (release) used for reactor emergencies is typical of that postulated for the range of low probability accidents that could potentially lead to severe deterministic effects off the site.

[c] The radii were selected on the basis of calculations performed with the RASCAL 3.0 computer model [41]. For the purpose of the calculation, average meteorological conditions, no rain, a ground level release and an exposure for 48 hours to ground shine are assumed, and the centreline dose to a person outside for 48 hours is calculated.

[d] The suggested radii are the approximate distances for which the total effective dose for inhalation, cloud shine and ground shine for 48 hours will not exceed 1–10 times the GIL for evacuation, with a maximum radius of 5–30 km, as recommended for the reasons discussed elsewhere in this appendix.

[e] A distance of between 5 and 30 km may be considered reasonable if supported by a site specific analysis.

[f] Assuming that 10% of the inventory is released to the atmosphere.

[g] The radial distance (500 m) is the distance at which the GIL for evacuation is exceeded, on the assumption that the building containing the criticality (fissile material) does not provide significant shielding and that the criticality results in 10^{19} fissions [42]. This includes the dose due to external irradiation (gamma and neutron) and was calculated using the RASCAL 3.0 model [41].

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II.6. The suggested sizes for the PAZ are based on expert judgement made in consideration of the following:

- Urgent protective actions taken before or shortly after a release within this radius will avert doses exceeding the thresholds for early death for the vast majority of major emergencies postulated for these facilities.
- Urgent protective actions taken before or shortly after a release within this radius will prevent doses exceeding the urgent protective action GILs for the majority of emergencies postulated for the facility.
- Dose rates that could be fatal within a few hours were observed at these distances during the Chernobyl accident.
- The maximum reasonable radius for the PAZ is assumed to be 5 km because: (a) except for the emergencies with the most severe consequences, it is the distance limit out to which doses that would lead to early deaths are postulated [25, 26]; (b) it provides a reduction in dose by a factor of about ten in comparison with the dose on the site; (c) it is very unlikely that urgent protective actions will be warranted at a significant distance beyond this radial distance; (d) it is considered the practical limit of the distance to which substantial sheltering or evacuation can be promptly implemented before or shortly after a radioactive release; and (e) implementing precautionary urgent protective actions to a larger radius might reduce the effectiveness of the actions for the people nearer the site who are at the greatest risk.

Urgent protective action planning zone (UPZ)

II.7. The UPZ, which applies to facilities in threat categories I and II, is the area where preparations are made to promptly shelter in place, to perform environmental monitoring and to implement urgent protective actions on the basis of the results of monitoring within a few hours following a release.

II.8. The suggested sizes of the UPZ are based on expert judgement made in consideration of the following:

Threat category I facilities

- These are the radial distances, studies [26] suggest, out to which monitoring to locate and evacuate hot spots (due to deposition) within hours may be warranted to significantly reduce the risk of doses that would lead to early deaths in the emergencies with the most severe consequences postulated for power reactors.

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— At these radial distances there is a reduction by a factor of approximately ten in concentration (and thus risk) due to a release in comparison with the concentration at the PAZ boundary.
— This distance provides a substantial base for the expansion of response efforts.
— A distance of 5–30 km is assumed to be the practical limit for the radial distance within which to conduct monitoring and to implement appropriate urgent protective actions within a few hours.
— For average meteorological (dilution) conditions, beyond this radius, for most postulated emergencies with severe consequences the total effective dose to an individual would not exceed the urgent protective action GILs for evacuation.

Threat category II facilities

Atmospheric release

— For average meteorological (dilution) conditions, beyond the UPZ radius, only the postulated emergencies with the most severe consequences would result in a total effective dose to an individual in excess of the urgent protective action GILs for evacuation.
— Preparations within this radius provide a substantial base for the implementation of effective urgent protective actions beyond it, if needed.
— A distance of 0.5 km was selected as the smallest radius, in consideration of possible wake effects caused by buildings.

Fissionable mass (criticality)

— The radiological risk due to a criticality is dominated by the external dose due to gamma and neutron radiation.
— Beyond this radius, most accidental criticalities would not result in a total effective dose to an individual in excess of the urgent protective action GILs for evacuation.
— The off-site doses due to past criticality accidents have not warranted urgent protective actions beyond a distance of 0.5–1 km.

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Appendix III

DANGEROUS SOURCES

III.1. The Requirements [2] use the term 'dangerous source' in the definition of threat category IV (see Table 1) and establish requirements for operators using dangerous sources or emergencies involving dangerous sources (paras 3.19, 4.17–4.19, 4.37, 4.38 and 5.13).

III.2. This appendix provides guidance on:

- Determining the quantity of radioactive material that should be considered dangerous;
- Providing plain language statements of the risks to the public and emergency responders and typical public warnings and instructions for radiological emergencies.

DETERMINING DANGEROUS QUANTITIES (*D* VALUES)

III.3. A source or uncontrolled radioactive material should be categorized as a dangerous source in accordance with the process described below, with the following exceptions:

- This guidance does not apply for irradiated fuel (e.g. reactor spent fuel). In these cases, Table 4 should be used to determine the threat category.
- Radioactive material being transported in accordance with international requirements [40] should not be considered a dangerous source provided that it is properly controlled and only removed from the packaging under supervised conditions. However, if it is lost, stolen or inadvertently removed from its packaging, this guidance should be applied to determine whether it should be considered a dangerous source.

III.4. For all materials, calculate the following:

$$A / D_1 = \Sigma_i \frac{A_i}{D_{1,i}}$$

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where

A_i is the activity (TBq) of each radionuclide i over which control could be lost in an emergency or an event;

$D_{1,i}$ for each radionuclide i is taken from Table 9.

III.5. For dispersible material[36] calculate the following:

$$A / D_2 = \Sigma_i \frac{A_i}{D_{2,i}}$$

where

A_i is the activity (TBq) of each radionuclide i that is in a dispersible form and over which control could be lost in an emergency or an event;

$D_{2,i}$ for each radionuclide i is taken from Table 9.

III.6. A source or uncontrolled material should be categorized as a dangerous source if either of the A/D values calculated above is greater than 1.[37] Reference [50] provides an explanation of the basis for the D values and the actual D values for over 400 radionuclides.

PLAIN LANGUAGE STATEMENTS OF THE RISKS AND TYPICAL PUBLIC WARNINGS FOR RADIOLOGICAL EMERGENCIES

III.7. This section provides plain language statements of the risks to the public and to emergency responders in the event of a radiological emergency, and typical warnings that should be given to the public.

III.8. The risks are assessed on the assumption that the source or material concerned is not being managed safely or kept securely, and that someone

[36] Powders, gases and liquids, and especially volatile, combustible, water soluble and pyrophoric material, should be considered to be at risk of dispersal.

[37] It is possible, but unlikely, that a smaller amount than this could cause injury. However, sources this large are considered sufficiently dangerous to warrant taking extraordinary measures (searches, public announcements) to secure them if control over them is lost (e.g. by their being stolen or lost) and if they could be in the public domain.

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TABLE 9. D VALUES (TBq) [3]

Source and material[a]		
Radionuclide	D_1[b]	D_2[c]
H-3	UL[d]	2.E+03[e]
C-14	2.E+05	5.E+01
P-32	1.E+01	2.E+01
S-35	4.E+04	6.E+01
Cl-36	3.E+02	2.E+01[f]
Cr-51	2.E+00	5.E+03
Fe-55	UL[d]	8.E+02
Co-57	7.E–01	4.E+02
Co-60	3.E–02	3.E+01
Ni-63	UL[d]	6.E+01
Zn-65	1.E–01	3.E+02
Ge-68	7.E–02	2.E+01
Se-75	2.E–01	2.E+02
Kr-85	3.E+01	2.E+03
Sr-89	2.E+01	2.E+01
Sr-90 (Y-90)[g]	4.E+00	1.E+00
Y-90	5.E+00	1.E+01[h]
Y-91	8.E+00	2.E+01
Zr-95 (Nb-95m/Nb-95)[g]	4.E–02	1.E+01
Nb-95	9.E–02	6.E+01
Mo-99 (Tc-99m)[g]	3.E–01	2.E+01
Tc-99m[h]	7.E–01	7.E+02
Ru-103 (Rh-103m)[g]	1.E–01	3.E+01
Ru-106 (Rh-106)[g]	3.E–01	1.E+01
Pd-103 (Rh-103m)[g]	9.E+01	1.E+02
Cd-109	2.E+01	3.E+01
Te-132 (I-132)[g]	3.E–02	8.E–01[h]
I-125	1.E+01	2.E–01
I-129	UL[d]	UL[d,f]
I-131	2.E–01	2.E–01[h]
Cs-134	4.E–02	3.E+01

TABLE 9. D VALUES (TBq) [3] (cont.)

Source and material[a]		
Radionuclide	D_1[b]	D_2[c]
Cs-137 (Ba-137m)[g]	1.E–01	2.E+01
Ba-133	2.E–01	7.E+01
Ce-141	1.E+00	2.E+01
Ce-144 (Pr-144m, Pr-144)[g]	9.E–01	9.E+00
Pm-147	8.E+03	4.E+01
Eu-152	6.E–02	3.E+01
Eu-154	6.E–02	2.E+01
Gd-153	1.E+00	8.E+01
Tm-170	2.E+01	2.E+01
Yb-169	3.E–01	3.E+01
Re-188	1.E+00	3.E+01
Ir-192	8.E–02	2.E+01
Au-198	2.E–01	3.E+01
Hg-203	3.E–01	2.E+00
Tl-204	7.E+01	2.E+01
Po-210	8.E+03	6.E–02
Ra-226 (progeny)[g]	4.E–02	7.E–02
Th-230	9.E+02	7.E–02[f]
Th-232	UL[d]	UL[d,f]
U-232	7.E–02	6.E–02[f]
U-235 (Th-231)[g]	8.E–05	8E–05[i]
U-238	UL[d]	UL[d,f]
U natural	UL[d]	UL[d,f]
U depleted	UL[d]	UL[d,f]
U enriched > 20%	8E–05[i]	8E–05[i]
U enriched > 10%	8E–04[i]	8E–04[i]
Np-237 (Pa-233)[g]	3.E–01[j]	7.E–02
Pu-238	3.E+02[i]	6.E–02
Pu-239	1.E+00[i]	6.E–02
Pu-239/Be[k]	1.E+00[i]	6.E–02
Pu-240	4.E+00[i]	6.E–02

TABLE 9. D VALUES (TBq) [3] (cont.)

Source and material[a]		
Radionuclide	D_1[b]	D_2[c]
Pu-241 (Am-241)[g]	2.E+03[i]	3.E+00
Pu-242	7.E–02[i]	7.E–02[f]
Am-241	8.E+00	6.E–02
Am-241/Be[k]	1.E+00	6.E–02
Cm-242	2.E+03	4.E–02
Cm-244	1.E+04	5.E–02
Cf-252	2.E–02	1.E–01

[a] The amount of material in the public domain, if not under control (i.e. because of allowing removal of shielding or allowing dispersal accidentally or by a malicious act), that could give rise to doses resulting in permanent injury that decreases the quality of life.

[b] D_1 is for external exposure and applies to both dispersible and non-dispersible materials.

[c] D_2 is for dispersible material. Airborne dispersal by fire or explosion, inadvertent ingestion and intentional contamination of water was considered.

[d] UL: unlimited quantity. Emergency planning for dealing with radiological consequences is not recommended.

[e] Assumes that skin absorption doubles the absorbed dose from inhalation.

[f] Emergencies involving these amounts of these radionuclides may result in airborne concentrations in excess of the concentrations posing immediate danger to life or health (IDLH) for chemical toxicity, and arrangements for dealing with these risks are warranted.

[g] The *D* values were calculated in consideration of both the parent and important decay products (radionuclides shown in parentheses) that are present after up to ten years. Decay products with a half-life of less than one year can be assumed to be in equilibrium with their parents.

[h] Does not pose a long term concern as it is short lived and within one month or less the radiological hazard will be greatly diminished.

[i] There is no immediate radiation hazard but the *D* value was established on the basis of the criticality hazard.

[j] The *D* value represents a radiological and criticality hazard.

[k] Neutron generator.

could — knowingly or unknowingly — remove the radioactive material from the container or packaging in which it was to be used or safely shipped. Handling of the material, contamination of public water supplies and fires and/or explosions were considered.

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Risks to public

III.9. An amount of radioactive material is considered 'dangerous' if it could cause permanent injury or be immediately life threatening if not managed safely and contained securely. Permanent injuries include burns requiring surgery and debilitating injuries to the hands. Temporary injuries include skin reddening and irritation and temporary changes in the composition of the blood. Exposures are considered to be immediately life threatening[38] if they could result in injuries to tissues or organs that are fatal within at most a few years. Exposures that are immediately life threatening:

- Typically arise from very high radiation doses received over a period of hours to months owing to the presence nearby of dangerous amounts of unshielded material, for example from a dangerous source placed in a drawer next to the bed.
- Arise in rare cases from inadvertently eating or drinking (or for someone very close by, inhaling) small amounts of dispersible material, for example if someone opens the container of a dangerous amount of radioactive material that is in a dispersible form. Powders, gases and liquids, and volatile, combustible, water soluble and pyrophoric materials are all dispersible.
- Could arise from 'inhalation' for radioactive material in a plume from a fire or explosion (e.g. from a radiological dispersal device).

III.10. It should be noted that there is the potential for amounts that are a very small fraction (e.g. 1/100) of the D values given in Table 9 to be dangerous. This would be the case in the event of intentional ingestion of radioactive material or intentionally exposing oneself to a radioactive source.

Risks to responders

III.11. There will be little or no health risks to response personnel provided that in taking response actions near any hazardous material they take normal precautions, such as the use of respiratory protection against material released in a fire or explosion. Limited stays (such as for rescues) near a radioactive source or material would probably not be dangerous. There would be little or no health hazard to medical staff who are treating or moving exposed or

[38] This does not refer to the possibility of causing cancer, which is very small, as discussed in the following.

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contaminated persons provided that they protect themselves against the inadvertent ingestion of radioactive material by normal barrier methods such as the use of surgical gloves.

Other concerns

III.12. Radiological emergencies involving radioactive material in these amounts are very unlikely to result in any detectable increase in the incidence of cancer due to radiation induced cases among the population groups exposed.

III.13. Public concern about any incident involving radioactive material must always be duly considered, regardless of the threat indicator. Significant adverse (and unwarranted, in terms of the radiological risks involved) public reactions have occurred in the past, even though the levels of contamination and exposure were not dangerous. Such reactions have included pregnant women having unnecessary abortions, discrimination against possibly exposed persons and boycotts of local businesses and products.

Public warnings and/or instructions

This section provides typical warnings/instructions for the public for various radiological emergencies.

For a radiological emergency involving possible public exposure, the public should be provided (as appropriate) with the following advice:

- Those who left the scene without being assessed or instructed as to further actions should be instructed: not to smoke, eat, drink or place their hands near their mouths until they have washed their hands; to shower and change clothes if possible and place their clothes in a plastic bag and keep them; and to go to the specified place to be assessed and be given instructions;
- Anyone who transported victim(s) must go to the specified place for individual monitoring and monitoring of vehicles.

If an airborne radioactive release is suspected, people within about 1 km of the site of the emergency should be advised:

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— To remain indoors during the release;
— Not to consume any food or water that may have been contaminated (e.g. vegetables grown outside or rainwater) until monitoring of food has been performed;
— That an announcement of the results will follow;
— To make sure that children do not play on the ground;
— To wash hands before eating;
— To avoid dusty areas or activities that will create dust;
— Not to be concerned about those evacuated (it is not dangerous to be near them);
— Not to go to the scene to volunteer to help — if assistance is needed, announcements will be made.

If a dangerous source is lost or stolen, the public should be provided (as appropriate) with the following information:

(1) Time and location of loss of control over the source;
(2) The governmental organization leading the response;
(3) The details of the request for help in finding this dangerous item;
(4) A description and if possible illustration or drawing of the item;
(5) Advice that:
— The item is very dangerous and if found should not be touched, and everyone should be kept at least 10 metres away from it;
— Any persons who think they may have seen the item should immediately report this to [specify];
— Any persons who have touched or been near the item should contact [specify].

Medical practitioners should be alerted to the possibility that patients may present themselves with symptoms of radiation exposure (e.g. burns with no apparent cause, i.e. the person does not remember being burned).

Scrap metal dealers are also asked to be alert.

Appendix IV

EMERGENCY CLASSES FOR EMERGENCIES AT FACILITIES[39]

IV.1. Table 10 describes the abnormal facility conditions that correspond to each type of facility emergency listed in the Requirements (para. 4.19 [2]), together with the immediate actions that should be initiated on and off the site upon declaration of one of these types of emergency. Emergency action levels should be developed for the abnormal conditions that correspond to each type of emergency (see para. 4.5).

[39] Facilities in threat categories I, II and III.

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TABLE 10. CLASS DESCRIPTION FOR EMERGENCIES AT FACILITIES

Emergency class description	Immediate response actions, threat category I and II facilities
General emergency	
Events resulting in an actual or substantial risk of an atmospheric release or radiation exposure due to a criticality or loss of shielding requiring implementation of urgent protective actions off the site. This could be: — Actual or projected[a] damage to the reactor core or large amounts of recently discharged fuel (see Table 4); — Actual damage to barriers or critical safety systems that would result in a release (e.g. of reprocessing waste) or criticality that would warrant taking precautionary protective action off the site;	Operator and on-site: — Take life saving actions and give first aid on the site; — Notify off-site officials; — Recommend protective actions in accordance with Appendix VII; — Summon the emergency services if needed; — Evacuate non-essential personnel and visitors or provide them with special on-site sheltering, and account for all persons on the site; — Provide protection from hazardous conditions for on-site emergency response personnel and for those arriving from off the site; — Take action to mitigate the consequences of the emergency, including requesting off-site assistance; — Provide technical assistance to the facility control room; — Conduct off-site monitoring near the facility and provide results to the radiological monitoring and assessment centre (see Appendix VIII); — Activate the full response coordinated under a unified emergency response management system similar to the incident command system;[b] — Establish continuous communication with off-site officials; — Establish, with off-site officials, a unified emergency response management system similar to the incident command system (see Appendix VIII); — Conduct, with off-site officials, joint media briefings at the public information centre (see Appendix VIII).

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TABLE 10. CLASS DESCRIPTION FOR EMERGENCIES AT FACILITIES (cont.)

Emergency class description	Immediate response actions, threat category I and II facilities
General emergency	
— Potential or actual criticality near the facility boundary; — Detection of radiation levels off the site warranting the implementation of urgent protective measures; — Terrorist or criminal act resulting in an inability to monitor or control critical safety systems needed to prevent a release or exposure that could result in doses off the site that warrant urgent protective actions.	Off-site: Within the PAZ and the UPZ: — Implement immediate protective actions as recommended at the facility and in accordance with Appendix VII; — Establish the radiological monitoring and assessment centre (see Appendix VIII), conduct monitoring in and around the UPZ and revise protective actions based on OILs; — Activate the full response coordinated under a unified emergency response management system similar to the incident command system;[b] — Provide radiation protection for emergency workers; — Ensure that all governmental agencies are informed; — Notify the IAEA; — Establish provision to monitor and decontaminate evacuees and manage the medical response and initial treatment, and consult experts on the treatment of persons with severe overexposures; — Initiate joint media briefings at the public information centre with on-site officials (see Appendix VIII). The area in which food and water contamination may warrant restrictions: — Issue instructions to protect water supplies[c] and for farmers to protect crops and put animals on stored feed as appropriate; — Restrict movement of contaminated food until it has been monitored; — Conduct monitoring to determine where ingestion OILs could be exceeded and to provide appropriate recommendations for protection.

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TABLE 10. CLASS DESCRIPTION FOR EMERGENCIES AT FACILITIES. (cont.)

Emergency class description	Immediate response actions, threat category I and II facilities
Site area emergency	
Events resulting in a major decrease in the level of protection for those on the site and near the facility. This could be: — A major decrease in the level of defence in depth provided for the core of a reactor or actively cooled fuel (see Table 4); — A major decrease in protection against an accidental unshielded criticality; — Conditions such that any additional failures could result in a general emergency; — Doses off the site approaching the urgent protective action intervention levels; — Terrorist or criminal act with the potential to disrupt the performance of critical safety functions or to result in a major release or severe exposure.	Operator and on-site: — Take life saving actions and give first aid on the site; — Notify off-site officials; — Recommend that preparations be made to implement protective actions in accordance with Appendix VII; — Summon the emergency services if needed; — Evacuate non-essential personnel and visitors or provide them with special on-site sheltering, and account for all persons on the site; — Provide protection from hazardous conditions for on-site emergency response personnel and for those arriving from off the site; — Activate the full response coordinated under a unified emergency response management system similar to the incident command system;[b] — Take action to mitigate the consequences of the emergency, including requesting off-site assistance; — Provide technical assistance to the facility control room; — Conduct off-site monitoring near the facility and provide results to the radiological monitoring and assessment centre (see Appendix VIII); — Establish continuous communication with off-site officials; — Conduct, with off-site officials, joint media briefings at the public information centre (see Appendix VIII); — Reassess the classification and revise if warranted.

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TABLE 10. CLASS DESCRIPTION FOR EMERGENCIES AT FACILITIES. (cont.)

Emergency class description	Immediate response actions, threat category I and II facilities
Site area emergency	Off-site: — Prepare to implement urgent protective actions off the site and take measures in accordance with Appendix VII to protect the food supply; — Alert the population in the PAZ or UPZ, advising them to remain attentive for further instructions; — Activate the full response coordinated under a unified emergency response management system similar to the incident command system;[b] — Provide radiation protection for emergency workers; — Provide firefighting, police or medical services in support of the facility if requested; — Establish the radiological monitoring and assessment centre (see Appendix VIII) and conduct monitoring in and around the UPZ, and revise the classification as appropriate; — Ensure that all governmental agencies are informed; — Notify the IAEA; — Establish provision to manage the medical response and initial treatment, and consult experts on the treatment of persons with severe overexposures; — Initiate, with on-site officials, joint media briefings at the public information centre (see Appendix VIII). Within the area where food and water contamination may warrant restrictions: — Issue instructions to protect water supplies[c] and for farmers to protect crops and put animals on stored feed as appropriate.

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TABLE 10. CLASS DESCRIPTION FOR EMERGENCIES AT FACILITIES. (cont.)

Emergency class description	Immediate response actions, threat category I and II facilities
Facility emergency	
Event resulting in a major decrease in the level of protection for on-site personnel; however, these events cannot evolve into a general or site area emergency warranting the implementation of protective actions off the site. For threat category I and II facilities, this could be: — A fuel handling emergency; — An in-facility fire or other emergency not affecting safety systems; — Terrorist or criminal activity resulting in hazardous on-site conditions but with no potential to result in a criticality or release off the site that would warrant urgent protective actions.	Operator and on-site: (see Ref. [43] for further guidance for radiotherapy facilities): — Take life saving actions and give first aid on the site; — Notify off-site officials and summon emergency services if needed; — Evacuate non-essential personnel and visitors from the potentially hazardous area and account for all persons on the site; — Monitor on-site personnel for contamination and ensure that contaminated individuals or items do not leave the site undetected; — Provide first aid, decontaminate, estimate exposures and take injured and exposed individuals for treatment; — Confirm that off-site protective actions are not needed; — Provide protection from hazardous conditions for on-site and off-site emergency response personnel; — Activate partial response; — Take actions to mitigate the emergency and to provide technical assistance to control room or operating staff; — Establish continuous communication with off-site officials; — Activate a partial response coordinated under a unified emergency response management system similar to the incident command system;[b] — Conduct, with off-site officials, joint media briefings at the public information centre (see Appendix VIII); — Reassess the classification and revise if warranted.

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TABLE 10. CLASS DESCRIPTION FOR EMERGENCIES AT FACILITIES. (cont.)

Emergency class description	Immediate response actions, threat category I and II facilities
Facility emergency	
For threat category III, this could be: — A major decrease in the level of defence in depth provided for the core of a small reactor (see Table 4); — Loss of shielding or control of a large gamma emitter or spent fuel; — Rupture of a dangerous source; — A criticality away from the site boundary; — High doses on the site approaching urgent protective action intervention levels; — Emergencies resulting in significant exposure or contamination of the public or staff on the site; — Terrorist or criminal activity potentially resulting in hazardous on-site conditions.	Off-site: — Conduct monitoring around the facility to confirm that off-site actions are not needed; — Activate the full response coordinated under a unified emergency response management system similar to the incident command system;[b] — Ensure that governmental agencies are informed; — Provide fire, police or medical services in support of the facility if requested; — Provide initial treatment for the injured and consult experts to determine a treatment strategy for those with overexposures; — Initiate, with on-site officials, joint media briefings at the public information centre (see Appendix VIII).

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TABLE 10. CLASS DESCRIPTION FOR EMERGENCIES AT FACILITIES. (cont.)

Emergency class description	Immediate response actions, threat category I and II facilities
Alert	
Events involving an unknown or significant decrease in the level of protection of the public or on-site personnel.[d]	Operator and on-site: — Take life saving actions and give first aid on the site; — Notify off-site officials; — Activate, by using the incident command system under an incident commander, the appropriate part of the response needed to analyse and resolve the condition resulting in the alert or to reduce the potential threat; — Conduct off-site monitoring near the facility (if appropriate); — Implement actions to mitigate the consequences of the event and to provide technical assistance to control room or operations staff (if required); — Initiate, with off-site officials, joint media briefings at a public information centre if the alert receives media or public attention. Off-site: — Increase readiness; — Implement the minimum components of a unified management system for emergency response similar to the incident command system; — Ensure that all governmental agencies are informed; — Provide fire, police or medical services in support of the facility if requested; — Initiate, with on-site officials, joint media briefings at the public information centre if the alert receives media or public attention.

[a] Indicated by a loss of critical safety functions needed to protect the core or large amounts of recently discharged fuel.
[b] Incident command systems as described in Ref. [3].
[c] Typically only small open water supplies or water supplies that use rainwater are at risk.
[d] Such events may involve release barriers, critical safety systems, instrumentation, staff, natural occurrences, and fires or terrorist or criminal acts.

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Appendix V

OVERVIEW OF URGENT PROTECTIVE ACTIONS AND OTHER ACTIONS

ISOLATION AND PREVENTION OF INADVERTENT INGESTION

V.1. In most radiological emergencies involving uncontrolled dangerous sources, individuals can be protected from the radiological hazards by isolating the source and preventing inadvertent ingestion. They can avoid significant exposure due to contact and shine by moving away from a dangerous source, and workers can greatly reduce their dose by the use of remote handling tools. Keeping hands and possibly contaminated objects out of the mouth can prevent inadvertent and possibly fatal ingestion. These are all actions that individuals can take immediately, once they are aware of the hazard. Consequently, the Requirements [2] (para. 4.48) require that arrangements be made to issue a warning to the public in the event of a dangerous source being lost or illicitly removed and possibly being in the public domain. This warning should include instructions to the public on how to isolate a possibly dangerous source and how to prevent the inadvertent ingestion of radioactive material.

SHELTERING

V.2. Sheltering is relatively easy to implement, but it may not be possible to extend it for long periods of time. Sheltering will provide some protection against exposure via all the major exposure pathways during the early phase of a nuclear or radiological emergency. Sheltering 'in place' can also be used whenever individuals in a potential area of risk are instructed to 'go inside and shut the windows and doors and listen to the radio or television for further instructions' while further assessments of preparations for evacuation are being made. Sheltering can also be used whenever conditions make evacuation dangerous (e.g. in severe weather conditions).

V.3. The effectiveness of sheltering varies greatly, depending on the characteristics of the radioactive release or the sources of the exposure (e.g. a criticality), the construction of the shelter and the exposure pathway. External exposure can be reduced by a factor of ten by sheltering in a large structure, while a lightweight building provides little protection from external gamma radiation. Estimating the protection provided against inhalation of radioactive

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material in the plume by sheltering is very complex. For a short release, most buildings will reduce inhalation doses by a factor of two or three. However, the reductions in the inhalation doses resulting from long releases typically decrease rapidly after a few hours as the concentrations of radioactive material in the structure increase. After passage of the plume, the inhalation doses in most structures could even be greater than those outside if some of the contamination from the plume is trapped in the shelter. Consequently it should be recommended that normal shelters be ventilated (aired out) after a major release has terminated.[40]

V.4. Because of the great variability of building structures, shelters can be considered as belonging to one of three categories, as shown in Table 11.

V.5. Predetermined shelter locations should be provided with a means of determining whether radiation levels are acceptable (e.g. measuring instruments and criteria for judging the results) and arrangements for meeting human needs.

EVACUATION

V.6. A room, facility or geographic area can be evacuated. Timely evacuation can prevent exposures via all possible exposure pathways and removes individuals from the proximity of the emergency so that they are no longer an immediate concern for response officials.

V.7. Numerous evacuations have been carried out in response to emergencies involving natural, chemical and radiological hazards and terrorist activities. Studies of these evacuations show [44, 45] that the risks of the evacuation itself for the normal population were smaller than those due to normal travel under similar weather conditions. However, evacuation may be more dangerous for special groups in the population, such as hospital patients, if it is not prepared for adequately. The following should be taken into account in preparing for evacuation:

— Criteria and decision making;
— Established evacuation routes and traffic control;

[40] This is made difficult by the uncertainties associated with projections of the timing (duration) and size of major releases and plume movements, as was seen following the Chernobyl accident in 1986.

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TABLE 11. SHELTER TYPES AND USES

Type	Description	Uses and recommendations
Normal	Typical European and North American homes and their basements.	May not provide adequate protection (e.g. from a major airborne plume close to a facility[a] in threat category I). Should be used in the event of a major release if evacuation is impossible (e.g. in a severe storm) or when preparing to evacuate.
Substantial	Inside halls of large multistorey buildings or large masonry structures away from walls or windows. Estimated protection factor of 10 from external and inhalation dose.	May provide adequate protection for short periods. Can be used as urgent protection for up to a day. However, the effectiveness should be assessed by means of monitoring and users should be provided with instructions on application.
Special	Designed to provide a reduction by a factor of more than 100 in external and inhalation doses.	Provides adequate protection. Should be used as the primary urgent protective measure for the design period of the shelter.

[a] The distances within which shelter is ineffective in reducing the risk of severe deterministic effects should be based on site specific analysis; however, for the most severe emergencies postulated for nuclear power plants, shelter in a typical frame house of the type found in the USA is projected to provide inadequate protection within about the first 3 km from the site of the emergency.

— Access control and protection of property;
— Arrangements for special population groups and facilities;
— Consideration of farm animals and pets;
— Provisions for meeting the human needs of evacuees.

RESPIRATORY PROTECTION AND PROTECTIVE CLOTHING

V.8. The respiratory protection equipment typically used by firefighters provides good protection against the inhalation hazard for most emergencies involving an airborne release of radioactive material. Skin contamination is not a major threat, provided that simple steps are taken to protect the skin and to prevent inadvertent ingestion. However, conditions on the site of a facility in threat category I, II or III may be very severe and may require specialized

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protective equipment.[41] For example, the standard protective clothing worn by firefighters during the Chernobyl accident in 1986 did not provide adequate protection for the skin. Personnel responding to radiological emergencies should use respiratory protection equipment whenever an inhalation hazard is suspected. In addition, the Requirements [2] (para. 4.62) require that arrangements be made for taking all practicable measures to provide protection for emergency workers at facilities in threat categories I, II and III for the range of anticipated hazardous conditions in which they may have to perform response functions on or off the site.

V.9. Improvised respiratory protection (e.g. a wet cloth over the mouth and nose) has been shown to be effective but it has not been demonstrated that the public will apply it effectively during an emergency. Improvised respiratory protection should not be assumed to provide adequate protection from an inhalation hazard and therefore its implementation should not be allowed to interfere with evacuation or sheltering.

DECONTAMINATION OF INDIVIDUALS

V.10. People have been contaminated by airborne radioactive releases and by handling radioactive material. Significant levels of skin contamination are very rare, and for most emergencies contamination has not presented a health risk. However, skin contamination can have severe adverse psychological and economic effects. In some cases contaminated people have been shunned and medical professionals have refused to treat them. In addition, skin contamination did contribute to the deaths of several on-site responders (firefighters) during the Chernobyl accident in 1986, and the inadvertent ingestion of contaminated particles that were on the skin of persons who were contaminated in the accident in Goiânia, Brazil in 1987 may have been fatal. These accidents illustrate the two scenarios for which prompt decontamination may be important in preventing severe deterministic effects:

[41] In the Chernobyl accident, water contaminated with radioiodine soaked through the protective clothing of the fire-fighters, resulting in beta radiation burns that contributed to several fatalities. In many responses, on-site efforts have been hampered by a lack of protective equipment (e.g. field radiation detection instruments with a high range (e.g 10 Gy/h) or air tanks for self-contained breathing apparatus).

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— Those who may have been heavily contaminated by a major airborne radioactive release should be promptly decontaminated to prevent burns to large areas of the skin. This would probably only be an issue for those on the site during a major release from a facility in threat category I and possibly threat category II or III.
— Those who may have skin contamination that could be hazardous and which could possibly give rise to inadvertent ingestion (e.g. by placing a hand on or in the mouth) should be promptly decontaminated. This hazard would most probably be of concern to someone who handled a dangerous source containing dispersible material or something directly contaminated by such a source.

V.11. In the radiological accident in Goiânia, over 100 000 people were monitored in order to reassure them that they were not significantly contaminated. Similar reactions by the public should be expected in the event of an emergency that may possibly involve contamination of the public.

V.12. Contamination by a wide range of radioactive materials is easy to detect; however, criteria are needed to differentiate between significant and insignificant levels in terms of possible health consequences. Lack of criteria has resulted in unnecessary decontamination, diversion of resources, unwarranted anxiety among the public and loss of equipment or facilities.[42] Consequently, operational criteria should be established to assess levels of contamination on people and equipment.

V.13. Simply changing clothing, showering or washing exposed skin will reduce dangerous levels of contamination and prevent the spread of contamination at significant levels. These simple, cost effective decontamination measures should be used even for contamination at lower levels, provided that they are carried out in such a way as to minimize unwarranted anxiety and do not result in the waste or unjustified diversion of resources. In emergencies, especially when large numbers of people are involved, decontamination measures should be limited to these basic measures and only limited (i.e. easy and simple) efforts should be made to control the wastes arising from the decontamination.

[42] Some emergency plans state that vehicles or facilities that are contaminated cannot be used, but do not define what levels of contamination constitute being contaminated.

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PROPHYLAXIS WITH STABLE IODINE

V.14. The uptake by the thyroid gland of radioiodine from inhalation can be reduced by the administration of certain amounts of stable (non-radioactive) iodine which saturates the thyroid. This is called stable iodine prophylaxis, thyroid blocking or iodine blockade.

V.15. To achieve maximum effectiveness, stable iodine must be administered before or soon after the intake of radioiodine. The effectiveness of the measure decreases rapidly with delay, and can be reduced to 50% or less if administered 6 hours after a single intake of radioactive iodine. The reduction in the dose to the thyroid gland is only about 20% if stable iodine is given 10 hours after intake, while it falls almost to zero if stable iodine is given 24 hours after the intake of radioiodine [46].

V.16. There has been considerable concern about adverse side effects on health from the intake of stable iodine. The WHO, partly on the basis of experience gained from the response to the Chernobyl accident, found the risk of severe adverse side effects to be negligible and stable iodine prophylaxis to be both safe and effective [47] if the iodine is provided in the correct dosages and those with known severe allergic reaction are excluded. WHO has provided guidance on the appropriate dosages in Ref. [47]. These dosages are different for adults and children.

V.17. Emergencies involving core damage at large reactors (threat category I) can release significant amounts of airborne radioactive iodine (radioiodine) over several days, as was seen in the Chernobyl accident. The thyroid gland absorbs and concentrates iodine once it has been inhaled or ingested; thus, the potential exists for large thyroid doses following the occurrence of severe core damage at a large reactor. A large dose to the thyroid can result in deterministic effects in the thyroid gland and radiation induced thyroid cancer. In the event of actual or possible core damage, stable iodine prophylaxis should therefore be used:

- To prevent deterministic effects in the thyroid gland (e.g. hypothyroidism);
- To reasonably reduce the risk of stochastic effects (e.g. radiation induced thyroid cancer) from the inhalation of radioiodine within or near the facility.

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V.18. The risks of deterministic effects to the thyroid are principally of concern for individuals on the site and for the population close to the site (e.g. within the UPZ).

V.19. To be most effective, stable iodine prophylaxis should be provided before or shortly after an intake of radioiodine (i.e. before or shortly after a radioactive release). Consequently, for emergencies involving severe core damage at reactors of facilities in threat categories I and II, arrangements should be made to provide stable iodine prophylaxis promptly (i.e. before or within hours of a release) to individuals who are on the site and to the population within the UPZ, including emergency workers. In developing these arrangements, the following should be considered:

- Criteria and decision making;
- The logistics of storage, restocking and distribution;
- The need for instructions to users to ensure that the correct dosages are taken and that individuals with known severe allergies are excluded from the iodine prophylaxis;
- Medical follow-up of those with actual or perceived side effects.

V.20. Appropriate arrangements should be made for the continuation of stable iodine prophylaxis for more than one day if there is:

- Potential for significant releases of radioiodine for several days following the onset of an emergency;
- Potential for inadvertent ingestion after passage of the radioactive plume;
- In-growth of ^{132}I from the decay of ^{132}Te in the environmental contamination following a release.

V.21. Doses to the thyroid, in the vast majority of cases, will not give rise to life threatening effects if individuals are properly treated. However, death could result from doses to the bone marrow, lungs and other organs, which are not protected by stable iodine prophylaxis. Only substantial sheltering or evacuation can protect these organs. The sheltering or evacuation of people at risk of life threatening doses should therefore not be delayed for the provision of stable iodine prophylaxis.

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PROTECTION OF THE FOOD AND WATER SUPPLY AND RESTRICTION OF SIGNIFICANTLY CONTAMINATED FOOD AND WATER SUPPLIES

V.22. Following a major release from a facility in threat category I or II, one of the primary sources of exposures may be the ingestion of contaminated food or milk.[43] Ingestion of radioactive material may also be of concern if an explosion or human activity spreads dispersible material from a dangerous source.

V.23. The Chernobyl accident showed that the contamination of drinking water sources due to an airborne radioactive release might not be a major concern, except if rainwater is being used directly for drinking or cooking.

V.24. Consequently, for facilities in threat categories I and II (with the potential for an emergency that may result in a major release) arrangements should be made:

- To instruct the public not to eat locally produced food within the UPZ that may have been directly contaminated and not to consume milk from animals that may graze on possibly contaminated ground;
- To instruct the public to protect sources of water (e.g. to disconnect rainwater collection pipes) and to protect important sources of food that may become contaminated;
- Promptly to conduct monitoring and to implement the appropriate restrictions on food and on drinking water from rainwater within the area where food or water may be contaminated to levels warranting restrictions.

V.25. These arrangements should be developed in consideration of:

- Arrangements for the distribution and processing of food;
- Instructions for the public and for farmers;

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[43] The consumption of milk contaminated with radioiodine was the primary cause of an increase in the incidence of thyroid cancers among children following the Chernobyl accident. Radiation induced thyroid cancers due to the Chernobyl accident occurred among people living at different distances from the plant and the vast majority were observed at more than 50 km from the plant. The most effective protective action to prevent or reduce these thyroid cancers would have been to restrict the consumption of potentially contaminated food and milk.

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— Availability of replacement foods;
— Operational criteria.

V.26. If restrictions could result in severe health effects (e.g. malnutrition), they should not be applied unless ingestion of the food could result in severe deterministic effects.

PROTECTION OF INTERNATIONAL TRADE AND COMMERCIAL INTERESTS

V.27. Nuclear and radiological emergencies that have occurred in the past have had major adverse economic consequences. This was in part because steps were not taken immediately to reassure people, including national and international customers. It should be noted that threats as reported in the media or as perceived internationally can be as influential as real threats. Consequently, in the event of a nuclear or radiological emergency (or in the event of reports of such an emergency) that may have or that may be perceived to have an impact on trade, there should be provision for taking measures immediately to ensure that all goods in trade meet international standards. The exemption levels and clearance levels in Ref. [48] may be considered as a basis for protecting international trade after an emergency.

MEDICAL MANAGEMENT

V.28. Nuclear and radiological emergencies have occurred that warrant taking immediate action to treat and to identify those who should receive long term medical follow-up. These actions are discussed in the section on managing the medical response, paras 4.37–4.46.

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Appendix VI

RESPONSE TIME OBJECTIVES

VI.1. Response time objectives are suggested time objectives for selected critical response functions or tasks for facilities in threat categories I, II and III. They should, once established, be part of the performance objectives for a response capability and should be used as part of the evaluation criteria for exercises (Ref. [2], para. 5.36). These time objectives were developed on the assumption that: (a) emergencies resulting in severe conditions can be classified and off-site officials can be notified within minutes [49];[44] (b) severe conditions warranting protective action on the site can occur within minutes; (c) releases can occur from a facility in threat category I that require the implementation of urgent protective action to prevent deterministic effects within the PAZ within one or two hours; (d) monitoring within the UPZ may be warranted within 4–6 hours following a release to identify locations where additional protective actions may be needed; and (e) the news media will become aware of events and will become a major source of information for the public within hours.

TABLE 12. RESPONSE TIME OBJECTIVES

Element/task	Threat category I facility			Threat category II facility			Threat category III facility	
	Facility level	Local level	National level	Facility level	Local level	National level	Facility level	Local level
Establishing emergency management operation (the objective is timed from the time at which the emergency is classified by the facility operator)								
Announce who is the director of on-site emergency response to those on the site	<15 min							

[44] This should be accomplished as soon as possible. Over the past 20 years, the USA has demonstrated that this goal can be achieved within 15 minutes of detection of the event. This goal has been further formalized as part of the US emergency preparedness requirements in accordance with Ref. [49].

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TABLE 12. RESPONSE TIME OBJECTIVES (cont.)

Element/task	Threat category I facility			Threat category II facility			Threat category III facility	
	Facility level	Local level	Natio-nal level	Facility level	Local level	Natio-nal level	Facility level	Local level
Activate emergency operations facility and/or incident command post (see Appendix VIII)	<1 h	<1 h		<1 h	<1 h			<2 h
Emergency operations facility/ incident command post is fully functional (all organizations represented)	<2 h	<2 h		<2 h	<2 h			<3 h
Identifying, notifying and activating (the objective is timed from the time at which conditions indicating that emergency conditions exist are detected)								
Classify the emergency (declaration of emergency)	<15 min			<15 min			<15 min	
Notify local authorities (PAZ and UPZ) after classification[a]	<15 min			<15 min			<1 h	
Fully activate emergency organization	<2 h	<6 h	<12 h	<2 h	<6 h		<2 h	
Notify all States within the UPZ	<1 h		<1 h			<1 h		
Notify the IAEA			<2 h			<2 h		
Performing mitigatory actions (the objective is timed from the time at which the emergency is classified)								
Initiate mitigatory actions	<15 min			<15 min			<15 min	

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TABLE 12. RESPONSE TIME OBJECTIVES (cont.)

Element/task	Threat category I facility			Threat category II facility			Threat category III facility	
	Facility level	Local level	Natio-nal level	Facility level	Local level	Natio-nal level	Facility level	Local level
Have operational support centre functional (see Appendix VIII)	<30 min							
Provide technical assistance to the on-site responders (activate technical support centre) (see Appendix VIII)	<1 h							
Provide on-site damage control teams	<30 min			<1 h			<1 h	
Obtain support of off-site emergency services	<30 min			<30 min			<30 min	
Taking urgent protective action								
Recommend urgent protective actions for the public on the basis of the emergency classification	<30 min			<30 min				
Make decisions on urgent protective actions	<30 min	<30 min		<30 min	<30 min			
Complete implementation of facility protective actions	<1 h			<1 h			<1 h	

TABLE 12. RESPONSE TIME OBJECTIVES (cont.)

Element/task	Threat category I facility			Threat category II facility			Threat category III facility	
	Facility level	Local level	National level	Facility level	Local level	National level	Facility level	Local level
Providing information and issuing instructions and warnings to the public (the objective is timed from the time at which the initial notification by the facility of a general emergency is received)								
Initially warn and inform the public within the PAZ and UPZ of urgent protective actions required		<1 h			<2 h			
Activate the public information centre and commence coordinated (between the facility and off-site officials) briefings for the news media		<4 h			<4 h			<6 h
Assessing the initial phase								
Conduct environmental monitoring near the facility	<1 h			<1 h			<2 h	
Conduct environmental monitoring within the PAZ, near the facility		<4 h						
Conduct environmental monitoring within the UPZ		<12 h	<12 h		<12 h	<12 h		

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TABLE 12. RESPONSE TIME OBJECTIVES (cont.)

Element/task	Threat category I facility			Threat category II facility			Threat category III facility	
	Facility level	Local level	National level	Facility level	Local level	National level	Facility level	Local level
Radiological monitoring and assessment centre fully functional (see Appendix VIII)		<24 h			<24 h			

[a] This should be accomplished as soon as possible. Over the past 20 years, the USA has demonstrated that this goal can be achieved within 15 minutes of detection of the event. This goal has been further formalized as part of the US emergency preparedness requirements in accordance with Ref. [49].

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Appendix VII

URGENT PROTECTIVE ACTION OFF THE SITE

RADIOLOGICAL EMERGENCIES

VII.1. For instances of transport emergencies, found sources, radiological dispersal devices, contamination or accidents involving a nuclear weapon (all emergencies in threat category IV), the following urgent actions should be promptly taken before an assessment of monitoring results becomes available.

First responders

VII.2. Within the inner cordoned area (inside the safety perimeter; see Appendix II): warn that women who are or who may be pregnant should not work within the cordoned area; perform life saving actions (do not delay life saving actions on account of possibly elevated levels of radiation); limit stays in the area to the performance of critical tasks; use available respiratory protection (if airborne contamination is suspected); take action to prevent inadvertent ingestion; change clothing and wash, especially hands, face and hair, as soon as possible; get monitored if needed. As soon as possible the doses received by emergency workers should be monitored and controlled in accordance with international standards by the radiological assessor at the scene.

Public

VII.3. Within the inner cordoned area (inside the safety perimeter; see Appendix II): evacuate (or use substantial sheltering) as directed by the authorities; avoid possibly contaminated smoke or dust; do not eat potentially contaminated food until it has been monitored; do not eat or smoke or place hands on or in the mouth to avoid inadvertent ingestion, and change clothing and wash, especially hands, face and hair, as soon as possible; get monitored as directed by the authorities.

VII.4. If a major airborne release is suspected, people within about 1 km of the site of the emergency should be advised:

— To remain indoors during the release;
— Not to consume any food or water that may have been contaminated (e.g. vegetables grown locally or rainwater) until informed of its safety;

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— To ensure that children do not play on the ground;
— To wash hands before eating, drinking or smoking until food has been monitored (after which the results will be announced);
— To avoid dusty areas or activities that will raise dust.

VII.5. The public should also be advised of what to do if they are concerned that they may have been contaminated and of where to get additional information (it should be ensured that any advice will not interfere with the immediate response).

VII.6. For other response actions that should be taken during a radiological emergency, see Appendix 7 of Ref. [3].

FACILITIES IN THREAT CATEGORIES I AND II

VII.7. Urgent protective actions for facilities in threat categories I and II are shown in Table 13.

TABLE 13. URGENT PROTECTIVE ACTIONS FOR THREAT CATEGORY I AND II FACILITIES

Threat category	Suggested protective action
I	General emergency: — Promptly evacuate or provide special sheltering[a] for the public and non-essential workers on the site; — Promptly evacuate or provide substantial sheltering[b] for the public in the PAZ (in all directions); — For an emergency involving a nuclear reactor, provide stable iodine for thyroid blocking within the PAZ and UPZ; — Recommend to the public within the UPZ that they remain indoors and listen to the radio or television for further instructions (in-place sheltering); — Promptly conduct monitoring within the UPZ (including the shelters in the PAZ) to determine where OILs could be exceeded and to evacuate if appropriate; — Restrict consumption of possibly contaminated food or water and provide instructions to protect food and water supplies and agricultural products; — Restrict access to the evacuated area and areas where sheltering is recommended; — Monitor the people evacuated and determine whether decontamination or medical treatment is needed.
II	General emergency: — Recommend to the public within the UPZ that they remain indoors and listen to the radio or television for further instructions; — Promptly conduct monitoring of the UPZ to determine where OILs could be exceeded and to evacuate if appropriate; — Restrict consumption of possibly contaminated food or water and provide instructions to protect food and water supplies and agriculture products; — Restrict access to the evacuated area and areas where sheltering is recommended; — Monitor the people evacuated and determine whether decontamination or medical treatment is needed.
I & II	Site area emergency: — Provide instructions to protect water supplies and agricultural products.

[a] Special shelters are designed to provide protection against dose due to inhalation and radiation shine (shielding and filtering); see Table 11.

[b] Substantial sheltering is provided by large multistorey structures without any special features; see Table 11.

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Appendix VIII

EMERGENCY FACILITIES AND LOCATIONS

VIII.1. There are two different types of emergency related facilities or locations: those established in advance and those established at the time of the emergency. In both cases the functions of and operational conditions and requirements for the facilities or locations should be carefully considered, and necessary advance preparations should be made. Facilities or locations established in advance (e.g. the technical support centre for a nuclear power plant) are designed, built and equipped to support their functional and operational requirements. If the facility or location is to be established at the time of an emergency, advance preparations should be made to find a suitable location and to establish the centre rapidly under field conditions. These preparations would include: developing site selection criteria; assigning the responsibility for acquiring a site during an emergency; and also, having procured and prepared in advance equipment (e.g. generators), supplies and other items needed to establish the centre in the field, establishing a team for setting up the centre. Establishing such a centre under field conditions should be exercised.

VIII.2. Each emergency facility or location should be:

— Designed to support the functions that take place within it;
— Usable under emergency conditions;
— Integrated into the incident command system.

VIII.3. The steps in developing an adequate facility or a capability to establish a centre are as follows:

(1) Determine the functions of the facility;
(2) Determine the relationship of the facility to other facilities, areas or functions in the response system;
(3) Determine the operational conditions under which the facility must function (e.g. environmental and radiological conditions);
(4) Establish a design team;
(5) Analyse the organization of the facility or area;
(6) Assess the flows (e.g. of people, information, samples) associated with each position within the organization;
(7) Determine the workstation requirements for each position;

(8) Determine the needs for space, light and power and other environmental needs for each position, including food and water supplies and sanitary and sleeping arrangements;
(9) Determine the possible radiological and environmental conditions during operation;
(10) Develop a conceptual design;
(11) Develop and test a prototype.

VIII.4. The facilities and locations recommended for each threat category are listed in Table 14 and described in Table 15.

TABLE 14. RECOMMENDED EMERGENCY FACILITIES AND LOCATIONS

Facility or location	Threat category				
	I	II	III	IV	V
Assembly point	✓	✓	✓		
Assistance centres[a,b]	✓	✓	✓	✓	✓
Control room[c]	✓	✓	✓		
Designated hospital[d]	✓	✓	✓	✓	
Emergency operations facility[c]	✓	✓			
Facility medical service	✓	✓			
Incident command post[e]	✓	✓[a]	✓[a]	✓[a]	✓[f]
Laboratory	✓	✓			
Notification point	✓	✓	✓	✓	
Operational support centre	✓				
Public information centre	✓	✓[a]	✓[a]	✓[a,b]	✓[b,f]
Radiological monitoring and assessment centre	✓	✓	✓[b]	✓[b]	✓[f]
Referral hospital[g]	✓	✓	✓	✓	✓
Reception centres	✓	✓	✓	✓	✓
Response organization emergency operations centres	✓	✓	✓	✓	✓
Staging area	✓	✓	✓	✓	
Technical support centre	✓				
Triage area[a]	✓	✓	✓	✓	
Warning point				✓	

[a] The location will be determined at the time of the event.
[b] If needed.
[c] A backup emergency operations facility should be provided at a different location for use if the primary facility is unusable. The backup emergency operations facility can be located in an existing facility and may be provided with only minimum capabilities.
[d] This will be a designated hospital near each facility in category I, II or III. A single hospital would be sufficient in a State without any facilities in category I, II or III.
[e] The incident command post may be located in an existing facility (e.g. in the emergency operations centre).
[f] A single national facility would probably be established for an emergency involving major contamination.
[g] A referral hospital could be a single highly specialized hospital in or outside the State.

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TABLE 15. DESCRIPTIONS OF RECOMMENDED EMERGENCY FACILITIES AND LOCATIONS

Facility/ location	Functions	Characteristics
Assembly points	Locations where non-essential personnel at the facility are assembled, accounted for and sheltered or evacuated.	Areas (one or more) within the facility security boundary with sufficient room for on-site non-essential (non-response) staff (including construction workers or other non-permanent personnel). Easily accessible, provides some protection against a release or exposure, and is continuously monitored. Activation time: within 15 minutes of the declaration of an emergency.
Assistance centres (e.g. reception or relocation centres)	For providing members of the public with financial and other assistance during and after an emergency.	Locations determined at the time of an emergency; easily accessible to the affected public.
Control room	For operational control of the facility, detection and classification of the emergency, and activation of the response organization. Non-operational functions should be transferred to other facilities as soon as possible.	Access to data needed to detect and classify an emergency and to implement mitigatory actions; provided with sufficient protection to remain habitable[a] during major emergencies; provided with continuous monitoring of radiation levels; and provided with security to prevent unauthorized access.
Designated hospital	For providing treatment to individuals exposed and/or contaminated as a result of a nuclear or radiological emergency at the facility.	Provision — made in advance — for treating contaminated/exposed personnel from the threat category I, II or III facility, including provisions for contamination control and access to qualified personnel.

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TABLE 15. DESCRIPTIONS OF RECOMMENDED EMERGENCY FACILITIES AND LOCATIONS (cont.)

Facility/ location	Functions	Characteristics
Emergency operations facility	Coordination of the on-site and off-site response to an emergency warranting off-site protective actions. Typically staffed by the director of the on-site response, the director of the off-site response and the incident commander. When the incident commander is present, this becomes the incident command post.	Access to the information required to coordinate on-site and off-site response decisions; reliable communications with on-site and off-site response centres and organizations; continuous monitoring of radiation levels; security to prevent unauthorized access. If located within the UPZ, it should be provided with sufficient protection to remain habitable[a] during an emergency or provided with a backup. Activation time: within 1 hour of declaration of a site area or general emergency.
Facility medical service	For providing contaminated workers and members of the public (if applicable) with first aid at the facility and preparing them to be taken to the designated hospital.	Available 24 hours a day. Only first aid and minimal provisions to prepare contaminated persons for transport (e.g. blankets).
Incident command post	Location of the incident commander and other members of the unified command and support staff.	Could be located in another emergency facility (e.g. emergency operations facility or emergency operations centre). For facilities in threat category I or II it will most probably be located within the emergency operations facility. For other emergencies it will most probably be located in an area that is secure, safe and convenient for directing operations. Activation time: within 1 hour of declaration of an emergency.

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TABLE 15. DESCRIPTIONS OF RECOMMENDED EMERGENCY FACILITIES AND LOCATIONS (cont.)

Facility/ location	Functions	Characteristics
Laboratory (backup)	Analysis of radioactive samples from the facility, environmental samples and bioassay samples or reading of thermoluminescence dosimetry (TLD) badges.	Should be in a secure location and not within the PAZ or UPZ.
Notification point	The facility where notification of an actual or potential nuclear or radiological emergency is received and from which the appropriate off-site response is initiated.	Should be continuously operational (24 hours a day, 7 days a week) and in a secure location, and should have a redundant power supply and secure communications. This should be the facility used to receive notification of and initiate the off-site response to conventional emergencies (e.g. fires). If located within the emergency zones, it should be habitable during an emergency at the associated threat category I or II facility.
Operational support centre	Operational control of personnel performing tasks within the facility (e.g. environmental monitoring, health physics, damage control and firefighting) and providing health physics support for personnel responding from off the site.	Within the facility security boundary; secure and reliable communications with the control room, with teams in the facility and with off-site responders (e.g. fire services); with sufficient room to assemble, equip and prepare teams; continuous monitoring of radiation levels; in a location that will probably remain habitable under emergency conditions; ready access to equipment, instruments and protective clothing needed by response teams. Activation time: within 30 minutes of declaration of an emergency.

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TABLE 15. DESCRIPTIONS OF RECOMMENDED EMERGENCY FACILITIES AND LOCATIONS (cont.)

Facility/ location	Functions	Characteristics
Public information centre	Coordination of all information released to the news media concerning the emergency by the facility, local governments and national governments. Staffed by representatives of all these organizations.	Located in the vicinity of the site of the emergency with space and infrastructure to support use by the news media and for conducting media briefings. For facilities in threat category I, it is a predesignated facility outside the UPZ. Activation time: within 4 hours of the declaration of an emergency requiring use of the facility.
Radiological monitoring and assessment centre	Coordination of the radiological monitoring, sampling and assessment provided by all response organizations (facility, local governments, national governments).	Location to be determined at the time of the emergency on the basis of radiological and operational considerations. Activation time: within 24 hours of the declaration of an emergency requiring use of the facility.
Referral hospital	Provides highly specialized treatment to exposed and/or contaminated individuals as well as for persons with combined injuries as a result of the nuclear or radiological emergency.	Hospital that specializes in the treatment (haematology, surgery) of radiation induced injuries. If there is no such hospital in the State, national arrangements should be put in place to request treatment at such a facility through the IAEA or the WHO under the Assistance Convention.
Reception centres	Locations for the initial reception, monitoring, decontamination and registration of evacuated members of the public. Provides or arranges for humanitarian support (e.g. food, housing).	Located in an existing facility (e.g. a school). For facilities in threat category I and II, it should be beyond the UPZ boundary.

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TABLE 15. DESCRIPTIONS OF RECOMMENDED EMERGENCY FACILITIES AND LOCATIONS (cont.)

Facility/ location	Functions	Characteristics
Response organization emergency operations centres	Facilities established by various response organizations from which the organization's support for the response will be directed. An emergency operations centre should be established by the regulatory body, ministries with responsibility for radiological or conventional response, local governments, corporate headquarters for the facility, national laboratories with expertise and the response organization for radiological assessment.	Provision for effective coordination with the response of the incident command system.
Staging areas	Locations used to collect and organize additional resources as they arrive in the vicinity of the emergency.	Locations identified at the time of an emergency. Should be in a location that will remain habitable, will not interfere with other ongoing response actions and can be secured.
Technical support centre	Technical support for the control room operators in mitigating the consequences of the emergency.	Secure and reliable communications with the control room and outside sources of technical support; access to plant data, information and tools needed to develop strategies for dealing with major emergencies. If located at the facility, it should be protected to allow operation under major emergency conditions. Activation time: within one hour of the declaration of an emergency.
Triage area	Field location where medical and radiological triage is performed, first aid is provided and affected persons are prepared for being taken to hospital.	Location identified at the time of an emergency. Should be a safe and secure location near the scene with access for medical transport.

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TABLE 15. DESCRIPTIONS OF RECOMMENDED EMERGENCY FACILITIES AND LOCATIONS (cont.)

Facility/ location	Functions	Characteristics
Warning point	The facility that is set up to receive alerts at all times and to promptly respond to incoming notifications, warning messages, requests for assistance or requests for verification of a message from the IAEA. The facility through which the competent authority is contacted by the IAEA.	Continuously operational (24 hours a day, 7 days a week), in a secure location, with redundant power, secure communications and prompt access to speakers of English. The fax machines and other means used to receive notifications from the IAEA should be continuously operational and frequently monitored.

[a] This should include provisions to monitor and control radiological exposures and contamination, to control other hazards (e.g. heat, air quality) and to meet human needs (e.g. with food, water and sanitary and sleeping arrangements) if the facility may be isolated for an extended period during an emergency.

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Annex

SUPPORTING INFORMATION FOR ZONE SIZES IN APPENDIX II

REACTOR

A–1. For research reactors, owing to the wide variations in their design and operation, a facility specific analysis should be performed to determine whether sufficient inventory and energy could be contained in the reactor to result in a significant airborne release off the site in an accident. The methods described in Ref. [A–1] could be used.

A–2. For facilities in threat category I, calculations [A–2, A–3] were performed on the assumption of core melt and early containment failure.

A–3. For reactors with power levels less than 100 MW(th), calculations on the assumption of average meteorological conditions do not project doses that would lead to any early deaths off the site (>250 m), and thus these reactors fall into threat category II. The calculations were performed by using Refs [A–2, A–3].

A–4. For threat category II, it was assumed the reactor has been operating at this power level sufficiently long to build up the ^{131}I inventory close to 10 PBq/MW(th) [A–2, A–3].

A–5. Severe core damage and therefore a major off-site release is not considered credible for reactors with power levels below 2 MW(th), and thus these reactors fall into threat category III.

SPENT FUEL

A–6. Calculations [A–2, A–3] indicate that people off the site could suffer severe deterministic effects owing to a release resulting from a Zircaloy® fire (an exothermic $Zr + H_2O$ reaction) in a large amount of spent reactor fuel. Such a reaction might be possible in densely stored fuel that has been discharged from a reactor core in the past year. Zircaloy® fires are unlikely unless the fuel in the pool is substantially uncovered [A–4].

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A–7. Calculations [A–2 to A–4] indicate that doses warranting urgent intervention off the site might be possible if a large amount of spent reactor fuel reaches temperatures in excess of 1000°C, resulting in failure of the fuel cladding. Such temperatures are possible only if fuel that is being actively cooled in a pool becomes totally uncovered [A–4].

CRITICALITY

A–8. Calculations [A–2, A–5] show that a criticality farther than about 500 m from the site boundary will not cause shine doses (i.e. doses due to gamma plus neutron radiation) off the site that exceed the recommended GILs for urgent protective actions (i.e. 10 mSv [A–6]). These calculations assume that there is no shielding and a criticality resulting in 1×10^{18} fissions initially, resulting in an effective dose rate from shine (i.e. due to gamma plus neutron radiation) of 1 mGy/h at 0.3 km. It is also assumed that the criticality will continue until there are about 1×10^{19} fissions, resulting in a total off-site dose of 10 mSv. A criticality cannot produce sufficient fission products to result in a significant airborne release. However, the thermal energy (heat) from a criticality may be sufficient to result in a release of radioactive or other hazardous material already present in the vicinity of the criticality (e.g. in the process stream).

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GLOSSARY

accident. Any unintended event, including operating errors, equipment failures or other mishaps, the consequences or potential consequences of which are not negligible from the point of view of protection or safety.

arrangements (for emergency response). The integrated set of infrastructural elements necessary to provide the capability for performing a specified function or task required in response to a nuclear or radiological emergency. These elements may include authorities and responsibilities, organization, coordination, personnel, plans, procedures, facilities, equipment or training.

avertable dose. The dose that could be averted if a countermeasure or set of countermeasures were to be applied.

collective dose. The total radiation dose incurred by a population.

dangerous source. A source that could, if not under control, give rise to exposure sufficient to cause severe deterministic effects. This categorization is used for determining the need for emergency response arrangements and is not to be confused with categorizations of sources for other purposes.

deterministic effect. A health effect of radiation for which generally a threshold level of dose exists above which the severity of the effect is greater for a higher dose. Such an effect is described as a 'severe deterministic effect' if it is fatal or life threatening or results in a permanent injury that reduces quality of life.

emergency. A non-routine situation or event that necessitates prompt action, primarily to mitigate a hazard or adverse consequences for human health and safety, quality of life, property or the environment. This includes nuclear and radiological emergencies and conventional emergencies such as fires, release of hazardous chemicals, storms or earthquakes. It includes situations for which prompt action is warranted to mitigate the effects of a perceived hazard.

emergency action level (EAL). A specific, predetermined, observable criterion used to detect, recognize and determine the emergency class.

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emergency class. A set of conditions that warrant a similar immediate emergency response. This is the term used for communicating to the response organizations and the public the level of response needed. The events that belong to a given emergency class are defined by criteria specific to the installation, source or practice, which if exceeded indicate classification at the prescribed level. For each emergency class, the initial actions of the response organizations are predefined.

emergency classification. The process whereby an authorized official classifies an emergency in order to declare the applicable emergency class. Upon declaration of the emergency class the response organizations initiate the predefined response actions for that emergency class.

emergency phase. The period of time from the detection of conditions warranting an emergency response until the completion of all the actions taken in anticipation of or in response to the radiological conditions expected in the first few months of the emergency. This phase typically ends when the situation is under control, the off-site radiological conditions have been characterized sufficiently well to identify where food restrictions and temporary relocation are required, and all required food restrictions and temporary relocations have been implemented.

emergency plan. A description of the objectives, policy and concept of operations for the response to an emergency and of the structure, authorities and responsibilities for a systematic, coordinated and effective response. The emergency plan serves as the basis for the development of other plans, procedures and checklists.

emergency preparedness. The capability to take actions that will effectively mitigate the consequences of an emergency for human health and safety, quality of life, property and the environment.

emergency procedures. A set of instructions describing in detail the actions to be taken by response personnel in an emergency.

emergency response. The performance of actions to mitigate the consequences of an emergency for human health and safety, quality of life, property and the environment. It may also provide a basis for the resumption of normal social and economic activity.

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emergency services. The local off-site response organizations that are generally available and that perform emergency response functions. These may include police, firefighters and rescue brigades, ambulance services and control teams for hazardous materials.

emergency worker. A worker who may be exposed in excess of occupational dose limits while performing actions to mitigate the consequences of an emergency for human health and safety, quality of life, property and the environment.

emergency zones. The precautionary action zone and/or the urgent protective action planning zone.

exposure. The act or condition of being subject to irradiation. Exposure can be either external exposure (due to a source outside the body) or internal exposure (due to a source within the body).

first responders. The first members of an emergency service to respond at the scene of an emergency.

incident. Any unintended event, including operation errors, equipment failures, initiating events, accident precursors, near misses or other mishaps, or unauthorized act, malicious or non-malicious, the consequences or potential consequences of which are not negligible from the point of view of protection or safety.

initial phase. The period of time from the detection of conditions that warrant the performance of response actions that must be taken promptly in order to be effective until those actions have been completed. These actions include mitigatory actions by the operator and urgent protective actions on and off the site.

intervention. Any action intended to reduce or avert exposure or the likelihood of exposure to sources that are not part of a controlled practice or that are out of control as a consequence of an accident.

intervention level. The level of avertable dose at which a specific protective action is taken in an emergency or a situation of chronic exposure.

longer term protective action. A protective action that is not an urgent protective action. Such protective actions are likely to be prolonged over

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weeks, months or years. These include measures such as relocation, agricultural countermeasures and remedial actions.

mitigatory action. Immediate action by the operator or other party:

(1) To reduce the potential for conditions to develop that would result in exposure or a release of radioactive material requiring emergency actions on or off the site; or
(2) To mitigate source conditions that may result in exposure or a release of radioactive material requiring emergency actions on or off the site.

notification.

(1) A document submitted to the regulatory body by a legal person to notify an intention to carry out a practice or other use of a source;
(2) A report submitted promptly to a national or international authority providing details of an emergency or a possible emergency, for example as required by the Convention on Early Notification of a Nuclear Accident;
(3) A set of actions taken upon detection of emergency conditions with the purpose of alerting all organizations with responsibility for emergency response in the event of such conditions.

notification point. A designated organization with which arrangements have been made to receive notification (meaning (3)) and to initiate promptly the predetermined actions to activate a part of the emergency response.

notifying State. The State that is responsible for notifying (meaning (1)) potentially affected States and the IAEA of an event or situation of actual, potential or perceived radiological significance for other States. This includes:

- The State Party that has jurisdiction or control over the facility or activity (including space objects) in accordance with Article 1 of the Convention on Early Notification of a Nuclear Accident; or
- The State that initially detects, or discovers evidence of, a transnational emergency, for example by detecting significant increases in atmospheric radiation levels of unknown origin; detecting contamination in transboundary shipments; discovering a dangerous source that may have originated in another State; or diagnosing medical symptoms that may have resulted from exposure outside the State.

nuclear or radiological emergency. An emergency in which there is, or is perceived to be, a hazard due to:

(a) the energy resulting from a nuclear chain reaction or from the decay of the products of a chain reaction; or
(b) radiation exposure.

off-site. Outside the site area.

on-site. Within the site area.

operational intervention level (OIL). A calculated level, measured by instruments or determined by laboratory analysis, that corresponds to an intervention level or action level. OILs are typically expressed in terms of dose rates or of activity of radioactive material released, time integrated air concentrations, ground or surface concentrations, or activity concentrations of radionuclides in environmental, food or water samples. An OIL is a type of action level that is used immediately and directly (without further assessment) to determine the appropriate protective actions on the basis of an environmental measurement.

operator (or operating organization). Any organization or person applying for authorization or authorized and/or responsible for nuclear, radiation, radioactive waste or transport safety when undertaking activities or in relation to any nuclear facilities or sources of ionizing radiation. This includes private individuals, governmental bodies, consignors or carriers, licensees, hospitals, self-employed persons, etc. Operator includes either those who are directly in control of a facility or an activity during use of a source (such as radiographers or carriers) or, in the case of a source not under control (such as a lost or illicitly removed source or a re-entering satellite), those who were responsible for the source before control over it was lost.

practice. Any human activity that introduces additional sources of exposure or exposure pathways or extends exposure to additional people or modifies the network of exposure pathways from existing sources, so as to increase the exposure or the likelihood of exposure of people or the number of people exposed.

precautionary action zone. An area around a facility for which arrangements have been made to take urgent protective actions in the event of a nuclear

or radiological emergency to reduce the risk of severe deterministic effects off the site. Protective actions within this area are to be taken before or shortly after a release of radioactive material or an exposure on the basis of the prevailing conditions at the facility.

protective action. An intervention intended to avoid or reduce doses to members of the public in emergencies or situations of chronic exposure.

radiation protection officer. A person technically competent in radiation protection matters relevant for a given type of practice who is designated by the registrant or licensee to oversee the application of relevant requirements established in international safety standards.

radiation specialist. A person trained in radiation protection and other areas of specialization necessary in order to be able to assess radiological conditions, to mitigate radiological consequences or to control doses to responders.

radiological assessor. A person who in the event of a nuclear or radiological emergency assists the operator of a dangerous source by performing radiation surveys, performing dose assessments, controlling contamination, ensuring the radiation protection of emergency workers and formulating recommendations on protective actions. The radiological assessor would generally be the radiation protection officer.

regulatory body. An authority or a system of authorities designated by the government of a State as having legal authority for conducting the regulatory process, including issuing authorizations, and thereby regulating nuclear, radiation, radioactive waste and transport safety.

response organization. An organization designated or otherwise recognized by a State as being responsible for managing or implementing any aspect of an emergency response.

significant transboundary release. A release of radioactive material to the environment that may result in doses or levels of contamination beyond national borders from the release which exceed international intervention levels or action levels for protective actions, including food restrictions and restrictions on commerce.

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site area. A geographical area that contains an authorized facility, activity or source, and within which the management of the authorized facility or activity may directly initiate emergency actions. This is typically the area within the security perimeter fence or other designated property marker. It may also be the controlled area around a radiography source or a cordoned off area established by first responders around a suspected hazard.

source. Anything that may cause radiation exposure — such as by emitting ionizing radiation or by releasing radioactive substances or materials — and can be treated as a single entity for protection and safety purposes. For example, materials emitting radon are sources in the environment; a sterilization gamma irradiation unit is a source for the practice of radiation preservation of food; an X ray unit may be a source for the practice of radiodiagnosis; a nuclear power plant is part of the practice of generating electricity by nuclear fission, and may be regarded as a source (e.g. with respect to discharges to the environment) or as a collection of sources (e.g. for occupational radiation protection purposes). A complex or multiple installation situated at one location or site may, as appropriate, be considered a single source for the purposes of application of international safety standards.

special facility. A facility for which predetermined facility specific actions need to be taken if urgent protective actions are ordered in its locality in the event of a nuclear or radiological emergency. Examples include chemical plants that cannot be evacuated until certain actions have been taken to prevent fire or explosions and telecommunications centres that must be staffed in order to maintain telephone services.

special population groups. Members of the public for whom special arrangements are necessary in order for effective protective actions to be taken in the event of a nuclear or radiological emergency. Examples include disabled persons, hospital patients and prisoners.

stochastic effect (of radiation). A radiation induced health effect, the probability of occurrence of which is greater for a higher radiation dose and the severity of which (if it occurs) is independent of dose. Stochastic effects may be somatic effects or hereditary effects, and generally occur without a threshold level of dose. Examples include various forms of cancer and leukaemia.

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threat assessment. The process of analysing systematically the hazards associated with facilities, activities or sources within or beyond the borders of a State in order to identify:

(a) Those events and the associated areas for which protective actions may be required within the State;
(b) The actions that would be effective in mitigating the consequences of such events.

transnational emergency. A nuclear or radiological emergency of actual, potential or perceived radiological significance for more than one State. This includes:

(1) A significant transboundary release of radioactive material (however, a transnational emergency does not necessarily imply a significant transboundary release of radioactive material);
(2) A general emergency at a facility or other event that could result in a significant transboundary release (atmospheric or aquatic) of radioactive material;
(3) Discovery of the loss or illicit removal of a dangerous source that has been transported across or is suspected of having been transported across a national border;
(4) An emergency resulting in significant disruption to international trade or travel;
(5) An emergency warranting the taking of protective actions for foreign nationals or embassies in the State in which it occurs;
(6) An emergency resulting in or potentially resulting in severe deterministic effects and involving a fault and/or problem (such as in equipment or software) that could have implications for safety internationally;
(7) An emergency resulting in or potentially resulting in great concern among the population of more than one State owing to the actual or perceived radiological hazard.

urgent protective action. A protective action in the event of an emergency which must be taken promptly (normally within hours) in order to be effective, and the effectiveness of which will be markedly reduced if it is delayed. The most commonly considered urgent protective actions in a nuclear or radiological emergency are evacuation, decontamination of individuals, sheltering, respiratory protection, iodine prophylaxis and restriction of the consumption of potentially contaminated foodstuffs.

urgent protective action planning zone. An area around a facility for which arrangements have been made to take urgent protective actions in the event of a nuclear or radiological emergency to avert doses off the site in accordance with international safety standards. Protective actions within this area are to be taken on the basis of environmental monitoring or, as appropriate, prevailing conditions at the facility.

warning point. A contact point that is staffed or able to be alerted at all times for promptly responding to, or initiating a response to, an incoming notification (meaning (2)), warning message, request for assistance or request for verification of a message, as appropriate, from the IAEA.

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Evaluating Environmental Protection and Emergency Preparedness at the Pickering Nuclear Generating Station (Ref. 2018-H-03)

The Canadian Environmental Law Association's Submission to the Canadian Nuclear Safety Commission

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SUMMARY OF RECOMMENDATIONS

RECOMMENDATION NO. 1: To facilitate restoring the public's trust in the Commission, CELA recommends: (1) the CNSC publicly review the findings of federal expert panel tasked with restoring the public's trust in Canada's environmental assessment authorities, (2) ensure all documents and information considered by the CNSC are publicly available online and 'searchable', and (3) the CNSC provide justification, transparency and intelligibility of reasons in their Record of Decisions.

RECOMMENDATION NO. 2: OPG and CNSC must clearly demonstrate to Ontarians – through adequate documentation in the licence application submissions – that financial plans are in place to (1) safeguard the affordability of electricity for Ontarians throughout the lifetime of the plant, and (2) provide financial assurances for the actual costs of continued operation, maintenance, decommissioning, waste management and long term care.

RECOMMENDATION NO. 3: The CNSC and responsible authorities must require OPG to undertake greenhouse gas (GHG) emissions accounting, GHG monitoring, and GHG emissions reduction planning in order to consider the entire nuclear process chain, from cradle to grave.

RECOMMENDATION NO. 4: OPG's Pickering NGS PROL renewal application and all future licence applications for nuclear power generation and nuclear waste management projects should be evaluated under a reformed CEAA that provides the basis for an appropriately rigorous approach to the consideration of need and alternatives, among other critical considerations. As Gibson et al. (2016, pp. 5-10) have asserted, crucial components of an appropriately rigorous approach to EA would embrace sustainability in all aspects and require attention to

- the purposes of and need for the undertaking (with both purposes and need related to the lasting public interest)
- development and application of broad but comprehensive sustainability-based criteria for evaluations and decisions (see next section);
- emphasis on comprehensive and integrated attention to all factors affecting the long term as well as immediate desirability and durability of effects;
- comparative evaluation of potentially reasonable alternatives to identify best options for each undertaking, to move cumulatively to more sustainable practice; and
- application of case-specified sustainability-based purposes and criteria as the main structure for deliberations and decisions at all process stages for subject undertakings from initial identification of appropriate purposes and options (alternatives) to final deliberations on renewal, closure, decommissioning and continued management.

RECOMMENDATION NO. 5: In the interests of public access to information, all licence documents, including all supplementary studies/reports, must be conveniently accessible

through a public registry, with sufficient time allowed for participant review between posting and deadlines for public submissions.

RECOMMENDATION NO. 6: OPG must develop a transition plan to mitigate the adverse socioeconomic impacts of shutting down Pickering's reactor units on workers, families, and surrounding communities. This transition plan must be informed by best practices for just transition planning that maintains and enhances livelihood sufficiency and community economic wellbeing, and it must consider the larger transition of the electric power system to renewable technologies.

RECOMMENDATION NO. 7: The CNSC commissioners should require CNSC staff to exercise its authority under paragraph 3(1.1)(b) of the *General Nuclear Safety and Control Regulations* to require CNSC staff to undertake a comprehensive "need for", "alternative to", and "alternative means" analysis utilizing the best available scientific information and methods, Indigenous knowledge, and public consultation as part of the EA of the Pickering NGS PROL renewal application and all subsequent EA's under the NSCA. In the absence of this analysis, the Commissioner's should find that need for the Pickering renewal and life extension is not demonstrated.

RECOMMENDATION NO. 8: The CNSC should deny OPG's application to renew the Pickering NGS beyond the expiration of its PROL on August 31, 2018. The lack for an adequate "need for" the continued operation of the Pickering NGS; the history of poor performance and the increased risks to the public; the cost of its continued operation and decommissioning; and the existence of adequate "alternatives to" the nuclear facilities generation of electricity; coupled with the lack of any compelling evidence provided by OPG to extend the PROL beyond its current end date, demonstrates that the proposal to renew the PROL does not make adequate provision for the protection of the environment and the health and safety of persons – a condition for licencing under the NSCA.

RECOMMENDATION NO. 9: The CNSC should require, at a minimum, that decommissioning strategies are well documented and include a description of the options, the overall timescales for the decommissioning of a facility and the end state after completion of all decommissioning actions. The reasons for choosing the preferred option should be explained and justified in comparison to other feasible strategies based on the best available scientific information and methods, after public consultation, and require that no undue burdens be imposed on future generations.

RECOMMENDATION NO. 10: In anticipation of decommissioning the Pickering NGS, the CNSC should require OPG to develop a DDP as soon as possible. The development of the DDP must include meaningful participation of the public at the earliest possible opportunity, to ensure the DDP has a sound evidentiary basis and is publicly acceptable. The DDP should be sufficiently detailed to allow the evaluation of the licensee's justification and plans for, amongst others,

adaptive management and environmental monitoring, site remediation and end-use, costs and feasibility, cumulative effects, long-term waste management, security, and public safety.

RECOMMENDATION NO. 11: The CNSC should exercise its authority under paragraph 3(1.1)(b) of the *General Nuclear Safety and Control Regulations*, to compel OPG to undertake an "alternative means" analysis that utilizes the best available up-to-date science and methods, and input from the public and Indigenous communities. The analysis must demonstrate that the preferred strategy will ensure the Pickering NGS will be maintained in a safe configuration at all times, will reach the specified decommissioning end state, that no undue burdens will be imposed on future generations, and is acceptable to the public and Indigenous communities.

RECOMMENDATION NO. 12: Pickering NGS's emergency management licensing basis, RegDoc 2.10.1 Version 1 (2014) predates the IAEA's most recent standard on radiological emergencies, GSR-7. CELA recommends Pickering NGS's licensing basis be updated to reference RegDoc 2.10.1, Version 2 (2016), which is current with IAEA GSR-7. All Licence Condition Handbooks proposed by the CNSC should, at a minimum, be current with international guidance and standards at the time of licensing.

RECOMMENDATION NO. 13: CELA recommends the CNSC require the expansion of Ontario's nuclear emergency planning zones. First, the Contingency Planning Zone (20 km) must require the same level detailed arrangements and pre-planned protective measures as the Automatic Action Zone (3 km) or Detailed Planning Zone (10 km). Secondly, the current CPZ boundary should be re-evaluated based on better modelling and at a minimum, require a 20 km evacuation zone.

RECOMMENDATION NO. 14: CELA recommends that the Commission publicly review the PNERP's Technical Study on emergency planning zone sizes and its implications for all nuclear power plant licensees' on-site and off-site emergency planning arrangements. CELA recommends any further PNERP technical studies and findings be publicly reviewed by the Commission on an annual basis.

RECOMMENDATION NO. 15: CELA recommends the CNSC require the expansion of Ingestion Planning Zone to 100 km and include the additional requirement that all municipalities within this zone maintain nuclear emergency response plans.

RECOMMENDATION NO. 16: CELA recommends that the CNSC require robust evidence demonstrating that residents in the DPZ and CPZ zone have awareness of emergency planning procedures. Absent this level of knowledge, the Pickering NGS should not be operated beyond its current licencing period.

RECOMMENDATION NO. 17: Public notification and response systems must be tested and operable within the DPZ and CPZ and not limited to the immediate 10 km zone. Public alerting utilizing multiple communication methods must also be in place to a distance of 100 km.

RECOMMENDATION NO. 18: The CNSC must have evidence demonstrating that in the event of a radiological emergency, the provincial Alert Ready system can be promptly activated. The CNSC should request OPG to provide an update on its Alert Ready pilot project.

RECOMMENDATION NO. 19: We continue to encourage the CNSC to require licencees to provide KI by way of pre-distribution within a 50 km radius, and pre-stock to 100 km. In accordance with international best practice, the CNSC should extend KI stockpiles to 100 km and ensure stockpiles at places frequented by vulnerable groups, such as children and pregnant women, are maintained.

RECOMMENDATION NO. 20: Given the dense population within 50 kilometres of the Pickering NGS and children's particular vulnerability to radiation, we recommend the pre-stocking of KI in all schools within the 50 km zone be made a condition of licensing.

RECOMMENDATION NO. 21: CELA recommends that the CNSC require OPG to disseminate information on a more frequent basis, about the online KI-pill ordering website PrepareToBeSafe.ca in its outreach material to the public.

RECOMMENDATION NO. 22: We recommend the CNSC review the adequacy of medical care that could be provided during an evacuation. The CNSC should inquire if medical facilities within the DPZ and CPZ have long-distance, nuclear disaster-specific evacuation plans, and whether these plans have been practiced on a full-scale.

RECOMMENDATION NO. 23: CELA recommends the CNSC refuse the further extension of the Pickering's operating licence on the basis that medical response and evacuation are not detailed and operational beyond the 10 km DPZ. Detailed planning which is fully functional, and has been fully tested for efficacy, must be required within the CPZ.

RECOMMENDATION NO. 24: CELA recommends the CNSC extend detailed planning for large-scale evacuations into the IPZ. The CNSC should require OPG to demonstrate the adequacy of detailed planning within an expanded DPZ and IPZ, including planning for any schools, retirement homes, daycares, hospitals and correctional facilities in these areas. These plans should be communicated publicly.

RECOMMENDATION NO. 25: The CNSC should require OPG to update its Evacuation Time Estimate Report to reflect recent population objectives and growth trends in line with Ontario's Growth Plan (2017). The updated ETE should also review the impact of increased evacuation zones at a radial distance of 50 km on locations of Emergency Workers Centres, numbers of

emergency workers required for evacuation management, traffic routes, size of evacuation centres, and locations and capacity of Decontamination and Monitoring Units. These findings should be reported to the CNSC and publicly reviewed.

RECOMMENDATION NO. 26: The CNSC should require OPG's public awareness program to contain more detailed information about evacuation routes, the location of emergency shelters and decontamination centres and how vulnerable people, including seniors and children, will be protected.

RECOMMENDATION NO. 27: The CNSC should inquire as to the availability of decontamination centres and whether the public is aware of their use and location.

RECOMMENDATION NO. 28: The CNSC should require OPG's public awareness program to contain information on how to self-decontaminate in order to foster great awarnesss of this default protective measure.

RECOMMENDATION NO. 29: Methods to review risks and obtain consent from workers to exceed maximum radiation exposure limits should be explicitly clarified in plans by the operator as a condition of licensing.

RECOMMENDATION NO. 30: The IPZ should be extended to 100 km to account for weather contingencies and the aerial dispersion of radionuclides beyond 50 km.

RECOMMENDATION NO. 31: The CNSC should require proof of adequate contingency planning for the protection of drinking water in the event of an emergency as a requirement for licensing. The CNSC ensure that provisions are in place for an alternative source of drinking water for residents whose current drinking water source is Lake Ontario.

1. Introduction

The Canadian Environmental Law Association (CELA) submits this report in response to the Public Notice dated September 29, 2017[1] requesting comments on the application from Ontario Power Generation (OPG) to renew its Nuclear Power Reactor Operating Licence for a period of 10 years, commencing September 1, 2018.[2]

1.1 Interest and Expertise of the Intervenor

CELA is a non-profit, public interest law organization. For nearly 50 years, CELA has used legal tools to advance the public interest, through advocacy and law reform, in order to increase environmental protection and safeguard communities across Canada. CELA is funded by Legal Aid Ontario as a speciality legal clinic, to provide equitable access to justice to those otherwise unable to afford representation.

CELA has engaged in detailed research and advocacy related to the improvement of public safety and environmental protection by seeking improvements to nuclear emergency preparedness. Our documented history and collection which reviews the sufficiency of emergency preparedness in the context of nuclear power plant relicensing is publicly available on our website.[3] CELA has also been actively involved in discussions and consultations regarding the Province of Ontario's revised Provincial Nuclear Emergency Response Plan.[4]

1.2 Background

The Pickering Nuclear Generating Station (NGS) is located on the north shore of Lake Ontario, in the City of Pickering in the regional municipality of Durham, Ontario. The facility lies 32 km northeast of downtown Toronto and 21 km southwest of Oshawa. The facility is owned and operated by Ontario Power Generation Incorporated (OPG). The Pickering facility consists of eight nuclear reactors, Units 1 - 4 (Pickering A) and Units 5 - 8 (Pickering B). Six of the reactors are operational (Units 1 and 4, and Units 5 - 8) while two (Units 2 and 3) have been placed in a safe storage state.[5]

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[1] Canadian Nuclear Safety Commission, "Notice of Public Haring and Participant Funding (Ref. 2018-H-03)" (29 Sept 2017), online: http://nuclearsafety.gc.ca/eng/the-commission/pdf/NoticePublicHearingPFP-2018-H-03-OPG-Pickering-e.pdf

[2] Ontario Power Generation, "Application for Renewal of Pickering Nuclear Generating Station Power Reactor Operating Licence" (28 August 2017) **[Licence Application]**

[3] Canadian Environmental Law Association, "Publications: Emergency Planning around Canadian Nuclear Plants," online: http://www.cela.ca/test-emergency-planning-around-canadian-nuclear-plants

[4] CELA, "Re: Discussion Paper on Planning Basis Review and Recommendations and List of Proposed Changes to the PNERP 2009" (28 July 2017), online: http://www.cela.ca/sites/cela.ca/files/EmergencyPlg.pdf

[5] Canadian Nuclear Safety Commission, "CMD 18-H6: A Licence Renewal – Ontario Power Generation Inc. Pickering Nuclear Generating Station," (5 March 2018), p 1 **[CNSC CMD]**

On August 28, 2017, OPG requested a ten-year renewal (from September 1, 2018, to August 31, 2028) for the Pickering NGS Power Reactor Operating Licence, PROL 48.03/2018.[6] The current power reactor operating licence for Pickering NGS expires on August 31, 2018.

OPG has also requested approval to operate up to 295,000 Effective Full Power Hours (EFPH), beyond the current approved limit of 247,000 EFPH, which corresponds with the requested end of commercial operation (ECO) date of December 31, 2024. As OPG has signalled its intent to cease commercial operation of Pickering NGS on December 31, 2024,[7] the licence period from September 1, 2018, to August 31, 2028, will cover three phases of operational activities: continued commercial operation ending December 31, 2024; a stabilization phase (post-shutdown defueling and dewatering) lasting approximately 3-4 years; and the beginning of safe storage for Units 1, 4 and 5-8 in 2028.[8] Following which, OPG will presumably file an application to decommission the NGS. There is no assurance, however, that OPG will not once again request an extension of the PROL for a nuclear facility that, by 2028, will be close to 60 years old.

This renewal application marks the second request by OPG to extend the Pickering NGS operating licence beyond its design life. On July 4 and August 31, 2012, OPG applied to renew the Pickering NGS PROL for a 5-year period ending in December 2020. As 2020 was beyond the assumed design life of certain operational parts in the PNGS, especially the pressure tubes, OPG was required to demonstrate that the Pickering NGS could be operated safely until the end of 2020. The CNSC renewed the OPG PROL for Pickering on August 9, 2013, valid to August 31, 2018, but imposed hold points to review additional safety information from OPG about the ability of the pressure tubes and other components to withstand longer operations. The hold-points were removed in 2014.

The Pickering NGS reactors are the oldest operating nuclear power reactors in Canada. The original Pickering Generating Station licence application to operate Unit 1 was submitted to the CNSC's predecessor, the Atomic Energy Control Board on August 14, 1970; the construction permit was issued February 24, 1966. The original application to operate Unit 5 was submitted to the then Atomic Energy Control Board on May 6, 1980; the original construction permit had been issued July 19, 1974.[9]

As Canada's oldest operating nuclear power reactor, the Pickering NGS has had a history of poor performance and created a risk to the public. It has also been plagued by substantial operating costs while producing energy that is not needed in the face of much more feasible alternative sources of power. This has left OPG with no rational basis to establish that it will be able make

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[6] Licence Application, *supra* note 2, p 1.
[7] OPG Letter, R. Lockwood to G. Frappier, "End Date of Commercial Operations for Pickering NGS", (June 28, 2017), CD# P-CORR-00531-04930, e-Doc 5290277
[8] CNSC CMD, *supra* note 5, p 1.
[9] Canadian Environmental Law Association, "Emergency Planning at Pickering NGS - Submission to the CNSC," (May 3, 2013), online: http://www.cela.ca/sites/cela.ca/files/899PickeringEmergencyPlanning.pdf

adequate provision for the protection of the environment and the health and safety of persons if it were to be granted a renewal of the Pickering NGS PROL for operation beyond its current end date. For this and the reasons outlined below, CELA requests the CNSC deny OPG's application to renew the Pickering NGS beyond the expiration of its PROL on August 31, 2018.

1.3 Scope of Review

This report aims to review the whether, per section 24(4) of the *Nuclear Safety and Control Act,* the CNSC has the requisite basis to find the applicant will, in carry on the proposed licence activity, make adequate provisions for the protection of the environment and health and safety of persons.[10] Preliminary matters are reviewed in Section 2 of this report, Sections 3 – 6 review the sufficiency of OPG's licence application and CNSC Staff's CMD as its relates to sustainability, environmental assessment and emergency preparedness and planning, respectively, and Section 7 summarizes our findings and outlines our requested order from the Commission.

2. Preliminary Matters

2.1 Restoring Public Trust

CELA seeks to respond to the issue of public trust which was raised during Day 1 of the Pickering NGS hearing on April 4, 2018. As raised by Commissioner Velshi, the CNSC sought feedback from CNSC Staff and provincial authorities on "building [public] trust and confidence" and specifically, sought suggestions on how it "could be addressed in a more proactive way."[11] The Office of the Fire Marshall and Emergency Management (OFMEM), who was in attendance for Day 1, responded that "it's one that we struggle with on a daily basis" and CNSC Staff echoed, "it is a very difficult problem."[12]

As a starting point, CELA provides the following comments in response to this discussion:

1. The CNSC should publicly review the findings of federal expert panel tasked with restoring the public's trust in Canada's environmental assessment authorities (of which the CNSC is one) and adopt the panel's recommendations.[13] As the expert panel's final report notes, "The apprehension of bias or conflict of interest, whether real or not, was the single most often cited concern by participants with regard to the … CNSC."[14]

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[10] *Nuclear Safety and Control Act,* SC 1997, c 9 **[NSCA]**

[11] CNSC Member Velshi, Webcast - Pickering Hearing Day 1 April 4, 2018.

[12] *Ibid*

[13] Report of the Expert Panel for the Review of Environmental Assessment Processes, "Building Common Ground - A New Vision for Impact Assessment in Canada" (2017) online: https://www.canada.ca/content/dam/themes/environment/conservation/environmental-reviews/building-common-ground/building-common-ground.pdf **[EA Panel Report]**

[14] EA Panel Report, *supra* note 13, p 49

2. All documents and information considered by the CNSC should be publicly available online and 'searchable'. Each party to the hearing, which includes public intervenors, is entitled to be informed of and to make presentations with respect to the evidence which affects the disposition of the CNSC's decision. Material documents before the CNSC must be equally as accessible to public intervenors and, publicly available at the time when the notice of public hearing is released.

3. The CNSC in its Records of Decision, should give full reasons that provide justification, transparency and intelligibility of reasons,[15] and foster better decision-making by ensuring the depth of analysis is commensurate to the complexity of issues being decided.[16]

CELA has previously provided comments to the Commission on ways it could facilitate public trust. This includes our submissions on the following recent CNSC matters:

- Bruce Power licence renewal (Ref. 2018-H-02), "The Role of the Commission – Regaining the Public's Trust"[17]
- Chalk River Laboratories licence renewal (Ref. 2018-H-01), "Using CSA-Standards as Part of Licensing Basis Significantly Reduces Public Access"[18]
- Regulatory Oversight Report for Uranium and Nuclear Substance Processing Facilities in Canada – 2016, "Public Information and Disclosure"
- Consultation on Draft RegDoc 3.2.1, "Scope of Public Information and Disclosure"[19]

RECOMMENDATION NO. 1: To facilitate restoring the public's trust in the Commission, CELA recommends: (1) the CNSC publicly review the findings of federal expert panel tasked with restoring the public's trust in Canada's environmental assessment authorities, (2) ensure all documents and information considered by the CNSC are publicly available online and 'searchable', and (3) the CNSC provide justification, transparency and intelligibility of reasons in their Record of Decisions.

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[15] Report of the Expert Panel on the Modernization of the National Energy Board, "Forward Together: Enabling Canada's Clean, Safe, and Secure Energy Future: Volume II" (2017) online: https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/pdf/NEB-Modernization-Annex-EN-WebReady.pdf, p 200

[16] *Kane v Board of Governors (University of British Columbia)*, [1980] 1 SCR 1105, pp 1115-1116; *Pfizer Co v Canada (Deputy Minister of National Revenue, Customs and Excise)*, [1977] 1 SCR 456, p 463.

[17] CELA, "Bruce Power's Proposed Life Extension and Refurbishment: Evaluation Emergency Preparedness and Environmental Protection," (16 April 2018), online: http://www.cela.ca/sites/cela.ca/files/1185LicRenBrucePwr.pdf

[18] CELA, "CNL Site Licence Renewal Application for Chalk River Laboratories Ref 2018-H-01," (11 December 2017), online: http://www.cela.ca/CELASubmissionstoCanadianNuclearSafetyCommission

[19] CELA, "Consultation on Draft RegDoc 3.2.1 Public Information and Disclosure," (28 September 2017), online: http://www.cela.ca/CELAcommentsonREGDOC3.2.1

2.2 Anonymous Email

CELA also seeks to make the Commission aware of an encrypted email received April 30, 2018, by an anonymous engineer working for a nuclear service supplier. While CELA is not seeking the opportunity to comment on the email's contents, we have provided this email to the Commission under separate cover.

As Canada's nuclear regulator we believe it is within the CNSC's public interest mandate to consider the issues raised by the anonymous individual. Furthermore, as a public interest, legal-aid funded clinic, it is also within CELA's mandate that the views of the public, and concerns of transparency be considered within the CNSC's decision-making process.

3. Sustainability Analysis of OPG's Licence Application

3.1 Introduction

This section presents CELA's analysis of Ontario Power Generation's (OPG) consideration of sustainability in its August 2017 *Pickering Nuclear Generating Station (NGS) Power Reactor Operating Licence Application (PROL),* as well as the Canadian Nuclear Safety Commission's (CNSC) Environmental Assessment (EA) of OPG's licence application as per the requirements of the *Nuclear Safety and Control Act* (NSCA) and associated regulations.

The CNSC regulatory document REGDOC-2.9.1, "Environmental Protection: Environmental Principles, Assessments and Protection Measures" states that the licensee's application shall demonstrate that their environmental protection measures respect the concept of sustainable development.[20] In Section 3.2 of this report, we explain how OPG and the CNSC should have incorporated a consideration of sustainability in the Pickering NGS PROL renewal application process, and we set out the major generic and context-specific sustainability concerns that should have been addressed.

In Section 3.3 we discuss the findings of our analysis with respect to five critical sustainability issues that remain unaddressed by OPG and the CNSC:

- Costs to future generations,
- GHG emissions,
- Consideration of need and alternatives,
- Public participation process, and
- Transition planning.

[20] CNSC, "RegDoc-2.9.1 Environmental Protection: Environmental Principles, Assessments and Protection Measures: Version 1.1," (April 2017).

In Section 3.4, we summarize our findings and recommendations for the decision on OPG's Pickering NGS PROL renewal application.

3.2 The Basics of Sustainability-Based Planning and Analysis

It should be noted that REGDOC-2.9.1 is very brief and insufficiently helpful on the key matter of how to specify and apply sustainability in analysis in order to ensure that nuclear projects make positive overall contributions to community wellbeing. Expansions and revisions are needed to clarify the obligations of the licencee, and to guide other participants in this and other application processes. This need for clarification is underscored by the failure to recognize and incorporate some basic implications of the concept of sustainable development in REGDOC-2.9.1. Three key adjustments are needed:

- Elaboration of the main generic sustainability implications for studies and reporting, particularly with regard to frameworks and criteria for evaluation of effects and options;
- Addition of requirements for specifying the frameworks and criteria to recognize the particular context and concerns for each project for which an application is prepared; and
- Revisions to ensure that guidance on other matters is consistent with the commitment to sustainability (see Gibson & Markvart, 2008).

In contrast to REGDOC-2.9.1, some clarification of the implications of incorporating sustainability concerns in analysis has been provided in previous panel review processes under the Canadian Environmental Assessment Act, specifically by the parties establishing Terms of Reference for assessment review panels, and by the panels themselves. Of particular importance have been the following documents:

- Voisey's Bay Mine and Mill Environmental Assessment Panel, "Environmental Impact Statement Guidelines for the Review of the Voisey's Bay Mine and Mill Undertaking" (20 June 1997), and *Environmental Assessment Panel Report on the Proposed Voisey's Bay Mine and Mill Project* (March 1999);
- Mackenzie Gas Project Joint Review Panel, "Joint Review Panel determination on sufficiency," (18 July 2005), and the panel's final report, "Mackenzie Gas Joint Review Panel, *Foundations for a Sustainable Northern Future: Report of the Joint Review Panel for the Mackenzie Gas Project,* CEAA 2009";
- Kemess North Copper-Gold Mine Project Joint Review Panel, *Joint Review Panel Report* (September 17, 2007), especially pages 233-241 on the panel's sustainability framework and its application; and
- White's Point Quarry and Marine Terminal Project Joint Review Panel, "Environmental Impact Statement Guidelines" (March 2005) and *Joint Review Panel Report* (October 2007).

Markvart (2014), Gaudreau et al., (2013), Gibson and Markvart (2008), and Gibson et al., (2008) illustrate how the sustainability test should be incorporated in assessments of nuclear energy and other energy projects specifically. Gibson (2005, 2017) and other experts in the field of sustainability-based environmental assessment provide further elaboration, including on

specification of sustainability criteria for case and context in particular applications (see Pope et al., 2004; Morrison-Saunders & Pope, 2013; Dalal-Clayton and Sadler, 2014; Markvart, 2015).

3.2.1 Generic Sustainability Evaluation Criteria

The generic requirements for progress towards sustainability have been set out in many ways, and many different frameworks have been proposed and applied (see Markvart, 2015). In this report, we use Gibson's (2005, 2017) generic sustainability assessment criteria, which are based on a synthesis of insights from the sustainability literature and applied sustainability experiences as well as from a review of applied sustainability assessment criteria (see Appendix A). Briefly, they devote attention to:

- the capacity of natural systems to maintain their structure and functions and to support biological diversity and productivity;
- the capacity of social and economic systems to deliver opportunities and sufficiency, and to achieve, maintain or enhance conditions of self-reliance and diversity;
- the capacity of human environments, including local and regional institutions, to respond to and manage externally induced change;
- the attainment and distribution of lasting and equitable social and economic benefits and openings to participate meaningfully in decision making;
- the rights of future generations to the sustainable use of renewable resources; and
- the protection and conservation of wildlife and the environment for present and future generations (see Gibson & Markvart, 2008).

These criteria are a package in that all of the requirements are necessary for sustainability, and positive gains in all areas must be achieved. Efforts to meet the various requirements for sustainability – to strengthen ecological stewardship and sustainable livelihoods and informed citizen engagement and energy/material efficiencies and equitable distribution of benefits and risks, etc., are mutually reinforcing. Consequently the aim of sustainability-based planning and decision making is not to balance these requirements as competing ends but rather to integrate and pursue them jointly, aiming for mutually reinforcing gains.

3.2.2 Specification of Generic Sustainability Evaluation Criteria

For practical considerations, it is necessary to specify the generic evaluation criteria in order to recognize the particular concerns and possibilities raised by case- and context-specific factors. This specification step ensures proper sensitivity to the factors that may affect how the generic requirements for sustainability can be pursued over the long term. The factors include particular conditions and trends, resources, capacities and other assets, opportunities and barriers, concerns and aspirations, stresses and vulnerabilities. All of these vary more or less significantly among different cultures, ecosystems, jurisdictions and sectors, etc. And all of them involve a particular mix of considerations at various interrelated scales from the global to the local.

Once the generic sustainability requirements are recognized and the case- and context-specific concerns have been identified, the next step is to consolidate them into one coherent and comprehensive set of criteria. In Table 1, below, we provide an example of Gibson's generic sustainability criteria, specified for the context of nuclear energy generation projects. Note that the table may not be comprehensive of all concerns that OPG should have considered in its Pickering NGS PROL renewal application. Also note that Table 1 considers all phases of nuclear power generation (uranium mining, uranium refining, conversion, and fuel fabrication, nuclear plant operation, and waste fuel management).

Table 1. Sustainability Evaluation Criteria for Nuclear Energy Generation Projects

Sustainability Criteria	**Nuclear Energy Generation-Specific Sustainability Concerns**
Socio-Ecological System Integrity **Resource Maintenance and Efficiency**	• Potential long term contamination from radioactivity and radionuclides (alpha, beta, neutron particles, gamma rays, isotopes produced in uranium mining and milling, fuel production and nuclear power plant operations) • Insufficiently low standards for cancer risk arising from radiological hazards, with greatest risks to women and young children • Low-, intermediate-, and high-level, long-lived radioactive wastes from nuclear energy generation • Generation and release of hazardous contaminants (arsenic, cadmium, chromium, lead, mercury, nickel, selenium, uranium, molybdenum dioxins and furans, hexachlorobenzene, asbestos, hydrazine, ammonia, hydrogen fluoride, hydrogen sulphide) • Nutrients generated in nuclear energy generation (excessive phosphorous, nitrate) • Air pollutants generated in uranium mining, milling, fuel production, plant operations (sulphur and nitrogen oxides, particulate matter, volatile organic compounds) • Volatile organic compounds • Greenhouse gases generated in uranium mining, milling, transportation, fuel production, plan operations (carbon dioxide, nitrous oxide, ozone, methane, hydrofluorocarbons, perfluorocarbons, water vapour) • Landscape disturbances from construction, mining, processing, energy production, waste management, decommissioning, removal of large amounts of surface water • Occupational health and safety risks associated with mining, industrial processes, plant operations, decommissioning • Higher radiation dose limits for nuclear energy workers vs. the general public • Community-scale exposure to routine and accidental releases of radiation, radionuclides, conventional pollutants from nuclear facilities • Generation of excess energy • Energy supply diversity/resilience vs. reliance on nuclear energy generation for baseload supply • Relative economic efficiencies, considering full costs through the lifecycle, in comparison with other options

Livelihood Sufficiency and Opportunity **Intragenerational Equity** **Intergenerational Equity**	• Costs of nuclear energy generation facility construction and decommissioning • Fuel costs to public • Nuclear energy generation facility performance, reliability and maintenance costs • Costs to public of nuclear waste management • Costs to public of accidents, malfunctions, malevolent acts • Boom and bust effects of nuclear energy generation (loss of jobs and livelihoods over the course of different phases of nuclear energy generation) • Impacts of uranium mining on Indigenous way of life
Socio-Ecological Civility and Democratic Governance	• Security and weapons proliferation • Long-term security of fuel supplies and fuel costs • Capacity to plan for long-term nuclear waste management • Capacity to undertake long-term monitoring of nuclear wastes • Capacity to manage, safely store, and pass along vital information to future generations • Capacity to deal with unplanned releases, catastrophic accidents, malfunctions, malevolent acts • Capacity for emergency planning and response • Reliance on nuclear energy generation and a centralized grid design, which excludes renewable energy sources • Capacity to implement open, inclusive, transparent public decision-making processes • Capacity to provide easily accessible, relevant information to the public • Capacity to educate public on nuclear accident emergency planning, including potassium iodide uptake
Precaution and Adaptation	• Need for comprehensive emergency planning • Need to distribute iodide tablets • Redundancy and retrievability in design • Inflexibility of nuclear-based electricity energy systems • Need for long-term precautionary management of nuclear generation facilities and nuclear waste facilities, and associated electricity energy systems

(Winfield et al., 2006; Thompson, 2008; Clean Air Alliance, 2018)

3.2.3 Application in Planning and Analysis

The sustainability objective and criteria should inform all steps and deliberations in the planning process, including but not limited to the following:

- how the particular purposes of the undertaking should be understood from the perspective of sustainability;
- how interested stakeholders are to be engaged in the planning process, including how different perspectives can be accommodated;
- what planning options and components (technologies, programs, etc.) should be examined, and how alternative system options should be elaborated and subjected to comparative evaluation;

- what possible effects (direct, indirect, cumulative effects) deserve detailed attention;
- which effects are likely to be most significant, given sustainability objectives;
- what important opportunities or perils need attention;
- how anticipated positive effects could be enhanced and how adverse effects and risks could be mitigated;
- the strengths and limitations of each system component, including interconnections;
- what specifics are needed in the plan, and/or what arrangements are needed for subsidiary and subsequent deliberations and decisions to ensure proper consideration of purposes, alternatives, effects, mitigation and enhancement options, trade-offs, etc. in light of the sustainability objective and criteria;
- whether and under what terms and conditions the proposed plan should be approved;
- what monitoring and adaptive response requirements are imposed; and
- what preparations by various parties are necessary and desirable to ensure that negative effects are avoided or mitigated, that unanticipated effects are identified and addressed quickly, that subsidiary planning and project development proceeds appropriately, that the plan is reviewed and revised regularly, that maximum mutually reinforcing gains are achieved and that significant adverse effects are avoided (see Gibson & Markvart, 2008).

3.3. Findings of Our Analysis

OPG's Pickering NGS PROL renewal application, including its Environmental Risk Assessment, Predictive Effects Assessment, and the CNSC's EA review of these and other studies, did not incorporate the concept of sustainability as an explicit consideration in planning and analysis. In the paragraphs that follow we briefly discuss critical gaps in OPG's and CNSC's analysis with respect to the implications of the PROL application on the following key sustainability concerns:

- Costs to future generations,
- GHG emissions,
- Consideration of need and alternatives,
- Public participation process, and
- Transition planning.

3.3.1 Costs to Future Generations

OPG and the CNSC did not provide a much-needed discussion about the transfer of financial burdens to future generations of the high costs of continued operation and maintenance of all Pickering reactor units until 2024, including the costs associated with stabilization, decommissioning, site restoration, and radioactive waste management. The financial costs of uranium mining, including remediation, should also be considered in cost estimates of the nuclear energy generation life cycle (Winfield et al., 2006).

Pickering has a history of having the highest operating costs of any nuclear facility in North America (see Spears, 2012; Clean Air Alliance, 2016; Laszlo, 2017). As Spears reported in 2012, Pickering A's cost per megawatt hour was almost triple the industry median, and Pickering B's costs were nearly double the industry standard. In 2014, Pickering's fuel and operating costs were more than double the average market price of electricity. Consequently, Ontario's Electricity System Operator provided OPG with payments totaling $912 million to subsidize Pickering's operating deficit (see Clean Air Alliance, 2016).

Indeed, to keep the Pickering units running until 2024, OPG has asked the Ontario Energy Board for permission to raise the price of nuclear-generated electricity nearly 180 percent, to 16.5 cents per kWh, which is more than almost any other electricity generation technology (Laszlo, 2017). One spin-off effect of this reliance on costly nuclear energy technology is that Ontario will be locking itself out of safer, more affordable, and more flexible electricity for generations to come.

It is beyond the scope of this report to provide a comprehensive account of the costs of the entire nuclear energy generation life cycle. A critical sustainability-related concern is whether OPG has sufficient funds to cover the associated costs. Winfield et al. (2006) cast doubt on OPG's financial capacity, noting that in 2005 the costs of decommissioning Ontario's existing reactors were estimated at $7.474 billion. The then decommissioning fund maintained by OPG was only $4.211 billion. Ontario provides a financial guarantee for any shortfall between OPG's fund and actual decommissioning costs.

RECOMMENDATION NO. 2: OPG and CNSC must clearly demonstrate to Ontarians – through adequate documentation in the licence application submissions – that financial plans are in place to (i) safeguard the affordability of electricity for Ontarians throughout the lifetime of the plant, and (ii) provide financial assurances for the actual costs of continued operation, maintenance, decommissioning, waste management and long term care.

3.3.2 Greenhouse Gas Emissions

In its licence renewal application, OPG claims that one major benefit of nuclear power from the Pickering Nuclear Generating Station is that it generates virtually no GHG emissions. Here, we discuss the critical matter of GHG emissions associated with nuclear energy, which have been almost completely ignored in OPG's licence application, accompanying documents, and the CNSC's review.

Nuclear power plants are not stand-alone systems. They are the most visible component of a sequence of industrial processes that keep nuclear power plants operating. Most accounts of nuclear energy GHG emissions are based on incomplete analyses of the entire nuclear process chain, and this perpetuates the false perception that nuclear energy generation is cleaner than other energy generation technologies.

Winfield et al. (2006) provide a rare life-cycle account of GHG emissions associated with the nuclear energy process chain, focusing primarily on CO_2 emissions. GHGs arise at each stage of the nuclear process chain, from uranium mining, milling, refining, conversion, enrichment, and fuel fabrication through to plant construction, operation, spent fuel storage, decommissioning and waste management. Each phase in the chain consumes thermal energy provided by fossil fuels, and electricity. Conservative (now outdated) estimates of total GHG emissions are between 240,000 and 366,000 tonnes of CO_2 per year for uranium mining, milling, refining, conversation and fuel fabrication, and between 468,000 and 594,000 tonnes of CO_2 for power plant construction. Total GHG emissions associated with nuclear power in Canada are estimated to be in the range of at least 840,000 tonnes per year (Winfield at al., 2006).

Moreover, CO_2 emissions associated with uranium mining depend on the ore grade. After the richest uranium resources are exploited, lower grades are exploited, which becomes more energy- and CO_2-intensive. Consequently, the CO_2 emissions of nuclear power rise with time as the richest uranium resources are depleted. According to Storm van Leeuwen (2017) this phenomenon is called the CO_2 trap, "When the average ore grade approaches 200ppm, the specific CO_2 emission of the nuclear energy system would surpass that of fossil-fueled electricity generation" (p. 6).

OPG's licence application, accompanying documents, and the CNSC's review do not address adequately this critical matter of GHG emissions. Their assumptions about Pickering's GHG emissions rest on consideration of nuclear generation only. A full life cycle analysis of the nuclear process chain is required to substantiate OPG's claims and demonstrate to the public that one major benefit of nuclear power from Pickering is that it generates virtually no GHG emissions.

OPG's and the CNSC's failure to consider appropriately the GHG emissions associated with the full life cycle of nuclear energy generation at Pickering is critical, especially in light of the following sustainability concerns:

- the total amount and cumulative effects of GHG emissions associated with all nuclear power process chains in Ontario and Canada;
- the GHG reduction goals set out in Ontario's *Climate Change Action Plan 2016-2020* for a low-carbon future;
- misconceptions about the GHG emissions associated with nuclear energy relative to other energy generation technologies; and
- the societal need to transition to renewable energy technologies for Ontario's baseload energy demands.

RECOMMENDATION NO. 3: The CNSC and responsible authorities must require OPG to undertake greenhouse gas (GHG) emissions accounting, GHG monitoring, and GHG emissions reduction planning in order to consider the entire nuclear process chain, from cradle to grave.

3.3.3 Consideration of Need and Alternatives

Respect for the concept of sustainable development in planning requires a consideration of the need for an undertaking, which sets part of the basis for an investigation of alternatives. In its licence application, OPG asserts that continued operation of Pickering until 2024 will ensure that Ontarians have a reliable source of baseload electricity to cover the period of refurbishment of Darlington nuclear generation station and the initial Bruce nuclear generation station units. In contrast, reputable public interest organizations argue that the energy generated at Pickering is surplus energy, most of which is sold at a loss to Michigan, and that these losses are absorbed by Ontarians (Stensil, 2016), "Ontario now has a large power surplus – the province now exports more power than is produced by the Pickering Nuclear Plant…", and this means that Pickering can be shut down when its licence expires in 2018 (Clean Air Alliance, 2016b).

This contested question about the need to keep Pickering in operation is crucial, given the costs and risks associated with operating Pickering's aged CANDU 6 reactors. Above, we briefly discussed the financial burdens to future generations of keeping Pickering in operation. The risks (to human health and environmental integrity) of keeping Pickering in operation have been discussed in depth elsewhere (e.g., Taylor & Spivak, 2001; Thompson, 2008), and in Table 6, above, we categorized most of these risks according to sustainability criteria.

OPG's licence application does not demonstrate adequately with pertinent data the baseload energy needs to cover the Darlington and Bruce refurbishment periods, as well as the specific need for Pickering NGS to generate energy to cover Ontario's baseload electricity demands. Nor do OPG and the CNSC discuss the critical matter of alternatives to keeping the Pickering NGS in operation.

OPG's and the CNSC's lack of appropriate consideration of need and alternatives is rooted in a failure of the NSCA and associated regulations to require proponents to consider alternatives to projects and alternative means of carrying out projects. Under the NSCA, the CNSC's EA of OPG's licence application rests on an assumption of need and it is narrowly focused on a review of various OPG studies and documentation as opposed to an appropriately integrative and comprehensive comparative analysis of alternatives that draws from actual studies conducted by independent experts of site, local, and regional impacts and benefits, among other considerations (e.g., cumulative effects).

The failure of the NSCA and associated regulations to require proponents to consider need and alternatives can be viewed in the light of the recent legislative reforms, which have weakened EA law and practice in Canada (see Doelle, 2012; Gibson 2012; Lindgren, 2016), and it signals the need for significant EA reforms aimed at ensuring net contributions to sustainability.

It is beyond the scope of this report to review the recommendations for EA reform that have been advanced by various experts and organizations (e.g., Gibson et al., 2016; Lindgren, 2016).

Here, we assert that the NSCA represents a fundamentally unacceptable legislative framework for the evaluation of OPG's Pickering PROL renewal application.

Here, it is important to note that the new federal *Impact Assessment Act*, now making its way through the Parliamentary process, includes a new core requirement to consider "the extent to which the designated project contributes to sustainability" (s.63(a)) and requires considerations of both alternatives to and alternative means of carrying out the proposed project (s.22(e) and (f)) (see Bill C69, 8 February, 2018).

OPG's licence and all future licences for nuclear power generation and nuclear waste management projects should be evaluated under a reformed 'next generation' CEAA that provides the basis for an appropriately rigorous approach to the consideration of need and alternatives.

RECOMMENDATION NO. 4: OPG's Pickering NGS PROL renewal application and all future licence applications for nuclear power generation and nuclear waste management projects should be evaluated under a reformed CEAA that provides the basis for an appropriately rigorous approach to the consideration of need and alternatives, among other critical considerations. As Gibson et al. (2016, pp. 5-10) have asserted, crucial components of an appropriately rigorous approach to EA would embrace sustainability in all aspects and require attention to

- the purposes of and need for the undertaking (with both purposes and need related to the lasting public interest)
- development and application of broad but comprehensive sustainability-based criteria for evaluations and decisions (see next section);
- emphasis on comprehensive and integrated attention to all factors affecting the long term as well as immediate desirability and durability of effects;
- comparative evaluation of potentially reasonable alternatives to identify best options for each undertaking, to move cumulatively to more sustainable practice; and
- application of case-specified sustainability-based purposes and criteria as the main structure for deliberations and decisions at all process stages for subject undertakings from initial identification of appropriate purposes and options (alternatives) to final deliberations on renewal, closure, decommissioning and continued management.

3.3.4 Public Participation Process

We assert that an EA conducted under the NSCA is not an adequate nor equivalent substitute for a federally directed EA, particularly as it relates to the level of public engagement and opportunities for review by technical experts. In the paragraphs that follow, we describe two key failures of CNSC's EA of OPG's Pickering NGS PROL renewal application: opportunities for public participation and expert review, and convenient access to information.

Convenient access to information is a cornerstone of fair public participation in decision making. Accountability of decision makers is enhanced when citizens have access to relevant documents, and there is a direct link between the accessibility of information and the ability of citizens to influence decision making. Meaningful public participation is not possible without an informed public; therefore, easy access to relevant studies, records, etc., is critical.

A CEAA-based environmental assessment would have provided greater opportunity for public review. For instance, under CEAA 1992, a screening environmental assessment was conducted for Pickering's waste management facility. There was a 60-day window for the public to comment on the draft environmental assessment guidelines, 40 days to comment on the Screening Report, and a public comment period prior to the CNSC's hearing process.

The timeframe and number of opportunities provided for public review contrasts with the CNSC's *NSCA* directed EA, where only approximately 60 days are provided for public comment. Of these 60 days, none of them are a specifically focused on the environmental assessment. Rather, the comment window pertains to the licencing hearing, generally. Unlike the CEAA-led EA, the CNSC did not release a draft environmental assessment report for review, with the potential for follow-up comments nor, did the CNSC seek the public's comments on guidelines or directives which should guide its EA review.

The analyses and data that comprise OPG's complete Pickering NGS PROL renewal application were presented in such a way that an in-depth public review was almost impossible. OPG's August 2017 application document contains scant information readily accessible to the public. Throughout the application OPG refers to lists of relevant studies that provide supplementary information to demonstrate OPG's attention to various requirements under the NSCA. Many of these studies, however, are inaccessible to the public through OPG's website, so citizens must request them. OPG's request for information process is problematic, however, because of OPG's long response time as well as the insufficient time and funding provided for citizens and independent experts to do appropriately comprehensive critical analyses.

RECOMMENDATION NO. 5: In the interests of public access to information, all licence documents, including all supplementary studies/reports, must be conveniently accessible through a public registry, with sufficient time allowed for participant review between posting and deadlines for public submissions.

3.3.5 Transition Planning

OPG's proposed 10-year licensing period covers two project phases: the Continued Operations phase consisting of the continued commercial operation of the Pickering facility to 2024, and the 2-3 year Stabilization phase proposed for completion in 2028, which involves the shutdown of reactors, removal of fuel and heavy water, and additional activities necessary to place the

facility in a state of safe storage. These two phases are followed by three additional phases (safe storage, dismantlement, and site restoration), which will require additional licences.

According to the Ontario Chamber of Commerce (2018), the economic contributions that the Pickering NGS will make to Ontario, to the point of decommissioning, are approximately $1.54 billion to Ontario's GDP, 7,590 full-time equivalent jobs per year, and $290 million in government taxation revenues. The 7,590 full-time jobs arise from direct employment at Pickering, indirect employment at suppliers, and induced spending from wages earned by workers across all industries. Direct employment at the Pickering station is approximately 2,300 jobs annually.

We assert that Pickering's economic contributions will prove to be an enormous incentive to keeping its aging reactor units in operation beyond 2024, with increasingly high costs and risks to the public, including costs associated with needed refurbishments. In this scenario, OPG will be obligated to apply for another PROL renewal to extend the current end of operation date beyond 2024, thereby breaking its promise to Ontarians to phase out Pickering's reactor units, and further locking Ontarians into high-risk nuclear energy for its base load energy demands.

OPG provides some detail about transition planning in its Sustainable Operations Plan and Stabilization Activity Plan, as well as other supporting documents. These plans, however, are primarily focused on transition management arrangements and technical/engineering matters related to safety. They do not adopt an appropriately broad scope that incorporates a concern for the socioeconomic impacts of Pickering's transition phases.

The overall lack of planning that considers the site/plant, local, and regional socioeconomic impacts of Pickering's transitions from operation to stabilization and decommissioning phases in OPG's PROL renewal application suggests that OPG has no intention of shutting down Pickering's reactor units. Given Pickering's economic contributions, a transition plan is critical to mitigate the direct and indirect impacts on workers' livelihoods, family incomes, and other boom and bust effects on the local economy.

In addition, we assert that because a large portion of Pickering's economic contributions come from the Ontario taxpayer and hydro ratepayer, and because continued operation of Pickering's reactor units is not economically viable, Pickering's contributions should be put to more beneficial uses. OPG's transition planning, therefore, should be situated within the broader transition to a renewable energy generation system.

It is beyond the scope of this report to provide a comprehensive, critical review of good transition planning in the energy sector and other industries. In the context of nuclear energy generation, transition planning must consider the full suite of socioeconomic, environmental and technical aspects of nuclear energy generation, as well as multiple scales (site/plant, local, and regional) – all in the context of a broader transition to an electric power system designed to

contribute to lasting wellbeing while avoiding adverse effects, risks and liabilities. In this report, we focus on the need for transition planning that mitigates adverse impacts, including on worker, family, and community livelihoods specifically.

A 2017 report by the Alberta Federation of Labour and Coal Transition Coalition provides case studies of planned transitions from the coal-fired electricity generation transitions in the U.S. The following key lessons learned from these case studies may begin to illuminate best practices with potential application in the nuclear energy sector with respect to livelihood sufficiency transition concerns:

- provide good jobs (of comparable value) to displaced workers, ideally within the same plant, industry, or community,
- aid workers' transition to growing industries, e.g., clean energy generation,
- provide relevant and targeted education, training, and career counselling to workers while they are still employed to mitigate the impacts of transition,
- provide tuition for displaced workers, consistent with the principle that the burden should be shared fairly, instead of falling on workers,
- provide interim support (or transitional allowances) to workers in transition to a new job to ensure workers and their families do not experience a substantive drop in their quality of life,
- work with affected communities to identify appropriate timing for workforce reductions, conduct studies on local economic sectors with growth opportunities, and to make strategic investments by targeting known areas of growth (e.g., renewable energy and energy efficiency).

RECOMMENDATION NO. 6: OPG must develop a transition plan to mitigate the adverse socioeconomic impacts of shutting down Pickering's reactor units on workers, families, and surrounding communities. This transition plan must be informed by best practices for just transition planning that maintains and enhances livelihood sufficiency and community economic wellbeing, and it must consider the larger transition of the electric power system to renewable technologies.

3.4 Summary of Findings and Recommendations

OPG and the CNSC failed to adequately consider critical sustainability concerns throughout planning and analysis. Below, we summarize our findings and recommendations with respect to

- REGDOC-2.9.1,
- Costs to future generations,
- GHG emissions,
- Consideration of need and alternatives,

- Public participation process, and
- Transition planning.

3.4.1 REGDOC-2.9.1 Environmental Protection

REGDOC-2.9.1 is insufficiently helpful on the key matter of how to specify and apply sustainability in analysis. Expansions and revisions are needed to clarify the obligations of the licencee, and to guide other participants in the application process. Our explanation in Section 3.2 of how OPG and the CNSC should have explicitly incorporated a consideration for sustainability in planning and analysis highlights the inadequacy of this regulation.

We recommend the following key adjustments to REGDOC-2.9.1:

- Elaboration of the main generic sustainability implications for studies and reporting, particularly with regard to frameworks and criteria for evaluation of effects and options;
- Addition of requirements for specifying the frameworks and criteria to recognize the particular context and concerns for the project; and
- Revisions to ensure that guidance on other matters is consistent with the commitment to sustainability (see Gibson & Markvart, 2008).

3.4.2 Cost to Future Generations

OPG and the CNSC did not provide a much-needed discussion about the transfer of financial burdens to future generations of the high costs of continued operation and maintenance of all Pickering reactor units until 2024, including the costs associated with stabilization, decommissioning, site restoration, and radioactive waste management.

RECOMMENDATION NO. 2*:* OPG and CNSC must clearly demonstrate to Ontarians – through adequate documentation in the licence application submissions – that financial plans are in place to (i) safeguard the affordability of electricity for Ontarians throughout the lifetime of the plant, and (ii) provide financial assurances for the actual costs of continued operation, maintenance, decommissioning, waste management and long term care.

3.4.3 GHG Emissions

Winfield et al.'s (2006) life-cycle account of GHG emissions associated with the nuclear energy process chain shows that GHGs arise at each stage of the nuclear process chain. Total GHG emissions associated with nuclear power in Canada are estimated to be in the range of at least 840,000 tonnes per year. Moreover, CO_2 emissions associated with uranium mining depend on the ore grade. After the richest uranium resources are exploited, lower grades are exploited, which becomes more energy- and CO_2-intensive.

In its licence renewal application, however, OPG claims that one major benefit of nuclear power from the Pickering Nuclear Generating Station is that it generates virtually no GHG emissions. OPG's and the CNSC's failure to consider appropriately the GHG emissions associated with the full life cycle of nuclear energy generation at Pickering is critical in light of the following sustainability concerns:

- the total amount and cumulative effects of GHG emissions associated with all nuclear power process chains in Ontario and Canada;
- the GHG reduction goals set out in Ontario's *Climate Change Action Plan 2016-2020* for a low-carbon future;
- misconceptions about the GHG emissions associated with nuclear energy relative to other energy generation technologies; and
- the larger societal need to transition to renewable energy technologies for Ontario's baseload energy demands.

RECOMMENDATION NO. 3: The CNSC and responsible authorities must require OPG to undertake greenhouse gas (GHG) emissions accounting, GHG monitoring, and GHG emissions reduction planning in order to consider the entire nuclear process chain, from cradle to grave.

3.4.4 Consideration of Need and Alternatives

OPG's and the CNSC's lack of appropriate consideration of need and alternatives is rooted in a failure of the NSCA and associated regulations to require proponents to consider alternatives to projects and alternative means of carrying out projects. Under the NSCA, the CNSC's EA of OPG's licence application rests on an unsupported and at best debatable assumption of need. It is narrowly focused on a review of various OPG studies and documentation as opposed to an appropriately integrative and comprehensive comparative analysis of alternatives that draws from actual studies conducted by independent experts of site, local, and regional impacts and benefits, among other requirements (e.g., cumulative effects).

The failure of the NSCA and associated regulations to require proponents to consider need and alternatives can be viewed in the light of the recent legislative reforms, which have weakened EA law and practice in Canada (see Doelle, 2012; Gibson 2012; Lindgren, 2016), and it signals the need for significant EA reforms aimed at ensuring net contributions to sustainability.

The new federal *Impact Assessment Act*, now making its way through the Parliamentary process, includes a new core requirement to consider "the extent to which the designated project contributes to sustainability" (s.63(a)) and requires considerations of both alternatives to and alternative means of carrying out the proposed project (s.22(e) and (f)) (see Bill C69, 8 February, 2018).

OPG's licence and all future licences for nuclear power generation and nuclear waste management projects should be evaluated under a reformed 'next generation' CEAA that provides the basis for an appropriately rigorous approach to the consideration of need and alternatives.

RECOMMENDATION NO. 4: OPG's Pickering NGS PROL renewal application and all future licence applications for nuclear power generation and nuclear waste management projects should be evaluated under a reformed CEAA that provides the basis for an appropriately rigorous approach to the consideration of need and alternatives, among other critical considerations. As Gibson et al. (2016, pp. 5-10) have asserted, crucial components of an appropriately rigorous approach to EA would embrace sustainability in all aspects and require attention to

- the purposes of and need for the undertaking (with both purposes and need related to the lasting public interest)
- development and application of broad but comprehensive sustainability-based criteria for evaluations and decisions (see next section);
- emphasis on comprehensive and integrated attention to all factors affecting the long term as well as immediate desirability and durability of effects;
- comparative evaluation of potentially reasonable alternatives to identify best options for each undertaking, to move cumulatively to more sustainable practice; and
- application of case-specified sustainability-based purposes and criteria as the main structure for deliberations and decisions at all process stages for subject undertakings from initial identification of appropriate purposes and options (alternatives) to final deliberations on renewal, closure, decommissioning and continued management.

3.4.5 Public Participation Process

The analyses and data that comprise OPG's complete Pickering NGS PROL renewal application were presented in such a way that an in-depth public review was almost impossible. OPG's August 2017 application document contains scant information readily accessible to the public. Throughout the application OPG refers to lists of relevant studies that provide supplementary information to demonstrate OPG's attention to various requirements under the NSCA. Many of these studies, however, are inaccessible to the public through OPG's website, so citizens must request them. OPG's request for information process is problematic, however, because of OPG's long response time as well as the insufficient time and funding provided for citizens and independent experts to do appropriately comprehensive critical analyses.

RECOMMENDATION NO. 5: In the interests of public access to information, all licence documents, including all supplementary studies/reports, must be conveniently accessible through a public registry, with sufficient time allowed for participant review between posting and deadlines for public submissions.

3.4.6 Transition Planning

The overall lack of planning that considers the site/plant, local, and regional socioeconomic impacts of Pickering's transitions from operation to stabilization and decommissioning phases in OPG's PROL renewal application suggests that OPG has no intention of shutting down Pickering's reactor units. Given Pickering's economic contributions, a transition plan is critical to mitigate the direct and indirect impacts on workers' livelihoods, family incomes, and other boom and bust effects on the local economy.

In addition, we assert that because a large portion of Pickering's economic contributions come from the Ontario taxpayer and hydro ratepayer, and because of the high financial risks and burdens associated with continued operation of Pickering's reactor units, Pickering's contributions should be put to more beneficial uses. OPG's transition planning, therefore, should be situated within the broader transition to a renewable energy generation system.

A 2017 report by the Alberta Federation of Labour and Coal Transition Coalition provides case studies of planned transitions from the coal-fired electricity generation transitions in the U.S. The following key lessons learned from these case studies may begin to illuminate best practices with potential application in the nuclear energy sector with respect to livelihood sufficiency transition concerns:

- provide good jobs (of comparable value) to displaced workers, ideally within the same plant, industry, or community,
- aid workers' transition to growing industries, e.g., clean energy generation,
- provide relevant and targeted education, training, and career counselling to workers while they are still employed to mitigate the impacts of transition,
- provide tuition for displaced workers, consistent with the principle that the burden should be shared fairly, instead of falling on workers,
- provide interim support (or transitional allowances) to workers in transition to a new job to ensure workers and their families do not experience a substantive drop in their quality of life,
- work with affected communities to identify appropriate timing for workforce reductions, conduct studies on local economic sectors with growth opportunities, and to make strategic investments by targeting known areas of growth (e.g., renewable energy and energy efficiency).

RECOMMENDATION NO. 6: OPG must develop a transition plan to mitigate the adverse socioeconomic impacts of shutting down Pickering's reactor units on workers, families, and surrounding communities. This transition plan must be informed by best practices for just transition planning that maintains and enhances livelihood sufficiency and community economic wellbeing, and it must consider the larger transition of the electric power system to renewable technologies.

4. Adequacy of the CNSC's *NSCA* Environmental Assessment

The Canadian Nuclear Safety Commission (CNSC) staff is correct that under the current federal environmental assessment regime, an Environmental Assessment (EA) under the *Canadian Environmental Assessment Act 2012* (CEAA 2012) is not required for this renewal application since the proposal is not for the licencing of a new facility.[21]

The CNSC staff did, however, conduct a review purported to be an "EA" under the *Nuclear Safety and Control Act* (NSCA) and its regulations. The retrograde EA conducted under the NSCA is insufficient; as noted by many commenters, an interim report as far back as the 2001 Standing Senate Committee on Energy, the Environment and Natural Resources,[22] and a recent Environmental Assessment Expert Panel report[23], a much more robust assessment is required to adequately account for the relevant factors involved in projects that are likely to have significant adverse environmental effects.

While Section 3 of CELA's submission sought to address the inadequacies in the current EA process under the NSCA with respect to sustainability, this section will address the EA process under the NSCA with a specific focus on identifying statutorily imposed limitations and how they may be improved to better reflect the purpose of environmental assessments – to protect the health and well-being of the environment and Canadians from the adverse effects of projects.

4.1 Comparing the Federal and *NSCA* EA Processes

The federal statutory requirements for the assessment of nuclear projects have been watered down since the *Canadian Environmental Assessment Act*[24] (CEAA 1992) was replaced by the CEAA 2012. CEAA 1992 identified certain projects likely to have significant adverse environmental effects and named them in a list of projects requiring comprehensive study. The repeal of CEAA 1992 and subsequent promulgation of CEAA 2012 replaced the Comprehensive Study List Rgulations with a narrowed scope of designated projects. Most importantly, since the reactors at Pickering NGS are not new facilities, they are not classified as designated projects

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[21] *Regulations Designating Physical Activities,* SOR/2012-147, s. 19(1)(g).

[22] Standing Senate Committee on Energy, the Environment and Natural Resources, "Interim Report, Canada's Nuclear Reactors: How Much Safety Is Enough?" (June 2001), online: https://sencanada.ca/content/sen/Committee/371/pdf/interim-enrg-e.pdf, p 31-39. The Interim Report argued that the failure of including the restarting of Pickering NGS under the Comprehensive Study List under CEAA 1992 must have been an oversight owing to the threat posed by a nuclear generating station such as Pickering A. This line of reasoning can be extended to include the renewal of an operating licence for an NGS past its operating design date and its decommissioning.

[23] EA Panel Report, *supra* note 12

[24] *Canadian Environmental Assessment Act*, SC 1992, c 37 **[CEAA 1992]**

and therefore not required to undergo an EA under CEAA 2012 when being refurbished or decommissioned.[25]

Even though most nuclear projects are not subject to a CEAA 2012 EA, CNSC staff does undertake a process, described as an "environmental assessment", or EA, under the NSCA.[26] Without an explicit requirement to consider the factors listed under s. 19 of the CEAA 2012 (or s. 16 of CEAA 1992) the process is more akin to a technical analysis of a proposed environmental monitoring program.

An EA under the NSCA is primarily based on information that the applicant or licensee is required to submit to the CNSC through the established licensing process, such as the licence application and its supporting documentation, and information on environmental protection measures.[27] In comparison, a comprehensive study under CEAA 1992 was required to consider, amongst others, technically and economically feasible alternatives; cumulative environmental effects; and the capacity of renewable resources that are likely to be significantly affected. A responsible authority could also consider the "need for" and "alternatives to" a project.[28] As a technical assessment with a narrower scope and without the requirement to consider the factors underlying s. 19 of CEAA 2012 or s. 16 of CEAA 1992, an EA under the NSCA cannot be considered an assessment that would ensure a proponent would make adequate provision for the protection of the environment and the health and safety of persons while carrying on a licensed activity. For the reasons discussed below, CELA submits that an EA conducted under the *NSCA* is not an adequate nor equal substitute for a federal, CEAA-based EA.

4.2 Important Factors to Consider in Environmental Assessments

The Pickering NGS has a history of having the highest operating costs of any nuclear facility in North America and risks associated. As also briefly outlined under Section 3.3.3 (Consideration of Need and Alternatives) of this document in the context of sustainability, the cost of operating the Pickering NGS, its unreliability, poor safety, and available alternatives for electricity generation, create legitimate questions as to the need for the continued operation of the Pickering NGS. This section will consider these factors in the context of an EA under the NSCA.

Given the importance of the operation and decommissioning of the Pickering NGS and the potential long-term environmental and public safety consequences of the use of nuclear power and its waste legacy, CELA submits that the application from OPG to renew and extend its Pickering NGS PROL should be classified as a designated project under the CEAA 2012 and

[25] CNSC CMD, *supra* note 5, p 13.
[26] NSCA, *supra* note 10.
[27] CNSC, "Environmental assessments" online: http://nuclearsafety.gc.ca/eng/resources/environmental-assessments/index.cfm
[28] CEAA 1992, *supra* note 24, s. 16.

undergo an EA under that statute. Alternatively, the CNSC is empowered with the discretion to conduct an EA under the NSCA that is comparably robust to one conducted under the CEAA 2012.

The CNSC has the authority, in accordance with paragraph 3(1.1)(b) of the *General Nuclear Safety and Control Regulations* (herein, *General Regulations*), to require additional information that would enable the Commission to determine whether a proposed project makes adequate provision for the protection of the environment and the health and safety of persons.[29] CELA submits that the additional information the Commission may request include an analysis of such factors as, amongst others, a consideration of the "need for" the project, "alternatives to" the project, "alternative means" to carrying out the project, and cumulative effects.

If the CNSC were to exercise its authority under the *General Regulations*, even a cursory analysis of "alternative means", "alternatives to", and the "need for" factors would likely lead CNSC staff to recommend the denial of OPG's application to renew the PROL past its expiration date. In its application, OPG has presented no compelling evidence for the need to renew the Pickering NGS PROL beyond its current expiration date; has not conducted a comparative analysis of the feasible alternatives to the continued operation of the facility; nor conducted an adequate analysis of the alternative means for the continued operation and decommissioning of the facility. To the contrary, there has been ample evidence, as briefly reviewed in the next section, over the course of the facility's history, that should have led CNSC staff to question whether it is prudent to grant the renewal application.

The Pickering NGS produces surplus energy that is not utilized. According to a 2016 Ontario Clean Air Alliance (OCAA) factsheet, Ontario's peak-hour demand for electricity declined by 17% between 2006 and 2015 while supply rose by 25% during the same period.[30] Ontario lost between $384 to $675 million in 2016 and $348 to $572 million for the first three quarters of 2017 worth of energy because of over generation of electricity.[31] Because of this falling demand and rising supply, Ontario now has a large electricity surplus.

The Pickering NGS is also an unreliable generator of power. According to OPG's own 2015 Nuclear Benchmarking Report[32] comparing the performance of its nuclear reactors to others in

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[29] *General Nuclear Safety and Control Regulations*, SOR/2000-202, s. 3(1.1)(b)
[30] Clean Air Alliance Research, How we can close the Pickering Nuclear Station and lower bills, (September 2016) online: http://www.cleanairalliance.org/wp-content/uploads/2016/09/pickering-replacementv4.pdf.
[31] Ontario Society of Professional Engineers, Empower Ontario's Engineers to Obtain Opportunity An Analysis of Ontario's Clean Electricity Exports online: https://www.ospe.on.ca/public/documents/advocacy/submissions/OSPE_Electricity_Export_Analysis.pdf at p 2.
[32] Ontario Power Generation, 2015 Nuclear Benchmarking Report, (November 2015) https://www.opg.com/about/regulatory-affairs/Documents/2017-2021/F2-01-01_Nuclear-Business_Planning_and_Benchmarking_20161110.pdf **[Benchmarking Report]**

North America, Pickering is the worst performer. When benchmarked against other nuclear facilities, Pickering's six reactors consistently come in near the bottom of the pack in terms of reliability and cost.[33] According to the World Association of Nuclear Operators (WANO), a key measure of a nuclear station's reliability is its forced loss rate; this is the ratio of its unplanned (forced) energy losses to its planned level of electricity generation.

OPG's Benchmarking Report compared the reliability of the Pickering NGS to that of North America's 64 other nuclear power plants. Pickering's forced loss rate is 10.08 times greater than WANO's excellent performance standard, i.e., a maximum nuclear performance index (NPI) of 1.0.[34] To address, in part, Pickering's poor performance, Mr. Randy Lockwood the Senior Vice President of Pickering Nuclear at OPG, indicated to the CNSC at the April 4th, 2018 public hearing on the PROL renewal application that, "the forced loss rate performance over the last three years has also been the best ever. And our maintenance backlog for safety critical equipment across the entire station, all six units, it is zero."[35] Mr. Lockwood's submission does not address the facility's performance in comparison to the 64 other nuclear power plants in North America. If recent history is any indication, the performance may still be closer to the lower end in terms of reliability and cost. In any case, without an updated Nuclear Benchmarking Report that provides a comparative analysis of the facility that covers the last three years, there is no data-driven evidence to suggest improvement in performance.

The electricity produced by the Pickering NGS is more expensive than that from other nuclear power plants in North America. According to the 2015 Nuclear Benchmarking Report,[36] the Pickering NGS operating costs per kWh, exclusive of fuel costs, are higher than those of any other nuclear station in North America. [37] The Pickering NGS fuel and operating costs (8.16 cents per kWh) was more than double Ontario's average wholesale market price of electricity in 2014 (3.60 cents per kWh). As a result, the Independent Electricity System Operator (IESO) was required to provide OPG with special payments totalling $917 million to subsidize Pickering's operating deficit.[38]

The operation of the Pickering NGS is unsafe for workers, the public, and the environment. The Pickering NGS has had a long history of significant accidents that call into question the safety of its continued operation. In 2001, the Standing Senate Committee on Energy, The Environment and Natural Resources released a report listed several accidents up to that point in the Pickering

[33] *Ibid*, p 41-42.
[34] *Ibid*, p 51.
[35] CMD 18-H6/18-H6.A 47, Oral presentation by CNSC staff online: http://nuclearsafety.gc.ca/eng/the-commission/pdf/TranscriptofPickeringHearing-April4,2018.pdf at p 13.
[36] Benchmarking Report, *supra* note 32, at p 70-71.
[37] *Ibid,* p 70-71.
[38] Clean Air Alliance Research, Closing the Pickering Nuclear Station in 2018: A Cost-Benefit Analysis, (June 2016) online: online: http://www.cleanairalliance.org/wp-content/uploads/2016/06/pickering-fs.pdf p 3.

NGS operation.[39] The OCAA noted further recent examples of accidents occurring between 2011 and 2015.[40] As noted by a joint publication by CELA and the Pembina Institute in 2004:[41]

> The Pickering A nuclear station should be shut down permanently for safety reasons alone. Due to its age, the Pickering A station is the only nuclear plant in the western world that has only one emergency shutdown system. All other nuclear plants in Canada and abroad have two complete emergency shutdown systems for back-up. Ontario Power Generation (Ontario Hydro) installed a cheaper alternative to save $300 million. The Pickering station is also closer to larger numbers of people than any other nuclear plant in the world. For that reason, regulatory authorities would not allow a new plant to be built at Pickering today.

The reduction in demand for electricity, coupled with the Pickering NGS operating costs, its unreliability, and historic lack of safety suggests that it is an unnecessary choice for Ontario's current needs and a poor choice for meeting Ontario's future needs. The failure of CNSC staff to consider the feasibility, reliability, necessity, or alternatives to OPG's proposed licence renewal in its EA under the NSCA has resulted in a lack of information available for the Commission and public's review. Without which, the CNSC does not have the requisite evidentiary basis to find the applicant can in carrying on the proposed licence, making adequate provision for the protection of the environment. On this this basis, CELA recommends the denial of OPG's application to renew the Pickering NGS PROL.

4.2 Conclusion

The CNSC should deny OPG's application to renew the Pickering NGS beyond the expiration of its PROL on August 31, 2018. The lack of any need for the continued operation of the Pickering NGS, its history of poor performance, increased risks to the public, cost of its operation and decommissioning, the existence of adequate "alternatives to" the nuclear facilities generation of electricity, coupled with the lack of any compelling evidence provided by OPG to extend the PROL beyond its current end date, demonstrates that the proposal to renew the PROL beyond its current end date does not make adequate provision for the protection of the environment and the health and safety of persons –- a condition for licencing under the NSCA.

RECOMMENDATION NO. 7: The CNSC Commissioners should require CNSC staff to exercise its authority under paragraph 3(1.1)(b) of the *General Nuclear Safety and Control Regulations* to

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[39] *Canada's Nuclear Reactors: How Much Safety Is Enough?* online: https://sencanada.ca/content/sen/Committee/371/pdf/interim-enrg-e.pdf.
[40] Ontario Clean Air Alliance, "Pickering Nuclear: Unsafe at any speed" (2016) online: http://www.cleanairalliance.org/pickering-safety/.
[41] Pembina Institute for Appropriate Development and the Canadian Environmental Law Association, "Power for the Future Towards a Sustainable Electricity System for Ontario," (May 2004) online: http://www.cela.ca/sites/cela.ca/pdf/energyreport-fullreport.pdf at p 107.

require CNSC Staff to undertake a comprehensive "need for", "alternative to", and "alternative means" analysis utilizing the best available scientific information and methods, Indigenous knowledge, and public consultation as part of the EA of the Pickering NGS PROL renewal application and all subsequent EA's under the NSCA. In the absence of this analysis, the Commissioner's should find that need for the Pickering renewal and life extension is not demonstrated.

RECOMMENDATION NO. 8: The CNSC should deny OPG's application to renew the Pickering NGS beyond the expiration of its PROL on August 31, 2018. The lack for an adequate "need for" the continued operation of the Pickering NGS; the history of poor performance and the increased risks to the public; the cost of its continued operation and decommissioning; and the existence of adequate "alternatives to" the nuclear facilities generation of electricity; coupled with the lack of any compelling evidence provided by OPG to extend the PROL beyond its current end date, demonstrates that the proposal to renew the PROL does not make adequate provision for the protection of the environment and the health and safety of persons – a condition for licencing under the NSCA.

5. Decommissioning of the Pickering NGS

This Section reviews the assessment of decommissioning the Pickering NGS undertaken by OPG under the current Canadian regulatory framework. While comparisons will be made to current IAEA standards and guidelines; and the regulations of other jurisdictions, they are done so to delineate relative practice, and should not be construed as a tacit endorsement of their respective regulatory framework. It should be noted that the IAEA Standards are the minimum standards required to be met by IAEA Statute Member States for the regulation of nuclear activity. The IAEA Standards should not be sufficient to meet the higher standard required to ensure the protection of the environment and public health now and in the future.

Furthermore, CSA N294-09 and CSA Standards in general, are privately developed standards not subject to the same level of public scrutiny as the legislative process for public laws and regulations.[42] As previously stated by CELA, the use of CSA Standards inappropriately delegates the setting of regulatory standards to an industry body, not easily accessible by the public. The reliance on CSA Standards creates unacceptable secrecy concerning nuclear licensing requirements. CELA has requested, and does so once again, that the CNSC cease reliance on CSA standards for any matters relevant to nuclear licensing, and instead conduct all standard setting and guidance within the CNSC's processes. Should the CNSC decide to continue this problematic reliance on CSA Standards, the CNSC should, as a minimum, ensure that members of the public are given unrestricted access to all CSA standards referenced in the licence documents free of charge.

[42] CSA, "N294-09 (R2014) Decommissioning of facilities containing nuclear substances" (2014) **[CSA N294-09]**

5.1 Inadequate Regulatory Framework for Decommissioning

As it stands, Canada does not have a comprehensive regulatory framework that adequately addresses nuclear waste or the decommissioning of nuclear facilities. There is an imminent need to develop publicly acceptable policies and strategies for the management of radioactive waste and the decommissioning of nuclear facilities that are scientifically sound.

In 2014, the CNSC commissioned a report, *International Benchmarking on Decommissioning Strategies*, RSP-0303,[43] that compared the Canadian regulatory framework and standards to the requirements of IAEA *Safety Requirements, Decommissioning of Facilities Using Radioactive Material*, WS-R-5, as well as other international jurisdictions. Since that time, WS-R-5 has been superseded by IAEA *General Safety Requirements* Part 6, GSR Part 6. While an update, GSR Part 6 has substantially the same requirements as WS-R-5. In addition, while Canada's regulatory framework has also undergone some change in the interim, its approach to regulating nuclear decommissioning activities has remained largely unchanged. Consequently, the conclusions drawn by RSP-0303 concerning the adequacy of the Canadian regulatory regimes compliance with IAEA requirements remain relevant today. The report found that while many of the IAEA requirements were adequately reflected in the Canadian regulatory framework or commissioned standards, a number were not.

The Canadian regulatory framework as it relates to the decommissioning of NPPs is, in general, similar to the regulatory regime of most of the other countries that were reviewed in RSP-0303 (and particularly those of Finland, Italy, the UK and Sweden). This is because all of these regimes primarily address planning for decommissioning, estimating the cost of decommissioning and assuring that funding for decommissioning will be available. According to the report, the statutes, regulations, licence conditions, codes and standards of these jurisdictions, including Canada, do not systematically address the execution of decommissioning or the release of a nuclear site following decommissioning.[44]

The CNSC regulatory guide G-219 stipulates that one of the primary roles of the preliminary decommissioning planning process and plan is to document a preferred decommissioning strategy which, considering current knowledge, represents a technically feasible, safe and environmentally acceptable approach.[45] CSA N294-09 recommends that a decommissioning strategy should contain a high-level approach and rationale for decommissioning a facility, be developed early, and be updated as new information is obtained. strategy.

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[43] Candesco, International Benchmarking on Decommissioning Strategies, RSP-0303, (2014), online: http://www.nuclearsafety.gc.ca/eng/pdfs/about/researchsupport/reportabstracts/RSP-0303-Final-Report-eng.pdf, p 9 [**RSP-0303**].
[44] RSP-0303, *supra* note 43, p 18.
[45] CNSC Regulatory Guide G-219, Decommissioning Planning for Licensed Activities (June 2000), online: http://nuclearsafety.gc.ca/pubs_catalogue/uploads/G219_e.pdf, s 6.1.1 **[G-219]**

The Finnish regulatory regime suggests that the preferred strategy for decommissioning is Prompt Dismantling, but that all options would be considered if sufficiently justified.[46] In Sweden, the primary decommissioning strategy for NPPs is that of immediate dismantling with the overarching goal the site of the nuclear facility to be eventually used for future energy production after decommissioning.[47] Although all three of the identified decommissioning strategies are available to licensees, in the United States the majority of NPPs have adopted the DECON strategy, equivalent to 'immediate dismantling', with only three facilities undergoing in-situ decommissioning.

The IAEA GSR Part 6 stipulates the preferred decommissioning strategy as immediate dismantling, but that when all relevant factors are considered, there may be situations where immediate dismantling is not a practical strategy.[48] SRS 50 suggests that the selection of a decommissioning strategy is dependent on waste generation and waste management. When selecting a decommissioning strategy, it is crucial to consider national waste management policies or to seek the establishment of a policy where one does not exist. The policy should establish both, an overall national framework for the management of all types of waste generated during decommissioning activities, and the classification of the waste and its long-term management. [49]

CNSC's regulatory guidance documents consist of the single G-219, published in 2000, that devotes only a page and a half to choosing decommissioning strategies, and uses discretionary language, suggesting that "…it may be useful to map out the basic strategic approach to decommissioning within each envelope." or "where a clear strategic preference is not immediately apparent, the alternative strategies should be compared using a simple detriment-benefit evaluation method." In any case, these documents cannot be considered government policy, given the CNSC's "arms-length governance structure" that "ensures that it remains independent from government."[3]

Consequently, there is no comprehensive regulatory framework that adequately addresses nuclear waste or the decommissioning of nuclear facilities. The Government of Canada should develop publicly acceptable policies and strategies for managing radioactive wastes and the decommissioning of nuclear facilities that reflect international best practices and have been developed in consultation with Indigenous peoples and the Canadian public. This should

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[46] Predisposal Management of Low and Intermediate Level Nuclear Waste and Decommissioning of a Nuclear Facility, Guide YVL D.4, draft L5, (2013) online: https://ohjeisto.stuk.fi/YVL/D.4e.pdf, Requirement 403, **[Guide YVL D.4]**

[47] OECD, Radioactive Waste Management and Decommissioning in Sweden, (2013) online: https://www.oecd-nea.org/rwm/profiles/Sweden_report_web.pdf, p 18.

[48] Decommissioning of Facilities Using Radioactive Material, IAEA Safety Standards Series No. GSR Part 6, IAEA, Vienna (2016), online: http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1652web-83896570.pdf, s 5.1 **[GSR Part 6]**

[49] Decommissioning Strategies for Facilities Using Radioactive Material, IAEA SRS 50, IAEA, Vienna (2007), online: http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1281_web.pdf, at 3.7 **[SRS 50]**

include, as a prerequisite, the development of a national classification scheme for radioactive waste, decommissioning strategies, and decommissioning execution that are scientifically sound and publicly acceptable.

RECOMMENDATION NO. 9: The CNSC should require, at a minimum, that decommissioning strategies are well documented and include a description of the options, the overall timescales for the decommissioning of a facility and the end state after completion of all decommissioning actions. The reasons for choosing the preferred option should be explained and justified in comparison to other feasible strategies based on the best available scientific information and methods, after public consultation, and require that no undue burdens be imposed on future generations.

5.2 A Detailed Decommissioning Plan Should Have Already been Completed

It is important that the CNSC require OPG to develop a detailed decommissioning plan (DDP) as soon as possible. The timely development and submission of a DDP allows for the vetting of the plan before any irrevocable decisions are made. Early submission also allows the CNSC to evaluate the justification and plans for, amongst others, adaptive management and environmental monitoring, site remediation and end-use, costs and feasibility, cumulative effects, long-term waste management, security, and public safety.

CELA is aware that OPG plans to begin decommissioning in 2028, however, if its application to renew the PROL were rejected by the CNSC, OPG would be required to commence decommissioning activities as early as 2021. Under these circumstances, a more fully-supported decommissioning strategy under a DDP should either be completed or be close to completion.

IAEA GSR Part 6 requires that prior to decommissioning actions, a final decommissioning plan must be prepared and submitted to the regulatory body for approval typically within two to five years of permanent shutdown.[50] Article 18 of IAEA TECDOC 1816, Model Regulations for Decommissioning of Facilities, indicates that proponents should also provide interested parties with the opportunity to provide their input prior to submitting the plan to the regulatory body.[51] The US Code of Federal Regulations 10 CFR 50.82(a)(4)(i),[52] specifies that prior to or within 2 years following the permanent cessation of operations, the licensee must submit a Post-Shutdown Decommissioning Activities Report (PSDAR). The PSDAR will include a description of the planned decommissioning activities, with a schedule for the accomplishment of significant milestones and an estimate of expected costs. Further guidance on the format and content of the PSDAR is provided in Regulatory Guide 1.185, *Standard Format and Content for Post-*

[50] GSR Part 6, *supra*, note 48 at Requirement 11.
[51] IAEA TECDOC 1816, Model Regulations for Decommissioning of Facilities, Article 18.
[52] Termination of License, 10 CFR 50.82, U.S. Nuclear Regulatory Commission, 2011.

Shutdown Decommissioning Activities Report.[53] Upon receipt of the PSDAR, the NRC will place a notice regarding its receipt in the Federal Register to solicit comments on the PSDAR from the public pursuant to 10 CFR 50.82(a)(4)(ii).[54]

Canadian CNSC guidance document G-219 lists the required contents of a detailed decommissioning plan, and CSA Standard CSA N294-09 stipulates the contents of a final decommissioning plan must specify the detailed work program, safety and environmental protection procedures, and management systems to be followed during decommissioning.[55] Clause 7.8.2 provides a description of the specific inclusions in the final decommissioning plan based on the complexity of an NPP being decommissioned.[56] Despite the level of detail, neither G-219 nor CSA N294-09 provide any requirement or guidance on when the final decommissioning plan is to be submitted, nor do they require meaningful consideration of input from the public.

The Canadian regulations and standards meet the minimum international standards for the content of a DDP but fall short of providing a schedule for its submission and the need for public input. The timely development of the DDP allows for the vetting of the proposed plan before any irrevocable decisions are made. This allows the regulator to evaluate the licensee's justification and plans for, amongst others, adaptive management and environmental monitoring, site remediation and end-use, costs and feasibility, cumulative effects, long-term waste management, security, and public safety.

Both, IAEA guidance and U.S. regulation, despite its varied efficacy in regulating the nuclear industry, also recognize the need for a timely DDP that has been subject to public accountability and acceptability for decommissioning activities. This also includes ready access to documents relevant to the development of the DDP. Meaningful public participation is not possible without an informed public. As previously noted in Sections 2.1 and 3.3.4 on CELA's submission, accountability of decision makers is enhanced when citizens have access to information and the ability to influence decision making. The lack of a meaningful opportunity for the public to participate in an activity that is likely to have an adverse effect on, not only current, but future generations is antithetical to a properly functioning democracy.

RECOMMENDATION NO. 10: In anticipation of decommissioning the Pickering NGS, the CNSC should require OPG to develop a DDP as soon as possible. The development of the DDP must include meaningful participation of the public at the earliest possible opportunity, to ensure the DDP has a sound evidentiary basis and is publicly acceptable. The DDP should be sufficiently

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[53] Standard Format and Content for Post-Shutdown Decommissioning Activities Report, Regulatory Guide 1.185, U.S. Nuclear Regulatory Commission, (2000) online: http://pbadupws.nrc.gov/docs/ML0037/ML003701163.pdf

[54] *Ibid*, p 1.185-2.

[55] CSA N294-09, *supra* note 42, at 7.8.1.

[56] *Ibid* at 7.8.2.

detailed to allow the evaluation of the licensee's justification and plans for, amongst others, adaptive management and environmental monitoring, site remediation and end-use, costs and feasibility, cumulative effects, long-term waste management, security, and public safety.

5.3 Minimal Analysis of Alternative Means in the Preliminary Decommissioning Plan

To ensure compliance with GSR Part 6, the CNSC should compel OPG to undertake an "alternative means" analysis for feasible decommissioning strategies that utilize the best available up-to-date science and methods. The analysis should demonstrate that the preferred strategy will ensure the Pickering NGS will be maintained in a safe configuration at all times, will reach the specified decommissioning end state, that no undue burdens will be imposed on future generations, and is acceptable to the public and Indigenous communities.

The OPG Preliminary Decommissioning Plan (PDP) for the Pickering NGS indicates that the deferred decommissioning strategy was selected based on decommissioning planning studies that OPG started in the 1980s.[57] Those studies indicated that the immediate decommissioning option would incur higher costs and higher occupational dose, while the dismantling costs and occupational dose would fall over time, favouring deferred decommissioning and in-situ confinement. The current post-decommissioning plan for the Pickering NGS site, however, is for the re-use of the site, and so in-situ confinement was not considered further. Notably, the studies concluded that deferred decommissioning, entailing a safe storage period, was the most suitable option for decommissioning OPG's NGSs. [58] Based on a study published in 1991, OPG determined that a safe storage period of nominally 30 years offered a reasonable time to defer dismantling. The currently available funding also assumes a deferred decommissioning strategy for the Pickering NGS.

It is unclear from the PDP whether the plans for employing the deferred decommissioning strategy have been revisited since the 1980s. What is explicit, however, is that the decision to employ the decommissioning strategy is based on science that is almost certainly three decades old. Despite the use of outdated science and the imminent need, OPG has only conducted a cursory review of available decommissioning strategies and their employment in various jurisdictions; it did not conduct a persuasive alternatives analysis using the best available scientific information and methods to present an evidence-based justification for selecting deferred decommissioning as the preferred strategy.

[57] OPG, Preliminary Decommissioning – Pickering Generating Stations, 2016 (Plan P-PLAN-00960-00001), p 54.
[58] OPG, Preliminary Decommissioning – Pickering Generating Stations, 2016 (Plan P-PLAN-00960-00001), p 55.

According to GSR Part 6, at a minimum, OPG is required to demonstrate to the CNSC that, under the decommissioning strategy selected, deferred decommissioning, the Pickering NGS will be maintained in a safe configuration at all times and will reach the specified decommissioning end state, and that no undue burdens will be imposed on future generations.[59]

As mentioned in Section 4.2 above, the CNSC has the authority to require additional information under paragraph 3(1.1)(b) of the *General Nuclear Safety and Control Regulations*, to determine whether the adequate provision will be made for the protection of the environment and the health and safety of persons.[60] OPG would be able to meet the minimal standard set by the IAEA under GSR Part 6 if it were to undertake an analysis of "alternative means" utilizing the most up-to-date best available science and methods, to establish an evidentiary basis for a preferred decommissioning strategy. The evidence presented by OPG should demonstrate that the preferred strategy will ensure the Pickering NGS will be maintained in a safe configuration at all times, will reach the specified decommissioning end state, and that no undue burdens will be imposed on future generations. This analysis should be undertaken in consultation with Indigenous peoples and the Canadian public to ensure the acceptability of preferred strategy. To ensure the public can provide meaningful feedback, the "alternative means" analysis should detail the criteria used to identify alternative means and how these criteria were applied to find the rejected alternative means unacceptable.

RECOMMENDATION NO. 11: The CNSC should exercise its authority under paragraph 3(1.1)(b) of the *General Nuclear Safety and Control Regulations*, to compel OPG to undertake an "alternative means" analysis that utilizes the best available up-to-date science and methods, and input from the public and Indigenous communities. The analysis must demonstrate that the preferred strategy will ensure the Pickering NGS will be maintained in a safe configuration at all times, will reach the specified decommissioning end state, that no undue burdens will be imposed on future generations, and is acceptable to the public and Indigenous communities.

5.4 Conclusion

In anticipation of Pickering NGS's decommissioning, the CNSC should exercise its authority under paragraph 3(1.1)(b) of the *General Nuclear Safety and Control Regulations*, to compel OPG to undertake an "alternative means" analysis for decommissioning strategies. The analysis must utilize the best available up-to-date science and methods, as well as input from the public and Indigenous communities. The decommissioning strategies put forth by OPG should be well documented and include a description of the options, the overall timescales for the decommissioning of a facility, and the end state after completion of all decommissioning actions. The "alternative means" analysis must demonstrate that the preferred strategy will ensure the Pickering NGS will be maintained in a safe configuration at all times, will reach the

[59] GSR Part 6, *supra* note 48 at Requirement 5.3.
[60] *General Nuclear Safety and Control Regulations*, SOR/2000-202, s. 3(1.1)(b)

specified decommissioning end state, that no undue burdens will be imposed on future generations, and is acceptable to the public and Indigenous communities. Finally, the CNSC should also require OPG to develop a DDP as soon as possible. The development of the DDP must include meaningful participation of the public at the earliest possible opportunity, to ensure the DDP has a sound evidentiary basis and is publicly acceptable. The DDP should also be sufficiently detailed to allow the evaluation of the licensee's justification and plans for meeting licencing conditions.

6. Improving Emergency Response and Preparedness

In this section, CELA reviews the current state of emergency planning and readiness in Ontario and comments on the sufficiency of the revised *Provincial Nuclear Emergency Response Plan* as a basis for emergency planning. As set out below, CELA recommends a number of improvements to Ontario's emergency response measures in order to: (1) ensure the emergency response for the Pickering NGS is 'best in class,' and (2) align protective actions with the minimum standards as set out in international guidelines and approaches exemplified by other jurisdictions.

6.1 The Current State of Emergency Planning and Readiness

Four and a half million people live within 50 kilometres of the largest nuclear facility in the world - the Pickering Nuclear Generating Station.[61,62] The inherent risk of operating a nuclear generating station of Pickering's size in a high-density area, necessitates emergency response planning which is commensurate to the complexity of evacuating, alerting and distributing KI in a populous area.

Emergency planning was a focus of the Ontario's Auditor General most recent annual report, which found Ontario's nuclear emergency response and planning to be critically deficient:

> Emergency response plans have not been updated to reflect current events or operations. Since many of the emergency response plans we reviewed had not been recently updated, these plans may not reflect current operations or incorporate program changes. They also may not include current information on best practices and lessons learned from past emergencies, practice tests of the response plans and recent worldwide events. This could result in confusion or delays during the response to an emergency.[63]

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[61] Office of the Auditor General of Ontario, (2017). "Emergency Management in Ontario," online: http://www.auditor.on.ca/en/content/annualreports/arreports/en17/v1_304en17.pdf, p 224 **[Auditor General Report];** Daniel Otis, "Is Toronto ready for a radiation emergency" 5 Jan 2016, The Toronto Star, online: https://www.thestar.com/news/gta/2016/01/05/is-toronto-ready-for-a-radiation-emergency.html **[Is Toronto Prepared]**

[62] "Pickering Nuclear" 2018, online: https://www.opg.com/generating-power/nuclear/stations/pickering-nuclear/Pages/pickering-nuclear.aspx

[63] Auditor General Report, *supra* note 61, p 226

The Auditor's General report was released just weeks before Ontario published its revised *Provincial Nuclear Emergency Response Plan* (herein, PNERP 2017). The revised PNERP released December 21, 2017, four years past its scheduled revision timeframe, exemplifies the Auditor's General finding that emergency planning in Ontario lacks regular updating and iterative review.[64]

6.2 The CNSC's Oversight of Emergency Planning

Emergency response planning and preparedness is multi-faceted and requires cooperation between the regulator, provincial authorities and licensee. CELA urges the CNSC to exercise its stringent oversight role as to whether emergency planning and preparedness has been proven prior to exercising its discretion with regards to the Pickering NGS licence renewal.

Not only does the CNSC have authority to require, review and approve emergency plans which are in the purview of its licensees; it also has authority to review emergency plans in place for off-site response and to use its assessment of the adequacy of those plans as part of its determination as to whether a nuclear power plant or other facility may operate, or under what terms and conditions. The CNSC's jurisdiction extends to the portions of plans which have been undertaken by other authorities external to the plant operator. That is, the CNSC must review the gamut of emergency preparedness measures, to make a determination whether the risk to the public is acceptably low per section 24(4) of the NSCA.

It is fundamental that in exercising its discretion to issue operating licences to licensees, the CNSC further its mandate of ensuring public safety and the protection of the environment. The CNSC must not limit its review of emergency planning to plant boundaries or operator action. Rather, it must specify expectations for emergency planning to the fullest extent of potential impacts on the public and environment.

6.3 International Guidance

CELA has reviewed the extent to which international standards have been referenced in the CNSC's Staff CMD and the proposed Licence Conditions Handbook (LCH). Unfortunately, we did not find that CNSC Staff sufficiently considered international best practice or international guidance related to emergency planning in either of these documents. As further discussed in this section, we identified that the proposed LCH for Pickering is not current with IAEA standards, specifically IAEA General Safety Requirements, Part 7, "Preparedness and Response for a Nuclear or Radiological Emergency" (herein, GSR-7).

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[64] The 2009 PNERP required updating every four years. The 2017 PNERP has amended this obligation to every five years. Ontario, "*Provincial Nuclear Emergency Response Plan, Master Plan 2009*" online: https://www.emergencymanagementontario.ca/sites/default/files/content/emo/docs/PNERP%202%20Approved%20Plan%202009_PDFUA.pdf, s 1.11.2.

6.3.1 Regulator Responsibilities

The CNSC's Staff CMD lacks substantive analysis of the licence application's confluence with international guidance and simply notes, "the CNSC has confirmed that the updated PNERP conforms with the both CSA N1600 and IAEA standards on emergency management."[65] While it is advantageous for PNERP 2017 to align with international guidance, it does not conversely mean that the CNSC, in its review of the emergency response, is compliant with international obligations and commitments. For instance, IAEA GSR-7 sets out responsibilities of a nuclear regulator.[66] As these IAEA recommendations are beyond the scope of PNERP 2017, which is provincial in basis and cannot impose responsibilities on a federal authority, Table 2 below summarizes some key requirements for a nuclear regulatory body.

Table 2: Regulator Requirements per IAEA General Safety Requirements, Part 7, "Preparedness and Response for a Nuclear or Radiological Emergency"

Section	Requirement
4.1	The government shall ensure that an emergency management system is established and maintained on the territories of and within the jurisdiction of the State for the purposes of emergency response to protect human life, health, property and the environment in the event of a nuclear or radiological emergency
4.4	The government shall ensure the coordination of and consistency of national emergency arrangements with the relevant international emergency arrangements
4.11	The government shall ensure that operating organizations, response organizations and the regulatory body establish, maintain and demonstrate leadership in relation to preparedness and response for a nuclear or radiological emergency
4.26	The government through the regulatory body shall ensure that operating organizations review appropriately and, as necessary, revise the emergency arrangements (a) prior to any changes in the facility or activity that affect the existing hazard assessment and (b) when new information becomes available that provides insights into the adequacy of the existing arrangements

During the previous renewal of Pickering NGS's licence in 2013, CELA detailed the expectations of the CNSC, as a regulator, flowing from GSR-7's predecessor, IAEA GS-G-2 (2006).[67] Unfortunately, the CNSC's Record of Proceedings dated August 2, 2013 did not respond to this issue nor, require the IAEA standard to form the licencing basis. [68] CELA reiterates its former

[65] CNSC CMD, *supra* note 5, p 100

[66] IAEA Safety Standards, "General Safety Requirements Part 7 - Preparedness and response for a Nuclear Radiological Emergency" (2015) **[GSR-7]**

[67] CELA, "Emergency Planning at the Pickering Nuclear Generating Station," 3 May 2013, online: http://www.cela.ca/publications/emergency-planning-pickering

[68] Pickering Nuclear Generating Station Nuclear Power Reactor Operating Licence (Effective 1 September 2013), online: https://www.opg.com/generating-power/nuclear/stations/pickering-nuclear/Documents/PickeringLCH.pdf

recommendation that the CNSC should require, as a minimum, that IAEA standards be met and demonstrated as a part of its licensing decision for the Pickering NGS.

6.3.2 Licence and Licensing Basis

OPG's licence application and CNSC Staff's proposed licence and LCH should be reviewed in tandem with IAEA standards, to ensure they are current and reflect the more recent updates to emergency planning and response. This requires reviewing both the planning basis for emergency response and specific emergency planning measure (ie. evacuation, public awareness and alerting, as detailed in later sections) to ensure alignment with international standards.

CELA has previously found applicants' material to be based on previous versions of IAEA standards and thus, not up to date. As we noted for the Commission in the recent relicensing hearing for the Point Lepreau NGS, the offsite plan relied on GS-R-2 (2002), and not the revised GSR-7 (2015). [69] As the IAEA notes in GSR-7, these standards differ in the following significant way:

> In 2011, the IAEA Secretariat, relevant international organizations and Member States began the review of IAEA Safety Requirements publication No. GS-R-2 on the basis of lessons identified in exercises and from the response to emergencies since its publication in 2002 (including the response to the accident at the Fukushima Daiichi nuclear power plant in Japan in March 2011), and in due consideration of recommendations of the International Commission on Radiological Protection (ICRP).[70]

In response to CELA's finding, the CNSC recommended in its Record of Decision that Point Lepreau implement GSR Part 7 "as soon as practicable."[71] The CNSC also confirmed in its Record of Decision that as RegDoc 2.10.1 was based on GSR-7 and RegDoc 2.10.1 served as the licensing basis for emergency management, the licencee was compliant with international guidance.[72]

Unfortunately, the proposed licence for the Pickering NGS is not based on the same version of RegDoc 2.10.1 that was relied upon for the Point Lepreau NGS. The proposed LCH for the Pickering NGS explicitly states that the licence compliance criteria for emergency planning is RegDoc 2.10.1, Version 1. [73] Unfortunately, because IAEA GSR-7 dates to 2015 and RegDoc 2.10.1 Version 1 dates to 2014, the licence it not current with international standards. [74]

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[69] CELA, "Submission to the CNSC: Emergency Planning at the Point Lepreau Nuclear Generating Station" (3 April 2017), online: http://www.cela.ca/publications/1108submissions-cnsc-pt-lepreau
[70] GSR-7, *supra* note 66, Preface.
[71] Canadian Nuclear Safety Commission, Summary Record of Decision – Application to Renew the Nuclear Power Reactor Operating Licence for Point Lepreau (14 June 2017), para 333
[72] *Ibid*, para 334
[73] CNSC CMD, *supra* note 5, p 99
[74] CNSC, "RegDoc 2.10.1 Nuclear Emergency Preparedness and Response," October 2014.

CELA submits Pickering NGS's licensing basis must be amended so that it complies with IAEA's standard on radiological emergency response, GSR-7. This requires the licensing basis in the proposed licence and LCH be updated to Version 2 of RegDoc 2.10.1. Absent this amendment, the licensee's emergency planning licence basis is non-compliant with international guidance and standards.

RECOMMENDATION NO. 12: Pickering NGS's emergency management licensing basis, RegDoc 2.10.1 Version 1 (2014) predates the IAEA's most recent standard on radiological emergencies, GSR-7. CELA recommends Pickering NGS's licensing basis be updated to reference RegDoc 2.10.1, Version 2 (2016), which is current with IAEA GSR-7. All Licence Condition Handbooks proposed by the CNSC should, at a minimum, be current with international guidance and standards at the time of licensing.

6.4 Emergency Planning Zones

The establishment of emergency planning zones (EPZ) is a principal tool for offsite emergency planning and response. Based on the revised PNERP, Ontario's planning zones are now as follows: [75]

- Automatic Action Zone (AAZ): 3 km
- Detailed Planning Zone (DPZ): 10 km
- Contingency Planning Zone (CPZ): 20 km
- Ingestion Planning Zone (IPZ): 50 km

6.4.1 Contingency Planning Zone

The revised PNERP amends its 2009 predecessor with the inclusion of a new emergency planning zone, known as the Contingency Planning Zone (CPZ). The CPZ is a pre-designated area where protective actions from the DPZ can be extended in the event of a nuclear emergency.

Unfortunately, the DPZ and CPZ are distinguishable in that PNERP 2017 specifies what planning activities "shall" occur within the DPZ but in the CPZ, only "considerations" are suggested. For example, in the DPZ detailed planning must occur to ensure evacuations can be implemented and the associated needs of the evacuated public met. However, in the CPZ, emergency measures such as KI pill distribution requirements, public awareness and monitoring, are listed as "considerations" only. As the Office of the Fire Marshall and Emergency Management (OFMEM) noted during Day 1 of the Pickering NGS licence renewal hearing:

[75] Ontario, "*Provincial Nuclear Emergency Response Plan, Master Plan 2017*" online: https://www.emergencymanagementontario.ca/english/emcommunity/response_resources/plans/provincial_nuclear_emergency_response_plan.html at 2.2.6 **[PNERP 2017]**.

> The CPZ does not require the same level or type of detailed arrangements as the Automatic Action Zone or Detailed Planning Zone, in so far as there are no default or pre-planned protective measures associated with the CPZ.[76]

As the efficacy of the "considerations" listed for the CPZ depend upon the level of preparedness and planning undertaken *prior* to a radiological emergency, CELA recommends the CPZ require the same level of detailed planning as the DPZ.

RECOMMENDATION NO. 13: CELA recommends the CNSC require the expansion of Ontario's nuclear emergency planning zones. First, the Contingency Planning Zone (20 km) must require the same level detailed arrangements and pre-planned protective measures as the Automatic Action Zone (3 km) or Detailed Planning Zone (10 km). Secondly, the current CPZ boundary should be re-evaluated based on better modelling and at a minimum, require a 20 km evacuation zone.

RECOMMENDATION NO. 14: CELA recommends that the Commission publicly review the PNERP's Technical Study on emergency planning zone sizes and its implications for all nuclear power plant licensees' on-site and off-site emergency planning arrangements. CELA recommends any further PNERP technical studies and findings be publicly reviewed by the Commission on an annual basis.

6.4.2 Ingestion Planning Zone

According to PNERP 2017, the ingestion planning zone requires plans to be made to protect the food chain and drinking water supplies, and restrict the consumption of potentially contaminated produce, dairy and wild-grown products in the event of a radiological emergency. While CELA supports the inclusion of these protective measures, unfortunately, the IPZ only extends to a distance of 50 km. In order meet international best practice (see section 6.4.3 below), CELA submits the IPZ should extend to 100 km and include the additional requirement that all municipalities within this zone maintain nuclear emergency response plans.

RECOMMENDATION NO. 15: CELA recommends the CNSC require the expansion of Ingestion Planning Zone to 100 km and include the additional requirement that all municipalities within this zone maintain nuclear emergency response plans.

[76] Office of the Fire Marshal and Emergency Management, Presentation - Commission Meeting April 4, 2018, "*Update on Emergency Management in Ontario and the Provincial Nuclear Emergency Response Plan (PNERP),"* slide 24 **[OFMEM Presentation]**

6.4.3 International Guidance

Despite the recent release of PNERP 2017, Ontario's emergency planning zones do not align with international best practice or IAEA guidance. For instance, following a 2014 joint meeting of the Western European Nuclear Regulators (WERNA), the Heads of the European Radiological Protection Competent Authorities (HERCA) concluded "an accident comparable to Fukushima would require protective actions such as evacuation up to 20 km and sheltering [and ITB] up to 100 km."[77] While HERCA does not propose a uniform approach to emergency planning, it does propose a framework which facilitates a 'minimum common level' of preparation. This approach, according to HERCA, is necessary in response to accidents like Fukushima which serve as a reminder that a "severe nuclear accident cannot be completed excluded anywhere in the world."[78]

As illustrated in Table 3 below, guidance from the IAEA also recommends detailed planning beyond Ontario's current DPZ. According to IAEA *Safety Guide GS-G-2.1,* [79] the following zones and accompanying safety measures are recommended:

Table 3: Emergency Planning Zones and Measures per IAEA *Safety Guide GS-G-2.1*

Zone	Size	Description	Response Measures
Precautionary Action Zone	3 – 5 km	Area within which arrangements should be made to implement precautionary urgent protective actions before or shortly after a major release with the aim of preventing or reducing the occurrence of severe deterministic effects[80]	Urgent protective actions include: Isolation of a contaminated area or radioactive source; Prevention of inadvertent ingestion; Evacuation; Sheltering; Respiratory protection and protection of skin and eyes; Decontamination of individuals; Prophylaxis with stable iodine; Protection of the food supply and prevention of the consumption of significantly
Urgent Protective Action Planning Zone	5 – 30 km	Area where preparations are made to promptly shelter in place, to perform environmental monitoring and to implement urgent protective actions on the basis of the results of monitoring within a few hours following a release.[82]	

[77] HERCA-WENRA (2014) Approach for a better cross-border coordination of protective actions during the early phase of a nuclear accident, online: http://www.herca.org/docstats/HERCA-WENRA%20approach%20for%20better%20cross-border%20coordination.pdf, p 9
[78] *Ibid*
[79] International Atomic Energy Agency, "Arrangements for Preparedness for a Nuclear or Radiological Emergency No. GS-G-2.1" (2007) online: http://www-pub.iaea.org/MTCD/publications/PDF/Pub1265web.pdf at p 76 **[IAEA GS-G-2.1]**
[80] GSR-7, *supra* note 66, p 76
[82] GSR-7, *supra* note 66, p 77

			contaminated foodstuffs and water; Management of the medical response; Protection of international trade.[81]

Despite the lessons learned in a post-Fukushima world, Ontario's emergency measures remain geographically limited to the areas close to nuclear stations due to the current small-scale "reference accident." Indeed, the advisory panel tasked with reviewing Ontario's emergency response plans recognizes that Ontario's "planning zone sizes may require revision if the planning basis includes a multi-unit failure event where none of the post-Fukushima improvements or mitigating actions are credited in the source term calculation."[83] Consequently, the PNERP 2017 is currently undergoing a technical study, to be completed at the end of 2018, which will identify any requirements to expand planning zone distances. The OFMEM has commented that until the Technical Study is complete, they will not be proposing any options for revisions to the PNERP.[84]

As Canada's nuclear regulator, the CNSC is ultimately responsible for ensuring the requisite level of emergency readiness and preparedness at each of Canada's nuclear generating stations. We have learned since Fukushima that we must extend planning for emergency response and evacuation beyond our current emergency planning zones. CELA submits that the CNSC must rule on the sufficiency of emergency planning at the time of the licensing decision and not, on actions yet to be performed. We remind the CNSC of the Maebashi District Court ruling in Japan from March 2017, which found both government and operator of the Fukushima nuclear plant responsible for failing to take preventative measures.[85] The judges found that the major risks from the plant were foreseeable by the government but were ignored and not acted upon.[86]

6.5 Public Awareness

Section 5.5.2 of the 2017 PNERP Implementing Plan for the Pickering Nuclear Generating Station (herein, Implementing Plan) requires that measures to the protect the public from radionuclides "*shall* be provided for in public awareness and education materials as well as in *emergency*

[81] IAEA GS-G-2.1, *supra* note 79, p 32
[83] OFMEM Presentation, *supra* note 76, slide 15
[84] *Ibid*, slide 16
[85] Daisuke Kikuchi, "In first, government and Tepco found liable for Fukushima disaster" (17 March 2017) The Japan Times, online: http://www.japantimes.co.jp/news/2017/03/17/national/crime-legal/first-government-tepco-found-liable-fukushima-disaster/#.WN3YwogrLIU
[86] Shaun Burnie, "Japan court shocks nuclear industry with liability ruling" (20 March 2017) Asia Times, online: http://www.atimes.com/article/japan-court-shocks-nuclear-industry-liability-ruling/

bulletins."[87] The 2009 PNERP Implementing Plan lacked an equivalent provision and while CELA welcomes this amendment, it must be noted that because the Implementing Plan was only released in March 2018, the Pickering NGS has not yet fulfilled this requirement. As discussed in this section, CELA has concluded that the members of the public living and working in the area of the Pickering NGS do not have sufficient knowledge to ensure prepared, and prompt action in the event of a radiological emergency.

CELA had the opportunity to review a poll which gauged the awareness of emergency plans and procedures of residents living within 20-kilometre of the Pickering NGS (herein, "Pickering poll"). The results illustrated that over 50% of the study group had a "poor" or "very poor" understanding of emergency procedures. Furthermore, 60% of respondents noted their level of readiness as "unprepared."

Without higher levels of public preparedness and readiness, OPG does not have the requisite level of public awareness necessary to continue operating the Pickering NGS. In the previous licensing hearing for the Pickering NGS, CELA recommended that the Commission require OPG to "conduct a study as to the awareness of the Pickering Nuclear Plan" and "their likely response in the event that a general emergency is declared and the Primary Zone [DPZ] is evacuated."[88] It is not evident from OPG's licence application that this study or survey has been undertaken.

As a regulator, the CNSC is vested with acting in the public[89] and, ensuring per section 24(4) of the *NSCA* that the licensee will "in carrying on that activity, make adequate provision for the … health and safety of persons." The CNSC lacks the evidentiary basis to find in favour of this statutory requirement and authorize the operations of the Pickering NGS beyond 2020. While the CNSC has proposed that OPG develop "a new public education campaign to provide guidance in the unlikely event of a nuclear emergency and how to prepare prior to an emergency,"[90] the necessary level of readiness will not be achieved by the end of this licencing period and in time for renewal.

While a public education campaign designed to 'provide guidance on what to expect' and 'how to prepare for a nuclear emergency' is also noted as a "planned improvement" in OPG's application, Pickering is Canada's older nuclear station and thus it should already be a leader in public awareness and education. With a 47-year long operating history, residents surrounding the Pickering NGS should be stewards of emergency preparedness, being the *most* informed, and *most* prepared. Unfortunately, even if a certain level public awareness, verified through studies and public surveying was made a condition of licensing, it would not change the

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[87] Ontario, "Implementing Plan for the Pickering Nuclear Generating Station" (March 2018) **[Implementing Plan]**

[88] Canadian Environmental Law Association, "Emergency Planning at the Pickering Nuclear Generating Station" (3 May 2013), online: http://www.cela.ca/publications/emergency-planning-pickering, p 48

[89] *Greenpeace Canada v. Canada (Attorney General),* 2014 FC 463, para 243

[90] CNSC CMD, *supra* note 5, p 103

immediate level of preparedness among the million people living within 20 km of the Pickering NGS. On this basis, CELA submits the CNSC must not grant OPG's request to continue operating to 2024.

RECOMMENDATION NO. 16: CELA recommends that the CNSC require robust evidence demonstrating that residents in the DPZ and CPZ zone have awareness of emergency planning procedures. Absent this level of knowledge, the Pickering NGS should not be operated beyond its current licencing period.

6.6 Public Alerting

Sections 6.2.2 and 6.2.3 of the Pickering Implementing Plan require public alerting systems which within 15 minutes of an initiation, can alert populations in the AAZ (3 km) and DPZ (10 km). Section 6.2.3 requires that the system be capable of reaching practically 100% of the population within this zone, whether located indoors or outdoors. Furthermore, the Plan notes that for population "within and beyond the DPZ," the provincial Alert Ready program shall be used to alert populations. According to the Implementing Plan, the "Alert Ready program ensures that emergency bulletins are broadcast in a timely manner via radio, television and mobile devise."[91]

Starting April 6, 2018, the province's Alert Ready program expanded its scope to notifications via cellular device. As OPG notes in its licence application, it conducted a pilot project with 80 Alert Ready phones in order to validate the systems functionality and effectiveness of the program.[92] We ask that findings from this pilot be shared with the Commission and lessons learned reviewed. We also ask that CNSC ensure Durham Region and OPG's respective emergency response plans be updated and communication channels verified, to ensure radiological emergencies are promptly communicated to the provincial Alert Ready program.

Furthermore, the Alert Ready system must be undertaken in tandem with other public alerting measures. As experienced during Ontario's test of the Alert Ready system on May 7, 2018, not all cellular customers received alerts or notifications. Additional public alerting considerations must be made for those who do not have a cell phone or those who have a cell phone, but it is either out of service or not turned on. In these instances, it is necessary for alternative means of notification to be operable.

Prompt alerting is necessary to prevent overexposure to radionuclides in the event of radiological dispersion.[93] Therefore, as CELA noted in section 6.4, the existing DPZ and IPZ are insufficient in size and should be expanded to 20 km and 100 km respectively. Detailed planning

[91] Implementing Plan, *supra* note 87, p 56
[92] Licence Application, *supra* note 2, p 101
[93] IAEA GS-G-2.1, *supra* note 79, p 55

for public alerting should extend beyond the DPZ and be required within the CPZ. Given the potential for aerial dispersion of radionuclides well beyond the current zones, a public alerting scheme enabling quick response should be operable within the DPZ and CPZ.

According to the Pickering public awareness poll CELA reviewed, respondents had a high degree of interest (88%) in information about alert systems, but only half understood the meaning of emergency sirens and what they represented. On this basis, CELA makes the following recommendations:

RECOMMENDATION NO. 17: Public notification and response systems must be tested and operable within the DPZ and CPZ and not limited to the immediate 10 km zone. Public alerting utilizing multiple communication methods must also be in place to a distance of 100 km.

RECOMMENDATION NO. 18: The CNSC must have evidence demonstrating that in the event of a radiological emergency, the provincial Alert Ready system can be promptly activated. The CNSC should request OPG to provide an update on its Alert Ready pilot project.

6.7 Potassium Iodide (KI) Distribution

It well established that potassium Iodide (KI) is an effective blocker of thyroid radioiodine uptake and it can provide protective benefits to individuals who are particularly vulnerable to thyroid disease, such as pregnant and nursing women, newborns and children.[94]

As noted in section 6.4, the Heads of the European Radiological Protection Competent Authorities recommend that emergency strategies for iodine thyroid blocking (ITB) extend to 100 km.[95] The distribution of ITB to 100 km is one of three requirements recommended in its 'general emergency response strategy'.[96] Other jurisdictions, such as Switzerland currently pre-distribute KI pills within 50km of each plant as a precautionary measure.[97]

A 2017 report from Association Pour Le Contrôle de la Radioactivité dans L'Ouest (ACRO) also found Ontario's failure to distribute KI to distance of 100 km to be a gap in its level of emergency preparedness. The report analyzed Ontario's readiness for a large-scale nuclear accident and recommended:

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[94] City of Toronto, "Prepare to be Safe," online: http://www.preparetobesafe.ca **[Prepare to be Safe]**.
[95] HERCA-WENRA (2014) Approach for a better cross-border coordination of protective actions during the early phase of a nuclear accident, online: http://www.herca.org/docstats/HERCA-WENRA%20approach%20for%20better%20cross-border%20coordination.pdf, p 9
[96] *Ibid*, p 38
[97] Be Prepared Grey Bruce Huron, "Be Prepared for a Nuclear Emergency - Potassium Iodide (KI)", online: http://www.bepreparedgreybrucehuron.com/nuclear/ki-tablets/

> Ontario should extend the distribution of iodine tablets up 100 km from nuclear power plants. Canada should introduce more protective intervention levels for children, pregnant and breast-feeding women. Clear information related to posology and multiple intakes should be provided to the populations.[98]

While the PNERP 2017 technical study currently being undertaken seeks to identify any requirement to expand protective measures, including KI pre-distribution,[99] this study will not be completed until the end of 2018 and thus its results not available for this relicensing. Therefore, CELA recommends OPG be required to expand the availability of KI beyond the existing range as an interim measure. Specifically, given the risk to vulnerable groups, like pregnant women and children, we recommend KI stockpiles be maintained at places they frequent within the broader 100 km zone.

CELA also recommends that residents in the eligible 50 km zone be informed of the online KI pill ordering site, "Prepare to be Safe". As the poll CELA reviewed demonstrated, less than 20% of respondents residing in the 20 km zone were aware that KI pills could be ordered online at http://PrepareToBeSafe.ca

Lastly, we ask that the CNSC require OPG to expand its pre-stocking of KI to schools within 50 km of the Pickering NGS. Bruce Power has already done so and since 2016, KI tablets have been pre-stocked in all schools, and parents informed of their use and provided directions for administration. Given the dense population within 50 kilometres of the Pickering NGS and children's particular vulnerability to radiation, we recommend the pre-stocking of KI in all schools within the 50 km zone be made a condition of licensing.

RECOMMENDATION NO. 19: We continue to encourage the CNSC to require licencees to provide KI by way of pre-distribution within a 50 km radius, and pre-stock to 100 km. In accordance with international best practice, the CNSC should extend KI stockpiles to 100 km and ensure stockpiles at places frequented by vulnerable groups, such as children and pregnant women, are maintained.

RECOMMENDATION NO. 20: Given the dense population within 50 kilometres of the Pickering NGS and children's particular vulnerability to radiation, we recommend the pre-stocking of KI in all schools within the 50 km zone be made a condition of licensing.

RECOMMENDATION NO. 21: CELA recommends that the CNSC require OPG to disseminate

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[98] Association Pour Le Controle de La Radioactivité Dans L'Ouest, "Ontario is not ready to face a large-scale nuclear accident," (2017), online: http://www.acro.eu.org/ontario-is-not-ready-to-face-a-large-scale-nuclear-accident/, p 19

[99] Conseil Supérieur de la Santé, Conseil Supérieur de la Santé Accidents nucléaires, environnement et santé après Fukushima. Planification d'urgence, AVIS DU CONSEIL SUPERIEUR DE LA SANTE N° 9235, février 2016 at 83

information on a more frequent basis, about the online KI-pill ordering website PrepareToBeSafe.ca in its outreach material to the public.

6.8 Medical Response and Treatment

Section 5.3(j) of the Pickering Implementing Plan requires arrangements be made for "mass transportation and medical transfers." Furthermore, evacuation planning for the 'affected public' must be undertaken in advance and planning advice on health issues, led by Local Public Health Units, Medical Officers of Health, Local Health Integration Networks and Paramedic Services. According to section 6.9.6, the Ministry of Health and Long-Term Care is responsible for leading and coordinating the health response.

Despite the medical response planning which is required to be 'undertaken in advance,' detailed planning only extends within the DPZ. This level of planning is insufficient and does not align with international best practice. As a recent case study of the Fukushima medical evacuation concluded, the death of 50 patients resulted because of "inappropriate medical care circumstances."[100] These patients had originally been evacuated to a hospital within the 20-km zone but transported a second time, when the government decided the evacuation zone had to be extended beyond the 20 km limit. The study noted medical evacuation to be "difficult task" which was "absolutely beyond the capacity" of the scheme in place.[101]

The study conclusively recommended that hospitals have a long-distance evacuation plan extending over 100 km, and conduct drills as a part of their emergency response planning. Further recommendations from this study are presented in Table 4, below.[102] CELA strongly encourages the CNSC to adopt the study's recommendations and require detailed planning within the CPZ.

Table 4: Medical Response Planning

Recommendations	
1. Plan for long-distance evacuation	Medical facilities, including nursing homes, should have a plan for long-distance disaster-specific (over 100 km) evacuation. This plan should be practiced with full-scale exercises and when flaws are found, they should be evaluated and eliminated
2. Securement of transportation measures and designated hospitals	A disaster-specific evacuation plan should include the securement of transportation measures and designated hospitals where patients can be sent

[100] New Brunswick Department of Justice and Public Safety, "Point Lepreau Nuclear Off-Site Emergency Plan" (August 2017), s 1.53.1
[101] Tetsu Okumura abd Shinichi Tokuno, "Case study of medical evacuation before and after the Fukushima Daiichi nuclear power plant acident in the great east Japan earthquake" (2015) 1:19 Disaster Mil Med, online: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5330112/#CR8
[102] *Ibid*

3. Multiple communication measures	Healthcare facilities should have two or three independent communication measures such as a radio, satellite phone, amateur radio, and multi-channel access radio systems
4. Supervision by emergency physicians and disaster specialists	Hospital evacuation in disaster settings should be supervised by emergency physicians and be handled by disaster specialists who are accustomed to patient transportation on a daily basis
5. The presence of an emergency physician or disaster researcher in the central government	The presence and availability of an emergency physician or disaster researcher in the central government can greatly contribute to the governmental response, especially for disaster-specific medical transportation

RECOMMENDATION NO. 22: We recommend the CNSC review the adequacy of medical care that could be provided during an evacuation. The CNSC should inquire if medical facilities within the DPZ and CPZ have long-distance, nuclear disaster-specific evacuation plans, and whether these plans have been practiced on a full-scale.

RECOMMENDATION NO. 23: CELA recommends the CNSC refuse the further extension of the Pickering's operating licence on the basis that medical response and evacuation are not detailed and operational beyond the 10 km DPZ. Detailed planning which is fully functional, and has been fully tested for efficacy, must be required within the CPZ.

6.9 Evacuation

Evacuation is one of the most immediate actions to be taken in the event of a general emergency at any nuclear generating station. According to section 5.3.1 of Pickering's Implementing Plan, "all available routes will be utilized to evacuate the public." Conversely, in the event of an ongoing or imminent radioactive emission, the Implementing Plan notes in section 6.6.2 that all traffic on Highway 401 and the CN/CP rail lines 'should be suspended'. As a result of shadow evacuations (ie. people who voluntarily leave an area following a nuclear incident or accident, beyond those who are asked by the authorities to do so) within the 10 km DPZ and traffic density on major routes, the Implementing Plan foresees that 'travel time in all directions may be longer than normal.'

For the following reasons, CELA has serious concerns about the sufficiency of detailed evacuation planning. First, as discussed in section 6.4, detailed planning for evacuation only extends within the DPZ. However, because evacuating the DPZ will have repercussive impacts on traffic movement in the CPZ, we strongly recommend detailed planning for evacuation be required within the CPZ. As the Implementing Plan notes, due to the close proximity of Hwy. 401 and the commuter-train corridor to the Pickering NGS, it is likely that transport on these high-volume transport routes would also be suspended. This not only effects those seeking to evacuate the DPZ, but drivers, trucks and trains attempting to exit or enter Ontario's most populous region.

Secondly, while OPG's Licence Application notes an updated Evacuation Time Estimate (ETE) study was issued in 2016, we query its sufficiency in light of new population predictions and objectives set in Ontario's Growth Plan for the Greater Golden Horseshoe, 2017 released in May 2017 (herein, Growth Plan).[103] In accordance with the Growth Plan, Downtown Pickering has been designated an 'urban growth centre.' This designation requires it meet a minimum density threshold (200 residents or jobs per hectare) and serve as a hub for regional transit networks. As the Pickering urban growth centre is located approximately 3 km from the Pickering NGS, CELA submits it is crucial CNSC require OPG to revise its ETE for Pickering.

Lastly, while the Pickering poll noted that 82% of respondents were interested in receiving information and maps with evacuation routes, only 32% of respondents were "aware" of evacuation plans in their community. Even fewer respondents (23%) were aware of emergency procedures in place for vulnerable populations, such as children and seniors.

RECOMMENDATION NO. 24: CELA recommends the CNSC extend detailed planning for large-scale evacuations into the IPZ. The CNSC should require OPG to demonstrate the adequacy of detailed planning within an expanded DPZ and IPZ, including planning for any schools, retirement homes, daycares, hospitals and correctional facilities in these areas. These plans should be communicated publicly.

RECOMMENDATION NO. 25: The CNSC should require OPG to update its Evacuation Time Estimate Report to reflect recent population objectives and growth trends in line with Ontario's Growth Plan (2017). The updated ETE should also review the impact of increased evacuation zones at a radial distance of 50 km on locations of Emergency Workers Centres, numbers of emergency workers required for evacuation management, traffic routes, size of evacuation centres, and locations and capacity of Decontamination and Monitoring Units. These findings should be reported to the CNSC and publicly reviewed.

RECOMMENDATION NO. 26: The CNSC should require OPG's public awareness program to contain more detailed information about evacuation routes, the location of emergency shelters and decontamination centres and how vulnerable people, including seniors and children, will be protected.

6.10 Self-Decontamination and Decontamination Centres

The Implementing Plan recognizes self-decontamination as a default protective measure which may be required, alongside evacuation, ITB or sheltering. Unfortunately, according to the Pickering poll CELA reviewed, only 33% of the respondents were "aware" of how to decontaminate either themselves or their family.

[103] Ministry of Municipal Affairs, "Growth Plan for the Greater Golden Horseshoe, 2017" (May 2017), online: http://placestogrow.ca/index.php?Itemid=14&id=430&option=com_content&task=view#2.2.3

Therefore, our request to the Commission is twofold: first, we request the Commission query the availability of decontamination centres and whether the public is aware of their availability and locations; and secondly, we recommend greater public awareness be provided by OPG in this regard. As previously noted in section 6.4, in the event the plume effects populations beyond the 10 km DPZ, we recommend there be detailed planning in the CPZ.

RECOMMENDATION NO. 27: The CNSC should inquire as to the availability of decontamination centres and whether the public is aware of their use and location.

RECOMMENDATION NO. 28: The CNSC should require OPG's public awareness program to contain information on how to self-decontaminate in order to foster great awarnesss of this default protective measure.

6.11 Worker Safety and Consent

Risks of exceeding maximum exposure limits must be discussed with workers in advance of any accident. While OPG's licence and Licence Conditions Handbook refer to worker safety in the context of conventional health and safety, they do not discuss maximum exposure limits or consent. Therefore, methods to review risks and obtain consent from workers to exceed those limits should be explicitly clarified in plans by the operator.[104]

RECOMMENDATION NO. 29: Methods to review risks and obtain consent from workers to exceed maximum radiation exposure limits should be explicitly clarified in plans by the operator as a condition of licensing.

6.12 Control of Agricultural Products

As PNERP 2017 notes in s 2.2.5(f), the Ingestion Planning Zone is a pre-designated zone for the purpose of (1) protecting the food chain, (2), protecting drinking water supplies and (3) restricting consumption and distribution of potentially contaminated produce, wild-grown products, milk from grazing animals etc. in the event of a radiological emergency. Accordingly, ingestion control measures shall be directed as based on results from the monitoring of food, milk and water per s. 6.3.3.

[104] This request has previously been made by CELA, as noted in the following submissions: CELA, "*A Review of Canada's Nuclear Emergency Preparedness and Response Plan*" (17 July 2017) online: http://www.cela.ca/review-nuclear-emergency; CELA, "*Emergency Planning at the Pickering Nuclear Generating Station*" (3 May 2013) online: http://www.cela.ca/sites/cela.ca/files/899PickeringEmergencyPlanning.pdf.

To ensure the sufficiency of these ingestion monitoring measures, it is necessary that the IPZ be extended to 100km, to account for weather contingencies and the aerial dispersion of radionuclides.

RECOMMENDATION NO. 30: The IPZ should be extended to 100 km to account for weather contingencies and the aerial dispersion of radionuclides beyond 50 km.

6.13 Drinking Water and Monitoring Radionuclides in Lake Ontario

The Pickering Implemeting Plan states that "if venting over Lake Ontario, ground monitoring teams from PNGS shall complete radiological surveys following the shoreline, out to 20 km on either side of the plant." While CELA welcomes the inclusion of radionuclide monitoring for Lake Ontario in the revised PNERP, it is unclear to what degree monitoring occurs in the inshore and offshore areas, and whether currents and flow unique to Lake Ontario have been considered.

As the Toronto Region Conservation Authority explains, the nearshore is the region which extends 3 – 5 km offshore.[105] Therefore, potentially 15 km of the '20 km monitoring on either side of the plant' could extend into the offshore region. There are a number of distinctions between the near and offshore regions, including coarser-grained bottom sediments in the nearshore and finer-grained sediments in the offshore,[106] and faster moving alongshore currents (which travel along the shoreline) than cross-shore currents (which move towards or away from the shoreline).[107]

The revised PNERP and the Implementing Plan lack contingency measures to protect and monitor Lake Ontario, despite its recognition that during a design basis accident, venting of containment will occur "over the lake."[108]

Given that all of Ontario's nuclear reactors are located on the Great Lakes - which supplies the drinking water to 40 million Canadians and Americans – it is necessary that detailed planning be required in the IPZ to protect drinking water supplies and require contingency planning in the event of an accident. With nine million people relying on Lake Ontario for drinking water, there is an even greater imperative that emergency planning be in place for the Pickering NGS.[109]

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[105] Toronto Region Conservation Authority, "Watershed Management" online: https://trca.ca/conservation/watershed-management/lake-ontario-waterfront/projects/western-durham-nearshore-monitoring-program/lake-comparison/
[106] Toronto Region Conservation Authority, "Lake Comparison" online: https://trca.ca/conservation/watershed-management/lake-ontario-waterfront/projects/western-durham-nearshore-monitoring-program/the-nearshore-environment/
[107] Toronto Region Conservation Authority, "Currents" online: https://trca.ca/conservation/watershed-management/lake-ontario-waterfront/projects/western-durham-nearshore-monitoring-program/currents/
[108] Implementing Plan, *supra* note 87, s 4.6.6(a)
[109] Is Toronto Prepared, *supra* note 61

In advance of relicensing, it is incumbent that the CNSC ensure that provisions are in place for an alternative source of drinking water for residents whose current drinking water source is Lake Ontario. The licensing materials do not demonstrate that either OPG or CNSC have studied drinking water and contingency planning. Such a study is not only necessary to identify alternative sources of drinking water, but to logistically plot how an alternative supply would be delivered to impacted communities, indefinitely.

RECOMMENDATION NO. 31: The CNSC should require proof of adequate contingency planning for the protection of drinking water in the event of an emergency as a requirement for licensing. The CNSC ensure that provisions are in place for an alternative source of drinking water for residents whose current drinking water source is Lake Ontario.

7. Conclusion and Order Requested

CELA respectfully requests the Canada Nuclear Safety Commission to deny OPG's request for a 10-year licence for the Pickering NGS. For the following reasons, we submit the licence renewal should not be allowed:

- **A federal environmental assessment is necessary before OPG can proceed with its proposed decommissioning plans.** The environmental assessment conducted by the CNSC under the *NSCA* does not adequately incorporate and consider critical sustainability concerns. The *NSCA* EA is not equivalent to a federal EA which requires the consideration of alternatives, relies on and incorporates expert review and includes, to a greater extent, the public in the decision-making process.

- **OPG and the CNSC did not address the critical matter of alternatives to keeping the Pickering NGS in operation.** OPG's application did not clearly demonstrate that financial plans are in place to safeguard the affordability of electricity for Ontarians throughout the lifetime of the plant. OPG's application rests on the false perception that nuclear energy generation is cleaner than other energy generation technologies. And it is based on an assumption of need for energy generation at Pickering for Ontario's baseload energy demands.

- **Conditions which advance democratic transparency and effective public engagement must guide the Commission.** OPG's public participation process failed to ensure that all pertinent studies and documentation were accessible to the public through OPG's website. OPG's request for information process was problematic because of the insufficient time and funding provided for citizens and independent experts to do appropriately comprehensive critical analyses.

- **OPG's licence application did not incorporate a transition plan to mitigate the adverse socioeconomic impacts of shutting down Pickering's reactor units on workers, families, and surrounding communities.** This transition plan must be informed by best practices for just transition planning that maintains and enhances livelihood sufficiency and community economic wellbeing, and it must consider the larger transition of the electric power system to renewable technologies.

- **An alternative means assessment should be completed for Pickering NGS's decommissioning activity.** The decommissioning strategies put forth by OPG should be well documented and include a description of options and overall timescales. An "alternative means" analysis is necessary to demonstrate that the preferred strategy will ensure the Pickering NGS will be maintained in a safe configuration at all times, will reach the specified decommissioning end state, cause no undue burdens to be imposed on future generations, and is acceptable to the public and Indigenous communities.

- **The CNSC should also require OPG to develop a DDP that has a sound evidentiary basis and is publicly acceptable.** The DDP should also be sufficiently detailed to allow the evaluation of the licensee's justification and plans for meeting licencing conditions.

- **Ontario's nuclear emergency response plans lack readiness.** The inherent risk of operating a nuclear generating station of Pickering's size in a high-density area, necessitates emergency response planning which is commensurate to the complexity of evacuating, alerting and distributing KI in a populous area. The level of emergency planning currently in place is not sufficient for the Commission to find the risk to the public is acceptably low per section 24(4) of the *NSCA*.

All of which is respectfully submitted this 7th day of May, 2018:

CANADIAN ENVIRONMENTAL LAW ASSOCIATION
Per



Theresa A. McClenaghan
Executive Director and Counsel

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Appendix A

Gibson's (2012, 2017) sustainability assessment criteria.

Socio-ecological system integrity
Build human-ecological relations to establish and maintain the long term integrity of sociobiophysical systems and protect the irreplaceable life support functions upon which human as well as ecological well-being depends.

Livelihood sufficiency and opportunity
Ensure that everyone and every community has enough for a decent life and that everyone has opportunities to seek improvements in ways that do not compromise future generations' possibilities for sufficiency and opportunity.

Intragenerational equity
Ensure that sufficiency and effective choices for all are pursued in ways that reduce dangerous gaps in sufficiency and opportunity (and health, security, social recognition, political influence, etc) between the rich and the poor.

Intergenerational equity
Favour present options and actions that are most likely to preserve or enhance the opportunities and capabilities of future generations to live sustainably.

Resource maintenance and efficiency
Provide a larger base for ensuring sustainable livelihoods for all while reducing threats to the long term integrity of socio-ecological systems by reducing extractive damage, avoiding waste and cutting overall material and energy use per unit of benefit.

Socio-ecological civility and democratic governance
Build the capacity, motivation and habitual inclination of individuals, communities and other collective decision-making bodies to apply sustainability requirements through more open and better informed deliberations, greater attention to fostering reciprocal awareness and collective responsibility, and more integrated use of administrative, market, customary and personal decision-making practices.

Precaution and adaptation
Respect uncertainty, avoid even poorly understood risks of serious or irreversible damage to the foundations for sustainability, plan to learn, design for surprise, and manage for adaptation.

Immediate and long term integration
Apply all principles of sustainability at once, seeking mutually supportive benefits and multiple gains.

Canadian Environmental Law Association
EQUITY. JUSTICE. HEALTH.

May 20, 2014

By email: consultation@cnsc-ccsn.gc.ca

Canadian Nuclear Safety Commission
P.O. Box 1046, Station B
280 Slater Street
Ottawa, Ontario, Canada K1P 5S9

Re: Further Comments from Canadian Environmental Law Association Re: Emergency Planning RegDoc 2.10.1

We write to provide further comments with respect to proposed Emergency Planning Regulatory Document 2.10.1.

Introduction:

On April 10, 2014, we received the communication provided to the Consultation list serve of the CNSC that the Commission is finalizing the draft Regulatory Document RegDoc-2.10.1, *Nuclear Emergency Preparedness and Response* (referred to hereafter as RegDoc-2.10.1). The communication outlined the consultation conducted by the CNSC between August and October 2013, and subsequent feedback on comments. CELA provided its comments on the original consultation dated October 18, 2013 (attached again to this letter for convenience).

In the April 10, 2014 communication, the CNSC outlined its proposal to add three additional requirements that were not included in the original consultation, to the RegDoc-2.10.1, applicable to licensees operating reactor facilities greater than 10MW (which would include of course the Darlington, Pickering and Bruce nuclear power generating plants in Ontario and the Pt. Lepreau plant in New Brunswick).

The three items are the subject of these further comments by CELA. The CNSC proposes to include:

- ``the pre-distribution of iodine thyroid blocking agents to all residences, businesses and institutions within the plume exposure planning zone (sometimes named the primary

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zone or the urgent protective action zone, typically sized at approximately 10 km), and selective pre-distribution in the ingestion planning zone (sometimes named secondary zone or extended planning distance, typically sized at approximately 50 to 80 km)``;

- ``the content of emergency information materials and the distribution of such materials in the plume exposure planning zone, as well as ensuring that emergency plan information is available online to all residents within the ingestion planning zone``;

- The provision of the CNSC and offsite authorities with the technical planning basis for the station`s emergency preparedness and response program.``

The April communication advises that RegDoc-2.10.1 is scheduled to go before the Commission for final approval on August 20 – 21, 2014, and that the final proposed draft will be sent at least 60 days prior to those who participated in the initial round of consultations. We presume that there is proposed language for the final proposal, and must indicate a caveat that the current submission from CELA is prepared without any further detail on the proposed three items other than the three bullets listed above as circulated by the CNSC on April 10, 2014. We therefore may find that upon reading the full amended proposal, we may wish to modify our comments but we will endeavour to provide useful commentary based on what was provided so far. CELA will provide additional comments to each of these three items.

CNSC Jurisdiction and Authority:

Firstly, as a general comment, CELA commends the CNSC for the proposal to add these three items to RegDoc-2.10.1. Their addition, if included in the final proposal, and approved by the Commission in August, 2014, may provide a major level of improvement to the level of emergency preparedness in Canada. Importantly, they could also significantly strengthen the Commission`s ability to assure itself of the state of emergency planning around nuclear power plants in Canada when considering applications for licences for those plants. As CELA noted in our original submission in October 2013 and in prior submissions such as during the Pickering hearing in 2013, this is what the IAEA Guide Standard, *Preparedness and Response for a Nuclear or Radiological Emergency, Series No. GS-R-2,* Safety Standards (Vienna: IAEA, 2002) expects of the national regulator of nuclear power plant licenses. The Commission is the only licensing authority in Canada for these plants as nuclear power plants, and this is an integral factor in licensing. The exercise by the Commission of its authority to review the offsite nuclear emergency plans and to satisfy itself as to their efficacy was also a matter that was the subject of the Fukushima Task Force Report 2011 and the IRSS Report, 2011. We reiterate here our review of these recommendations and the relevant IAEA Standard GS-R-2, edited and updated from our submission to the Pickering hearing in 2013.

The IAEA Standard, Preparedness and Response for a Nuclear or Radiological Emergency, Series No. GS-R-2, Safety Standards (Vienna: IAEA, 2002) sets out expectations as to the responsibility of the regulator. It is the regulator's responsibility, among other things, to do the following (excerpts from GS-R-2 paragraphs 3.8 to 3.12:

- The regulatory body shall require that arrangements for preparedness and response be in place for the on-site area for any practice or source that could necessitate an emergency intervention.
- The regulatory body shall ensure that such emergency arrangements are integrated with those of other response organizations.
- The regulatory body shall ensure that such emergency arrangements provide a reasonable assurance of an effective response, in compliance with these requirements, in the case of a nuclear or radiological emergency.
- The regulatory body shall require that the emergency arrangements "shall be tested in an exercise before the commencement of operation [of a new practice]. There shall thereafter at suitable intervals be exercises of the emergency [arrangements], some of which shall be witnessed by the regulatory body."
- In fulfilling its statutory obligations, the regulatory body… shall establish, promote or adopt regulations and guides upon which its regulatory actions are based;… shall provide for issuing, amending, suspending or revoking authorizations, subject to any necessary conditions, that are clear and unambiguous and which shall specify (unless elsewhere specified):… the requirements for incident reporting;…and emergency preparedness arrangements.
- In planning for, and in the event of [a nuclear or radiological emergency], the regulatory body shall act as an adviser to the government.
- The regulatory body shall ensure that the co-ordinated arrangements are implemented adequately by the operators.

The Fukushima Task Force 2011 discussed the lack of specific regulatory requirements in Canada for operators for emergency planning and the lack of specific and detailed requirements as well as the lack of sufficient regulatory oversight given the gap in the regulatory framework. (CNSC Fukushima Task Force Report 2011 at 40). CELA concurs with this concern, as in reviewing G-225 "Emergency Planning at Class I Facilities and Uranium Mines and Mills" and RD-353, "Testing the Implementation of Emergency Measures", we observed that the requirements were too high-level and non-specific to provide useful measures against which the nuclear emergency plans applicable to an accident at a plant could be compared and tested. The Fukushima Task Force reiterated this concern in its chapter reviewing the Canadian nuclear regulatory framework in view of lessons learned from the Fukushima accident. It again stated that the CNSC should require offsite emergency plans to be submitted along with applications to construct or operate nuclear power plants. (At 53). The CNSC's proposal for RegDoc 2.10.1 will address this issue to the extent that it adds these types of requirements.

The Fukushima Task Force report stated that: ``Federal and provincial nuclear emergency planning could be strengthened through establishing a formal, transparent, national-level oversight process for offsite nuclear emergency plans, programs and performance, and through scheduling of regularly planned full-scale exercises.``[1] The IRSS report also noted these

[1] (CNSC Fukushima Task Force Report, CNSC INFO-0824, October 2011 at iv, v)

Fukushima Task Force made recommendations that the CNSC should require the submission (to the CNSC) of the provincial nuclear emergency response plans. The IRSS report encouraged this to be done. (At 58) In the presentation by CNSC at the March, 2013 inter-jurisdictional emergency planning workshop, the responsibility of regulators to ensure emergency response capability and these Fukushima Task Force and IRSS recommendations were also noted. The IRSS report (conducted of CNSC from Nov 26 to Dec 2, 2011) also noted that there are a multiplicity of agencies and levels of government with responsibilities in nuclear emergency planning in Canada and recommended that the CNSC should "verify the requirements and standards described in the offsite emergency plans are met, through tests and assessments." (at page 59)

CELA submits that even without additional regulatory amendments recommended by the Fukushima Task Force and the IRSS, the CNSC already has jurisdiction to consider the adequacy of the emergency plans in place at nuclear power plants in deciding whether to issue the licence requested, and/or whether to impose additional requirements by way of licence conditions to better protect health, safety and the environment. (Sections 3, 9, 24 of the *Nuclear Safety and Control Act*, S.C., 1997, c. 9) However, the addition of specific requirements by way of a proposal such as RegDoc 2.10.1 will improve the CNSC's oversight and ability to assure itself of the sufficiency of offsite emergency planning.

CELA again urges that the Fukushima Task Force recommendations for CNSC oversight of the offsite nuclear emergency response plans be pursued forthwith by way of amendment of the CNSC regulations such as RegDoc 2.10.1 and requirements there-under. This particularly includes the recommendation for description of the regulatory requirements to address radioactive hazards during an emergency **in greater detail**. This also includes the recommendation of the Task Force to enhance regulatory oversight with periodic safety reviews and to increase requirements for "requirements and expectations for both design basis and beyond design basis accidents``. (Task Force at v).

As important as the role of the province is in developing their general emergency plans, and their specific nuclear emergency plans, they are not the approval authority for the licensing of nuclear power plants. It is untenable that the content and efficacy of those plans be determined entirely by agencies that are not regulated directly by the CNSC such as EMO, as important as they are in the undertaking of the plans. Constitutionally, the authority over nuclear power plants has, as you know, been definitely declared to be federal by way of the declaration of nuclear power to be for the general advantage of Canada (*Ontario Hydro v Ontario Labour Relations Board* [1993] *3 SCR 327*. We have noticed recent correspondence by the EMO to the CNSC objecting to the CNSC`s jurisdiction to set the content of offsite emergency planning and we respectfully submit that they are in error in this submission as this is a matter integral to the operation and licensing

of nuclear power in Canada. Furthermore, as noted it is the CNSC and only the CNSC which has the authority in furtherance of the purposes of the *Nuclear Safety Control Act* in granting licenses. While the EMO has a role, they do not have the jurisdiction over plant licensing, and plant licensing considerations cannot stop at the plant boundary. The Act requires the Commission in licensing assure itself that the licensee:

> s. 24(4) (*b) will, in carrying on that activity, make adequate provision for the protection of the environment, the health and safety of persons and the maintenance of national security and measures required to implement international obligations to which Canada has agreed*

It is a red herring that the Ontario cabinet approves the provincial nuclear emergency response plan. If nuclear power plants are to be operated in the province, then all requirements of the national regulator must be met. If these include specific components relevant to offsite protection of the public from effects of accidents at those plants, then the operators must comply, and must demonstrate a reasonable basis to rely on other actors such as EMO to ensure that the level of protection required by the CNSC is in place.

Turning to the specific three additional matters proposed to be added to RegDoc- 2.10.1, we will provide more specific submissions in respect of each one.

1. Pre-distribution of iodine thyroid blocking agents to all residences, businesses and institutions within the plume exposure planning zone, and selective pre-distribution in the ingestion planning zone.

(i) Predistribution within the Primary Zone:

CELA supports pre-distribution of iodine. In addition to predistribution within the Primary Zone, CELA submits that the selective pre-distribution in the ingestion planning zone should include in the case of Durham region, the geographical area between the Pickering and the Darlington nuclear generating plants that are outside of 10 kilometers, but between two plants. (We also submit that the plume exposure planning zone or "primary zone" should be expanded as per our prior submissions in the Darlington and Pickering licensing hearings in 2011, 2012 and 2013.)

We repeat here many of the submissions we made following our thorough review of the state of emergency planning during the Pickering 2013 licensing hearing, which includes a summary of some of the key documents and rationale pertaining to the issue of Potassium Iodide (KI) (referred to above in the CNSC proposal as ``thyroid blocking agents``). The following is edited for the current context as submissions respecting proposed RegDoc-2.10.1.

Potassium Iodide (KI) is important because its ingestion helps to block uptake of radioactive iodine in case of a severe offsite accident. Radioactive iodines are among the earliest radionuclides emitted from a nuclear power plant in case of breach of containment or in controlled venting following an accident. Emergency response to protect against radioactive

iodine is needed since iodine "concentrates in the thyroid gland... a quarter of all ingested iodine goes to the thyroid under normal circumstances. As a result, when iodine is ingested the thyroid receives a very large dose compared to the rest of the body (roughly 1000 times as much)"[2]. Health Canada states that: "Once in the bloodstream, about 20% of the iodine is absorbed by the thyroid.... It is particularly susceptible to beta and gamma irradiation from radioisotopes of iodine, especially I-131." (Health Canada Guidelines for Intervention During a Nuclear Emergency, 2003 at 21).

The ICRP notes that Iodine Thyroid Blocking is primarily intended as a short term measure to reduce uptake of radioiodines by the thyroid from inhalation over a few days. The prevention of uptake by ingestion should primarily be accomplished by controlling foodstuffs, milk and water that may be contaminated. (ICRP Publication 109 at 65). IAEA Guide GS-G-2.1 states that radioiodine uptake by the thyroid gland following an accident can be reduced by taking stable (non-radioactive) iodine. It outlines that "to achieve maximum effectiveness, stable iodine must be administered before or soon after the intake of radioiodine. The effectiveness of the measure decreases rapidly with delay, and can be reduced to 50% or less if administered 6 hours after a single intake of radioactive iodine." (at Appendix V, V.15) The IAEA Guide states that its reduction of dose is only 20% 10 hours after the intake of radioiodine and almost zero 24 hours after. (Ibid, V.15) ICRP publication 109 reinforces this – if stable iodine is taken up to 6 hours **before** the intake of radioactive iodine, "the protection provided is almost complete"; if at the time of radioiodine inhalation, its effectiveness is 90%; and 50% within a few hours. The ICRP stated that "to obtain the maximum reduction of the radiation dose to the thyroid, stable iodine should be administered **before** any intake of radioiodine or **as soon as practicable thereafter**." (At 65.) (emphasis added)

As long ago as 1984, the province of Ontario's Working Group #2 to the Ontario Nuclear Emergency Plan (established by the Solicitor General to make recommendations on the use of stable iodine in case of a nuclear emergency) recommended pre-distribution of KI because it must be ingested very early in or prior to a release from an accident in order to be effective. The Working Group #2 also reviewed the reasons for ingestion of KI for thyroid blocking as a significant preventive measure for public health to prevent early thyroid injury or longer term thyroid cancer risks. The Working Group stated that "The Group recognized that the cost-

[2] Working Group #8, 1988 at 4; see also IAEA Guide GS-G-2.1 at V.17 which states that "The thyroid gland absorbs and concentrates iodine once it has been inhaled or ingested; thus the potential exists for large thyroid doses following the occurrence of severe core damage at a large reactor. A large dose to the thyroid can result in deterministic effects in the thyroid gland and radiation induced thyroid cancer. In the event of **actual or possible** core damage, stable iodine prophylaxis should therefore be used: to prevent deterministic effects in the thyroid gland (e.g. hypothyroidism; to reasonably reduce the risk of stochastic effects (e.g. radiation induced thyroid cancer) from the inhalation of radioiodine within or near the facility." (emphasis added).

benefit ration was high, but that it would be prudent to consider pre-distribution." (at Recommendation #3) Provincial Working Group #2 also stated in 1984 stated that "if there is any use at all by KI as a blocking agent it would have to be by pre-distribution to an area considered to be at risk." – this was based on the time frame in which KI must be taken to be effective, and that if the warning time available before release is as little as thirty minutes, then "that will not be sufficient for house-to-house distribution from a central stockpile." (At 6).

CELA submits that KI MUST be pre-distributed because it must be ingested before or shortly after a radioactive release, and if necessary during a release[3]. It would not be reasonably feasible to quickly obtain KI after such a severe accident that requires ingestion of potassium iodide. In that scenario people will likely be required to shelter in place and/or evacuate so it will not be possible to attend pharmacies to obtain it, nor would it be practical to have extensive distribution at that time.[4] In any event there is no possibility this could happen on time for the affected population numbers if there was not adequate pre-distribution. The IAEA Guide GS-G-2.1 stresses that other organs (bone marrow, lungs and other organs) are not protected by KI and therefore "sheltering or evacuation of people at risk of life threatening doses should not be delayed for the provision of stable iodine prophylaxis." (at V.21)

There is a further concern about the adequacy of KI availability. This is highlighted by comparing the numbers of KI pills available. During the Pickering hearing, the CNSC staff submission noted that there is an inventory of 325,000 potassium iodide tablets for residents of the 10 km zone around Pickering (page 62 of the CNSC's submission CMD 13-H2.) This compares to the population of approximately 260,000 in the 10 km zone[5] but does not take account of the potential necessity for repeat doses nor for provision beyond the 10 km primary zone to the high populations in Scarborough and Pickering in the event of an offsite emergency requiring broader KI distribution.

We have compared the lack of a comprehensive KI pre-distribution approach in Ontario to the approach taken by France as described by J.C. Niel[6], in Ottawa during remarks made on April 10, 2013 during a session on Emergency Management. He stated that the approach taken by

[3] IAEA Guide GS-G-2.1 at V.19; See also Working Group #8, 1988 at 6.

[4] See also Working Group #8 Report 1988 where it notes that Emergency Planning Ontario considered the lower Protection Action Level for thyroid blocking to be "only for advising persons already in possession of potassium iodide pills to ingest them." (at 19)

[5] DRNERP 2011 and TNEP 2012 sources for total population numbers within 10 km of the Pickering NGS.

[6] J.C. Niel, of the Autorite' de surete' Nucle'aire (ASN) at the IAEA International Conference on Effective Nuclear Regulatory Systems hosted by the CNSC in Ottawa, April 8-12, 2013.

France for KI distribution had been first to mail all of the residents in the protective action zone coupons to redeem at local pharmacies for KI for the household, at no charge. After finding that the uptake was insufficient, they then mailed every single household the KI doses needed to ensure that they would have them on hand in the event of a severe accident. CELA submits that based on testimony heard by the Commission at several recent licensing hearings, it is obvious that there is a similar lack of awareness and lack of uptake of KI by households in advance of a potential accident and therefore pre-distribution is the only reasonable approach.

The CNSC Fukushima Task Force Report, 2011 also noted that the effectiveness of the approach of stocking the KI tablets at local pharmacies, as opposed to pre-distribution to all households "has not been confirmed." (at 52) It is notable that the CNSC 2011 Fukushima Task Force reported that Ontario is the only nuclear province in Canada that does not pre-distribute KI to the residents in the surrounding planning zones. (at 47)

CELA supports the proposal that the CNSC require and ensure 100% pre-distribution of KI tablets to the residents in the Primary Zone, as well as institutions and businesses and that this requirement be included in the licensing conditions for each of the nuclear generating stations in Canada.

(ii) <u>Selective Pre-Distribution in the Ingestion Planning Zone and Population Growth:</u>

Furthermore, CELA recommends that all residents of the area between the Pickering and Darlington nuclear power plants in Ontario be included in pre-distribution of KI, even if outside of the current 10 km primary zone. These residents are at increased risk of exposure from an accident with offsite consequences by virtue of being resident in close proximity to two sets of NPP units. The necessity for this recommendation is further indicated by the inclusion of Durham Region in the province of Ontario`s Places to Grow targets for increased density of populations therein, and the City of Pickering's plans for increased density by way of Official Plan amendments. See for further details the excellent letter written by Ms. Barbara Pulst to Ontario's Ministers of Infrastructure and Community Safety on May 2, 2014, and included here with her permission. Additionally, OPG commented at the recent hearing to remove the Hold Point at Pickering, in response to a question about their recent submissions to the Ontario Energy Board seeking resources for a research project, that there is the possibility of operating the plant for a longer time frame than has even been contemplated in recent CNSC licensing applications. (See CNSC Public Hearing Pickering Hold Point May 7, 2014 Edocs # 4433743 transcript – pages 134-136). In any event, the expectation that the Pickering plant may close in a few years is not a valid argument to avoid the costs of KI pre-distribution in this larger area, since the corollary is that it is an aging plant, with all of the technical and performance issues that entails. From the perspective of the public, the necessity of KI pre-distribution is as important as ever,

during every year of operation, and potentially more-so in the latter years of the plant`s operations.

(iii) **Access to KI pills by residents beyond the 10 km zone.**

During the recent hearing regarding removal of the Pickering holdpoint, CNSC staff (per Mr. Santini) stated that in the proposal for the amended RegDoc 2.10.1, licensees will also be required to ensure that sufficient stocking of KI pills for residents beyond the 10 km zone is provided[7]. CELA supports this, in addition to pre-distribution, and in addition to our recommendation for automatic pre-distribution in the zone between Pickering and Darlington in particular. CELA submits that the RegDoc must also require that information as to where these KI pills can be obtained, and clear direction to pharmacists to release them on request (as opposed to seeking proof of residency within the 10 km zone) must be provided and widely communicated to the public.

2. The content of emergency information materials and the distribution of such materials in the plume exposure planning zone, as well as ensuring that emergency plan information is available online to all residents within the ingestion planning zone.

CELA supports this addition to the RegDoc and recommends that the CNSC specify minimum content for the emergency information materials that are to be distributed and posted. CELA also submits that the CNSC should require demonstration of the effectiveness of the information program, and its reach, with verifiable objective measures to show the level of awareness of the general public as to what they would have to do in an emergency. Very basic information is required especially in the case of the Ontario plants, in all of Durham Region and a large portion of the City of Toronto where recent license hearings have demonstrated the general lack of availability of information for the public. For the Bruce and Pt. Lepreau plants, the situation may be similar (CELA will be examining the general state of emergency planning preparedness and compliance for the next Bruce licensing hearing with the assistance again of funding from the CNSC`s funding panel). There has been a recent initiative by OPG to distribute a `flashlight`` brochure with basic information in a format that has a better likelihood that it will be retained by home-owners. However, the level of awareness and state of knowledge by the general public is so lacking that it will take repeated and concerted efforts at outreach, public education, training, and communications to ensure that the residents of these areas around the OPG plants are sufficiently informed. In addition, this brochure is only the beginning and much more information needs to be disseminated. For example more details on decontamination; on sheltering efficacy; on specifics around family reunification; on transportation when there is no personal transportation, and many other practical examples require extensive public education for residents living in the vicinity of Canada's nuclear power plants. Furthermore, most communications efforts by the plant operators have been to communicate their perspective that

[7] (see CNSC Edocs # 4433743, transcript May 7, 2014 at page 68).

the plants are safe and it is therefore difficult, we predict, to have the public take in the message about the necessity of awareness about nuclear emergency planning. Given the decades of operation by these plants in these communities, this is a striking state of affairs and it is therefore evident that the CNSC as regulator must assume oversight on this topic for the sake of protection of the public from potential accidents at the plants. As the Japanese regulator attending the IAEA Regulator`s conference in Ottawa stated last year, the lack of emergency readiness was a significant factor in the extent to which the public was affected by the Fukushima accident. [8] An informed, well-educated public residing in the vicinity of operating nuclear power plants is essential. We repeat here, in edited form, the submissions we made on this topic during last year`s Pickering hearings:

To this point in time, it has been a matter of significant concern as to the extent to which the public for example in both Durham Region and the City of Toronto have been unaware of, and not engaged in providing input to the content of the nuclear emergency plans. This in itself increases the risks and potential consequences from a severe offsite accident at a nuclear power plant. During the recent Pickering and Darlington licensing processes, for example, it was evident that many residents of Durham region were unaware of provisions in the Nuclear Emergency Response Plan that anticipate that they will find their own accommodation with friends and family in case of evacuation; that they may be asked to "self-decontaminate" in some scenarios, and what that means; that KI is effective only if taken before or immediately upon commencement of a release; they were unaware of the transportation plans that would be available if they do not have their own vehicles; and they were concerned about family reunification in the event of evacuation scenarios in which members of their family are evacuated separately from the family such as from schools and long term care institutions.

IAEA Publication "Lessons Learned from the Response to Radiation Emergencies (1945 – 2010), (IAEA, August 2012) includes a comment in the chapter "providing information and issuing instructions and warnings to the public", about the importance of providing information to the public on protective actions to be taken in event of an emergency in **advance** of any emergency for threats such as Nuclear Power Plants. They stated that "This will engender confidence – the knowledge that the officials have their interest at heart – and, by doing so, improve compliance with protective action recommendations in the event of a real emergency. In addition, there will be a better understanding of the systems used to warn them of an

[8] The attitude in which lower levels of preparedness have until this point been accepted in Ontario is reminiscent of that described at an IAEA Regulator`s Conference hosted by the CNSC in Ottawa in April 2013, at which Toshimitsu Homma of the Japan Atomic Energy Agency stated in a Conference Panel on Emergency Management that the most important lesson of Fukushima was that before the accident, ``There was an implicit assumption that such a severe accident could not happen and thus insufficient attention was paid to such an accident by authorities.``[8]

emergency." (At 27) This requirement is reinforced by the comment in ICRP Publication 109[9] which recommends engagement with stakeholders and discussions of the plans, including with members of the public. The rationale is that "Otherwise, it will be difficult to implement the plan effectively during the response. The overall protection strategy and its constituent individual protective measures should have been worked through with all those potentially exposed or affected, so that time and resources do not need to be expended during the emergency exposure situation itself in persuading people that this is the optimum response." (at 42)

CELA agrees with these assessments but we have not seen a sufficient level of advance communication with the public in the 10 km zone and beyond, around at least the Pickering and Darlington NGS's, both within the Region of Durham and within the City of Toronto, to feel confident that people sufficiently understand the protective actions to be taken in the event of a nuclear generating station emergency. The recent distribution of the "flashlight" brochure is positive, but this will not be sufficient. CELA supports the CNSC in requiring extensive public engagement to be undertaken by licensees as a condition of operating licences of the Nuclear Generating Stations, to include detailed specific explanation of the protective actions that may be required, why, how they would be communicated and in what eventualities. In particular, CELA supports this addition to the RegDoc-2.10.1, provided the Commission includes an outline of detailed minimum content and expectations for public communications and its efficacy in terms of improving public safety and preventing harm to members of the public in the event of an accident.

3. The provision of the CNSC and offsite authorities with the technical planning basis for the station`s emergency preparedness and response program.

This requirement would be a significant improvement to RegDoc- 2.10.1. CELA submits that after obtaining the technical planning basis for the various Nuclear power generating stations' emergency preparedness and response programs, the next step will be to evaluate its suitability, and if necessary (as we submit is likely), to require improvements to the planning basis, i.e. to assure that more severe accidents such as multi-unit accidents as occurred at Fukushima, or severe catastrophic offsite releases as occurred at Chernobyl and Fukushima are part of the offsite emergency planning basis. This discussion must engage the public. In particular, given that CNSC staff stated during the May 2014 hearing on removal of the Pickering Hold-Point, that this would include provision of release and source term information, we submit that members of the surrounding community and public interest organizations such as CELA must be engaged in the discussion as to the appropriate planning basis. As we submitted during our comments on the recent Pickering and Darlington licensing hearings, it was obvious from the

[9] International Commission on Radiological Protection, "Application of the Commission's Recommendations for the Protection of People in Emergency Exposure Situations", (ICRP Publication 109, 2008)

documentation that the planning basis was a much smaller accident – at least in Ontario in the 2009 plan it was based on assumptions that radiation doses would not be over 250 mSv at the plant boundary, for example. The 2012 plan stated that with low probability, an accident could occur "which could result in a more severe offsite effect." The 2012 premise was a significant improvement over the 2009 plan, but on the ground detailed planning is not yet in place to respond to a catastrophic type accident. The CNSC should assume regulatory oversight over this issue in RegDoc 2.10.1 in terms of assuring itself BOTH that a sufficiently large accident is utilized as the planning basis for emergency planning AND that the emergency plans themselves are sufficiently detailed that there is a realistic prospect that such a large accident would meet a robust emergency response that would significantly reduce harm to people offsite. In our submission this includes evaluating the sufficiency and particularity of the public notification, evacuation planning, KI pre-distribution, decontamination, medical response and all of the other details of the plan. CELA strenuously submits that the response that the CNSC has been provided to date (that in Ontario at least) that the province's plans "are sufficiently flexible" to respond to a larger accident should be wholly unacceptable to the Commission. CELA is hopeful that the large offsite accident exercise that is planned for the end of this month will provide more information as to the extent to which the existing plans would be responsive, but urges the commission to demand strenuous demonstration of the efficacy of the offsite emergency plans to respond to large offsite emergencies as a routine condition of all licensing of nuclear power plants going forward. Given that the forthcoming exercise will not result in actual notification to hundreds of thousands of people, nor actual advice to ingest KI, nor actual advice to shelter, nor actual evacuation of those same numbers of people, there must be surrogates to establish confidence in the plans. The exercise (which is absolutely necessary) must be supplemented with other mechanisms to demonstrate sufficiency and efficacy of the plans and we submit that one measure of this is that there is sufficient detail in the planning for the Commission to be more assured that it would be sufficiently responsive. For example, the Commission being told the plans are "flexible enough" to respond does not provide a strong basis for the Commission members to have confidence in the emergency planning. Again as earlier submitted it is the Commission itself which must be satisfied under the NSCA that the public will be protected in the event of an accident.

Although CELA has a much more extensive treatment in our prior submissions, as to the background pertaining to the planning basis, we here repeat the portion of our prior submission dealing with the current state of planning readiness in Durham region, and reference therein the Fukushima Task Force and IRSS recommendations that support this addition to the RegDoc. We would also add that despite recent references by witnesses in various Commission hearing processes to "work that is underway" on these topics, there is no public documentary information available as to what improvements will be made to the requirements for emergency planning other than the present consultation (and the CSA consultation that was temporarily available to the public last August, but is not now available despite requests to the CSA.) We should also add that CELA and Greenpeace were invited to present our recommendations from the Pickering hearing on emergency planning and planning basis to the inter-jurisdictional committee on nuclear emergency planning in Ontario. This was appreciated, but it was a one-way exercise wherein we outlined again a high level overview of our findings and recommendations but we have not yet been engaged by the planning authorities in any discussion on the planning basis or any other concrete changes to the regulatory requirements or to the offsite plans themselves.

Accordingly the following remains the state of the public record in this respect regarding the planning basis, and our concerns remain relevant.

The IAEA's Integrated Regulatory Review Service (IRRS) report post Fukushima (November – December 2011) called on the CNSC to do a "national assessment of nuclear power plant off-site emergency plan that includes all relevant organizations". (at page 10) It made a specific recommendation: "**The Government of Canada should assure** that the review and assessment of off-site emergency plans for nuclear power plants includes all relevant authorities, are comprehensive, and that the relevant organizations which implement those plans are capable of performing the assigned duties." (IRSS at Recommendation RF7). (emphasis added)

The level of detail of emergency planning and preparedness is a significant issue. CELA submits that the CNSC must ensure a level of detail with specified time frames, tested and verified, to respond to large offsite severe accidents. CELA submits that the current level of planning in Ontario beyond the 10 km zone has hardly exceeded what Commissioner Hare in 1988 called "a conceptual framework" that would "enable a response to be improvised should an emergency occur before all preparations are complete." (Hare, Vol. 1, 1988, p. 230)[10] The CNSC Fukushima Task Force, 2011, confirmed that the PNERP, 2009 is "based on a single-unit accident and does not consider multi-unit accidents." (At 45.) The issue of the adequacy of the current emergency planning basis in Ontario was briefly discussed on December 3, 2012 hearings before the CNSC on the Darlington refurbishment application, when a witness[11] from Emergency Measures Ontario discussed their desire to have "a greater inclusivity of events beyond the normal planning horizon". Although they indicated they were satisfied with the responses provided by CNSC staff prior to that hearing in response to a letter[12] they had

[10] The Working Group #3 report (1984) is explicitly referenced in PNERP, 2012 as the basis for selection of Protection Action Levels. That report was described in the Working Group # 8 report (1988) as background that had been conducted pre-Chernobyl. They stated that Working Group #3 recommended that "in the case of accidents which were in fact more severe than the MPA {Maximum Planning Accident}, authorities should be able to cope by improvising on the plans which would already be in existence based on the MPA." The MPA was recommended to be one that "gives a dose to an unsheltered person 1 km from the nuclear station (that is, the assumed boundary fence). The 25 rem {250 mSv} was stated to be based on the assumption of good engineering practice and the operating experience to that time, together with the particular properties of CANDU reactors, especially that the moderator could act as an additional heat sink in case of failure of both the normal and the emergency cooling systems (and so prevent severe core damage), and the belief that detailed planning was unnecessary for events of probability less than once per million reactor years in situations where there are about 10 reactors per power station." (Working Group #8 at 8-9, describing Working Group #3's recommendations).

[11] Alison Stuart, ADM and Chief EMO, December 3, 2012, Darlington Refurbishment Hearing before the CNSC

[12] The letter is attached to CMD 12-H13.A in the Darlington Refurbishment and Continued Operations EA CNSC hearing.

submitted to the CNSC, they also recognized "this isn't the last time we will be sitting here" and it was not the only opportunity they would have to continue to push what EMO thinks is really important regarding emergency management in terms of how to plan and how to exercise and how to modify the nuclear emergency plans going forward. In response to a question by the CNSC President about what EMO would be able to do by 2014 for the refurbishment continued operations licence, the witness further stated that they are in a process of evolution – and would want to present a provincial position that represents various aspects of planning that goes well beyond traditional planning scenarios. She commented that they would be working with all partners in that expanded view of the world. She looked forward to being able to speak to that at subsequent hearings and being able to identify any areas of concern as well as hopefully areas of significant progress. CELA submits that the CNSC commissioners must demand details of the offsite emergency planning basis and independently assess its sufficiency in licensing applications.

Contrasted with the Ontario PNERP, 2009, the PNERP, 2012 states that, with low probability, an accident could occur "which could result in a more severe offsite effect." It is defined as one or more of: i) the time between the accident and release of radioactivity may be generally limited {also sometimes described in other regulatory and industry documents as "early release"}; ii) radiation doses could be high, greater than 250 mSv at the plant boundary; iii) radioiodines and particulates could form a component of the radioactive emission; iv) environmental contamination could be significant; v) area affected could be larger than for the basic offsite effect. (At 2.3.3 (d)). For these more severe but less probable accidents, the province outlines a limited number of issues for which to undertake preparedness: " i) timely public alerting and direction; ii) prioritizing evacuations for those closest to the hazard; iii) radiation monitoring and if necessary, decontamination; if needed, medical assessment, treatment and counselling." (At 2.3.3.(e)) The PNERP states that the detailed planning and preparedness "will establish an effective basis to deal with an emergency caused by any type of nuclear installation accident." Despite this provision, CELA is concerned that detailed planning is not yet in place for a very severe catastrophic accident. During our reviews for the Darlington and Pickering hearings, it was evident that the level of planning was more consistent with the prior PNERP 2009 and the traditional, smaller accident it outlined. And while some of those who intervened in these hearings (Canadian Environmental Law Association, Durham Nuclear Awareness, and Greenpeace) have had assurances by the province that the planning basis is under examination, we have not yet been provided any further information or been asked for input. For example, the inability to assess the extent to which the province and emergency responders are prepared to deal with medical assessment and treatment because of the lack of available Radiation Health Plans is one indicator that the province still does not have that capability in place. We should note that even now, in May 2014, the province's Radiation Health Plan has not yet been made public.

CELA has not yet seen evidence that more severe, beyond design basis severe accidents, initiated by a variety of severe external events such as hostile action, extreme weather events and others have been considered in Ontario as a basis for emergency planning[13]. Similarly, CELA has not seen evidence that the consequences of multi-unit events have been considered in Ontario as a basis for emergency planning. To the contrary, the CNSC Fukushima Task Force Report 2011 stated that none of the nuclear power plant operators in Canada had at that time considered `multi-unit accident scenarios in development of their emergency plans``. (at 37) The Task Force stated that it was confident that the operators could respond to a beyond design basis accident ``**provided they are single-unit accidents only**. `` (at 37, emphasis added). While there have been indications that the exercise planned for the end of May, 2014 will represent a multi-unit accident, no details have been made public.

CNSC should require multi-unit severe accident planning to be demonstrated by licensees, along with the effectiveness of off-site emergency response in such a case. Similarly, CNSC should ensure, contrary to previous practice, that extreme natural hazard initiated events and "gross human error" are also examined in terms of presenting an emergency planning basis, and that the on-site and off-site emergency preparedness and planning are demonstrated to be sufficient and reliable to respond to all of these undesirable scenarios in the event that they lead to severe offsite releases.

A related concern is that raised by the Fukushima Task Force Report (2011) that the licensee can perform "post-accident source term estimation" – however "these are designed for **an accident in only one unit**." (emphasis added) (At 38). As the Task Force noted, this is important information to be able to provide to offsite authorities in the case of a nuclear accident. CELA recommends that this post-accident source term information be required by the CNSC as a condition of licensing and that the CNSC require OPG to upgrade their capacity to provide source term information and its basis, for multi-unit accidents, as a condition of licencing. This should include reassessment of plume and dose modelling for multi-unit accidents at the Nuclear Generating Stations (see Task Force Report at 38).

For severe accident emergency planning, twenty-five years after the Hare commission, CELA is of the view that Ontario still only has a "conceptual framework" allowing for "improvisation" in the event of a catastrophic accident at Ontario nuclear power plants, including the Pickering NGS (what the EMO witnesses called "flexibility" in the recent hearings.) Despite all of the recommendations, Commissions, and world-wide accident experience that would suggest that planning for more severe accidents is required, post Fukushima there has been some discussion

[13] Even consideration for Severe Accident Management (i.e. on site response) was not adequately considered, analyzed, nor incorporated into licensing requirements in Canada pre-Fukushima. See Fukushima Task Force, CNSC INFO-0824, October 2011 at 35.

about increasing the basis for accident planning, and recommendations to do so, but changes in the Plans, in emergency preparedness on the ground, and in details of planning are not yet evident or proven. CELA recommends to this Commission that now is the time to end the situation of operating the nuclear power plants without sufficient detailed emergency planning for large scale catastrophic accidents in place.

In terms of a planning basis, in RegDoc 2.10.1 CELA recommends that the CNSC should require the licensees to demonstrate that there are, in place, properly resourced, sufficiently detailed emergency and preparedness plans that would address Chernobyl–size accidents or Fukushima–size accidents. The basis for this recommendation includes world-wide experience with these catastrophic accidents. This recommendation is independent of particular event sequences and rather takes account of the myriad ways that things that can go wrong resulting in an accident and resulting in a serious breach of containment, regardless of how caused. It also includes consideration of the fact that among the events that may initiate a catastrophe at a CANDU are those that are beyond the control of the operator such as hostile action or unforeseen external weather events or unforeseen combinations of failures including human error. There is no policy justification for excluding these types of events from emergency planning and preparedness since it is amply demonstrated (Three Mile Island, Chernobyl, Fukushima, 9/11) that all of them may occur in the real world, with disastrous consequences.[14]

RegDoc 2.10.1 should provide that licences will not be granted by the CNSC without demonstration of not only the planning basis, but the sufficiency of the planning basis, and the ability of the relevant emergency offsite planning to actually respond to severe offsite accidents with large releases and prevent and reduce harm from those accidents are actually in place and demonstrated to the regulator, with evidence, to be effective. CELA also submits that it is critical that this evidence be made public. Members of the surrounding communities must be

[141414] CELA notes that the Working Group #8 Report included a concept of Worst Credible Radiation Emission in its 1988 report, which it described as "the very worst that could happen: the maximum effects possible from any accident, however caused or however developed" and that it would thus encompass accidents including those that could not be calculated due to lack of quantifiable data as well as those with very low probabilities. For this accident that the Working Group #8 styled "WCRE", it recommended that planning be done to prevent "the worst consequences" of this type of accident; namely early morbidity or mortality. Their rationale was that the most severe consequences are "extreme enough to warrant consideration in planning" "however remote their likelihood." Working Group #8 also based this recommendation in part on the fact that provincial and other authorities, when interviewed at this time (1988) , were of the view that their ability to "improvise" for such a severe accident would begin after 24 hours, but "immediate and effective improvisation was not thought to be possible" before 24 hours in the case of a larger than anticipated event. (At 28.) The Working Group decided that "in general no probability could be associated with the WCRE... it represents the bounding case which subsumes all events, however low their probability." (At 62.) The WCRE would result from the "failure of a large number of fuel elements in a short period of time, with a simultaneous breach of containment."

able to understand what is in place; how effective it is; what has changed; and on what basis the regulator is judging the emergency plans to be in place.

We trust that the foregoing is of assistance, and we ask that we continue to be advised and engaged in the development of RegDoc 2.10.1 and its subsequent consideration by the Commission.

Yours very truly,



Theresa A. McClenaghan
Executive Director and Counsel

Encl:
Letter from B. Pulst to Ontario Ministers of Community Safety and Infrastructure, May 2, 2014
Letter from CELA to CNSC Consultations dated October 18, 2013

From:
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May 2, 2014

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Pickering "Urban Growth Centre" & Pickering Nuclear Generating Station & Public Safety

Minsters Murray and Naqvi,

By way of introduction, I live in the City of Pickering and through neighbourhood conversations, attending meetings, participating in community events, following the news and conducting research; I have seen a concern growing.

I believe a proposal to intensify residential development around the Pickering Nuclear Generating Station (PGNS) contravenes International Atomic Energy Agency (IAEA) siting and emergency planning standards.

As the Ministers responsible for Ontario's offsite nuclear emergency plans and municipal planning I ask the government to instruct the City of Pickering to put these plans on hold until the future of the PGNS has been clarified and adequacy of Ontario's offsite nuclear emergency plans has been properly assessed.

There are already over 260,000 people that live within 10 km of the PGNS which raises significant issues regarding the adequacy of a major accident at the station. Despite the questionable adequacy of current emergency plans, Ontario Power Generation (OPG) is proposing to run the station beyond its design life until 2020.

In this context, the City of Pickering is proposing to amend their *Official Plan* to intensify the designated 'Urban Growth Centre' to accommodate up to 6300 residents in City Centre South, including a school, within 3 km of the nuclear station by 2031.[1]

This proposed intensification around the PGNS is in contravention of IAEA safety standards for the purposes of emergency planning and the siting of nuclear power plants.

I see no evidence that the Ontario government has been monitoring population growth in the City of Pickering.

The IAEA's safety standards underline the responsibility of the government of Ontario to monitor and control population growth over the life of a nuclear station, up until decommissioning.

> *5.1 The characteristics of the natural and human induced hazards as well as the demographic, meteorological and hydrological conditions of relevance to the nuclear installation shall be monitored over the lifetime of the nuclear installation. This monitoring shall be commenced no later than the start of construction and shall be continued up until decommissioning.*[2]

The Province of Ontario's *Places to Grow Plan* identifies the City Centre of Pickering as an "Urban Growth Centre". [3] This growth centre is in close proximity to the PNGS.
The IAEA's safety standards state:

> *4.11 … information on existing and projected population distributions in the region, including resident populations and to the extent possible transient populations, shall be collected and kept up to date over the lifetime of the installation.*[4]

City of Pickering's proposed amendment 26 to the Official plan includes a school within 3 km of a nuclear power plant.
The IAEA's safety standards state:

> *4.11 cont'd … Special attention shall be paid to the population living in the immediate vicinity of the installation to densely populated areas and population centres in the region, and to residential institutions such as schools, hospitals and prisons.* [5]

Secondly, I see no evidence that the Ontario government has been assessing the feasibility of emergency plans to deal with this growth.

The City of Pickering's plan impedes evacuation by almost doubling the population dependent on existing emergency plans and evacuation routes, a population which is sandwiched between Hwy. 401 and Lake Ontario.
This contravenes the IAEA's safety standards:

> *6.1..There should be no adverse site conditions which could hinder the sheltering or evacuation of the population in the region or the ingress or egress of external services needed to deal with an emergency.*
> *6.4 The presence of large populations in the region or the proximity of a city to the nuclear power plant site may diminish the effectiveness and viability of an emergency plan.*
> *6.7 It is possible that conditions assessed for the purposes of approval of the site and design will change over time. The site related factors considered in the emergency plan, such as infrastructural development, should be reviewed periodically during the operational phase of the plant.*[6]

Furthermore:

> *5.14* and *5.15 if "radiological risk to the population associated with accident conditions including those that could lead to emergency measures being taken* is not found to be *acceptably low* then the *site shall be deemed unsuitable for the location of a nuclear installation of the type proposed".*[7]

The Canadian Nuclear Safety Commission (CNSC) reiterates the necessity of monitoring growth, special populations, future development, characteristics and land use in the protective zone which should not impede the implementation of emergency plans. [8]

I would like to remind you, Minsters, that the federal *Joint Panel Review* (JRP) that considered OPG'S proposal for additional reactors at the Darlington nuclear station in Clarington found in 2011 that population growth and the siting of sensitive public facilities needed to be controlled around the station to ensure the ability of nuclear emergency plans to protect Ontarians in the event of an accident.

Recommendation 44 (Section 6.2) states:

> *The Panel recommends that the Government of Ontario take appropriate measures to prevent sensitive and residential development within three kilometers of the site boundary.*[9]

And Recommendation 59 (Section 7.3) states:

> *The Panel recommends that the Municipality of Clarington manage development in the vicinity of the Project site to ensure that there is no deterioration in the capacity to evacuate members of the public for the protection of human health and safety*.[10]

While these recommendations are aligned with IAEA standards, the Durham Regional Official Plan and the City of Pickering Plan are in direct contradiction to both standard and JRP recommendations.

To illustrate, the *Durham Regional Official Plan* amendment (ROPA 128) approved January 9, 2013 by the Ontario Municipal Board (OMB) designates an area which lies within 3 km of the PNGS as a Regional Corridor.

> 8A.2.9 *Regional Corridors shall be planned and developed in accordance with Policy 8A.1.5 and the relevant Policies of the underlying land-use designation, as higher density mixed-use areas*.[11]

This designated area is referred to in the City of Pickering's Official Plan Amendment.

> *5.2 The lands within the City Centre that front onto … parts of Bayly Street are designated as Regional Corridor and are intended to be developed as mixed use areas.*[12]

This plan was approved in principal by the Pickering Council in July 2013. The information report was circulated to stakeholders and by April 2013 had not received comment from the Ontario Government. The Durham Region had also not commented. [13]

The City of Pickering Council is poised to approve the Official Plan Amendment before summer recess.

I believe this requires timely intervention from the provincial government.

As discussed, I feel the government of Ontario has ignored its responsibility under IAEA safety standards to monitor population growth around Pickering and assess the ability of offsite emergency plans to adequately protect residents of Pickering.

In light of the OPG's plan to run Pickering beyond its design life and the City of Pickering to intensify population density around the plant, I request the government of Ontario assume its responsibility to protect our Ontarians and our community.

It should be noted that your government approved OPG's plan to run Pickering beyond its design life in your most recent *Long Term Energy Plan* (LTEP). This energy plan also left an option for closing the Pickering plant earlier, stating:

> The Pickering Generating Station is expected to be in service until 2020. An earlier shutdown of the Pickering units may be possible depending on projected demand going forward, the progress of the fleet refurbishment program, and the timely completion of the Clarington Transformer Station. [14]

The LTEP, however, is silent on how the decision will be made on Pickering's closure. It also fails to mention whether the adequacy of offsite nuclear emergency plans will be considered in this decision as required under IAEA safety standards.

I recently attended a meeting of the Durham Nuclear Health Committee at which Mark Elliot, OPG's chief nuclear engineer, implied that OPG could propose to run Pickering beyond 2020. Similarly in the Wednesday April 30, 2014 *News Advertiser Pickering*, Robin Manley, OPG's director of nuclear regulatory affairs, is reported by Keith Gilligan to have said, "Our assessment shows the fuel channels are reliable and will be safe to operate until 2020" (230,000 hours) adding the tubes could last 300,000 hours. [15]

Such comments underline for me that we need more accountability and clarity on how decisions will be made regarding the future of the Pickering Nuclear Generating Station if we are to ensure public safety in the City of Pickering.

For these reasons I ask the following:

1) The government instruct the City of Pickering to put its intensification plans on hold, pending clarification on both the future of the PGNS and the adequacy of Ontario's offsite nuclear emergency plans.

2) The government instruct OPG to provide clarification on their business plans, as there is a clear discrepancy between assumed decommissioning and reoccurring 5 yr. license renewals without refurbishment.

3) Infrastructure Ontario and Emergency Management Ontario commit to annual reports on their obligations under IAEA safety standards to monitor population growth around nuclear stations in Durham Region and the adequacy of offsite nuclear emergency plans.

4) Lastly, an invitation should a committee be struck up to address this.

Thank you for your attention in this matter. I look forward to your response.

Sincerely,

Barbara Pulst

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Canadian Environmental Law Association
EQUITY. JUSTICE. HEALTH.

October 18, 2013

By email: consultation@cnsc-ccsn.gc.ca

Canadian Nuclear Safety Commission
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280 Slater Street
Ottawa, Ontario, Canada K1P 5S9

Re: CNSC Consultation: Emergency Planning RegDoc 2.10.1
Comments Due October 19, 2013

CELA takes this opportunity to review and comment on the proposed RegDoc 2.10.1 issued by the CNSC titled, Nuclear Emergency Preparedness and Response, Draft dated August 2013. Comments are open until October 19, 2013.

A. Regulatory Authority

CELA agrees that the CNSC has regulatory authority to issue a regulatory document regarding emergency planning. We made submissions on this point in our presentation to the Commission in respect of the Pickering application to extend its operating life. Our conclusion is that not only does the CNSC have authority to require, review and approve emergency plans which are in the purview of its licensees; it also has authority to review emergency plans in place for off-site response and to use its assessment of the adequacy of those plans as part of its determination as to whether a nuclear power plant or other facility may operate, or under what terms and conditions. This extends to the portions of plans which have been undertaken by other authorities external to the plant operator. The reason for this, fundamentally, is that it is the CNSC which is required to assure that public safety and the environment will be protected in the exercise of its discretion to issue operating and other licences to licensees. The CNSC must not limit its review on the topic of emergency planning to plant boundaries or operator action. Rather it must specify its expectations for emergency planning to the fullest extent of potential impact on members of the public or the environment, and must exercise its decision making in the context of requirements respecting those full potential consequences.

CELA urges the CNSC to exercise a stringent oversight role as to whether emergency planning and preparedness have been proven prior to exercising its discretion at all points in its decision making.

This is reinforced by the specifications of IAEA Guide Standard, Preparedness and Response for a Nuclear or Radiological Emergency, Series No. GS-R-2, Safety Standards

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(Vienna: IAEA, 2002) which sets out expectations as to the responsibility of the regulator. A more complete copy of this excerpt is provided as Appendix A to our submission in the Pickering licensing hearing which is attached hereto for reference. It is the regulator's responsibility, among other things, to do the following (excerpts from GS-R-2 paragraphs 3.8 to 3.12:

- The regulatory body shall require that arrangements for preparedness and response be in place for the on-site area for any practice or source that could necessitate an emergency intervention.
- The regulatory body shall ensure that such emergency arrangements are integrated with those of other response organizations.
- The regulatory body shall ensure that such emergency arrangements provide a reasonable assurance of an effective response, in compliance with these requirements, in the case of a nuclear or radiological emergency.
- The regulatory body shall require that the emergency arrangements "shall be tested in an exercise before the commencement of operation [of a new practice]. There shall thereafter at suitable intervals be exercises of the emergency [arrangements], some of which shall be witnessed by the regulatory body."
- In fulfilling its statutory obligations, the regulatory body… shall establish, promote or adopt regulations and guides upon which its regulatory actions are based;… shall provide for issuing, amending, suspending or revoking authorizations, subject to any necessary conditions, that are clear and unambiguous and which shall specify (unless elsewhere specified):… the requirements for incident reporting;…and emergency preparedness arrangements.
- In planning for, and in the event of [a nuclear or radiological emergency], the regulatory body shall act as an adviser to the government.
- The regulatory body shall ensure that the co-ordinated arrangements are implemented adequately by the operators.

Moving ahead to implement a regulation is consistent with the expectations of the IAEA standard, as well as with the external review recommendations of Canada`s regulatory system post-Fukushima.

B. Planning Basis

CELA has reviewed the provisions of the proposed regulation with respect to Planning Basis. The proposed regulation in our opinion is inadequate. It states that it is licensees who shall establish the planning basis for emergency planning. In CELA`s opinion, it is time for the CNSC itself to establish the planning basis for emergency planning in response to severe or catastrophic accidents at nuclear power plants in Canada. This planning basis must be specified to include severe, catastrophic accidents with extensive offsite consequences including potential early release of radionuclides, as well as geographically extensive release of radionuclides from an accident. This must be done in a manner that does not assume containment will hold; nor assume that controlled venting will proceed as designed. It must not be based on probabilistic accident scenario calculations. As the CNSC president has stated in the past, the thinking must consider ``doomsday`` scenarios. In other words, while CELA strongly agrees that if nuclear

power plants are going to be operated, there needs to be major investments in avoiding accidents, and in handling and mitigating accidents so that it is to be hoped they don`t proceed to major consequences, there also must be a mindset on the emergency planning front that in some cases it may be that nothing in the ``defence in depth`` scheme has worked and therefore the resources and planning must be in place to respond to that situation extremely quickly, and extremely effectively. While emergency planning and response alone will not be sufficient in such a case to prevent all harm such as damage to property or even to persons, it is well within the realm of appropriate and feasible emergency planning to prevent much harm to people. This will only be the case if the planning basis clearly includes catastrophic accidents; if it does not, then people will be unnecessarily harmed. Examples include scenarios where evacuation takes far too long; where there is massive uncertainty as to evacuation routes; where there is complete inadequacy of medical response and accommodation; and where people have not had access to KI in advance and so its effectiveness, if ingested at all, is needlessly reduced.

In this respect, CELA is extremely disappointed to see that the draft RegDoc 2.10.1 states in the Guidance section to the Planning Basis that ``all credible hazards`` be identified in the planning, and that ``all credible worst-case scenarios and plans should be developed accordingly.`` (page 6 of the draft).

This is the type of thinking that led to the Fukushima accident in the first place, and it is also the type of thinking that meant that emergency planning at Fukushima was insufficient, a fact which in itself greatly exacerbated the impacts of the accidents on people. The term ``credible`` should be deleted from the Guidance. This guidance should not encourage continued reliance on arguments that severe or catastrophic nuclear accidents are unlikely; but the inclusion of this term in this context will do just that. This will result in the continued situation of inadequate emergency planning and preparedness that we presently face in the vicinity of Canada`s nuclear power plants.

C. Section 2.2.3 Emergency Assessment Requirements

CELA agrees with the draft document provisions for offsite monitoring in the event of an accident (numbers 5 to 6 in section 2.2.3). However, CELA submits that the CNSC should require that this information also be made publicly available in the event of an accident; this is essential to build public trust in the decision making and instructions being provided at such a time. It also provides a mechanism for knowledgeable observers to challenge findings or decisions; in the case of Fukushima such possibilities might have saved a great deal of harm when people were evacuated to an area subsequently found to be severely contaminated, contrary to prior expectations.

In terms of the provisions numbered 1 to 4 in this section, requiring licensees to describe their methods by which they will assess and predict onsite and offsite conditions and parameters, CELA recommends that this must be done by way of public submissions to and approval by the Commission, with opportunity for public input. A mere requirement for a description of the methodology does not provide assurance that this will be a robust approach on which the public should have high confidence. And clearly this must be

done, not in the context of an actual emergency, but in prior thinking and planning. The public has an essential stake in such methods and approaches.

In the Guidance to this section, provision is made that during an emergency ``Source term sampling and estimation shall be determined and reported to the CNSC on a **best efforts** basis…`` (p. 10, emphasis added) CELA recommends that the phrase ``best efforts`` should be deleted.

D. Section 2.3.4 – Interface and Support of Offsite Response Organizations

The components listed in this section are appropriate. However, CELA submits that the CNSC should set requirements for this provisions and should undertake an assessment of the adequacy of these components as against specified requirements, both in terms of the plans, and in terms of the actual on-the-ground resourcing and preparedness associated with these components. This should be done as a condition precedent to any licensing decisions. In other words, the CNSC should not merely require components like maintaining current evacuation time estimates; it should also evaluate those components as part of licensing decisions.

The Guidance to this section speaks of including the nuclear emergency response plans of offsite response organizations including provinces, municipalities and first responders as part of licence applications. CELA strongly agrees with this; however as noted we also submit that the adequacy of those plans, and the issues as to whether they are actually in place and properly resourced must be included and made part of the CNSC licensing decision. In other words, it is the CNSC`s responsibility not to license applicants for operations or continued operations, if it is not convinced on an evidentiary basis that the plans will be effective and can be acted upon. An example of the prior approach, which must not be allowed to continue, is that even basic alerting has not been adequately in place around some of Ontario`s nuclear power plants even though they have been operating for decades. Even worse, after this problem was identified before the Commission, it has still taken years and that alerting is still not fully in place, and this is in respect of one of the most basic and easiest`` aspects of emergency response. The Commission should not be sanguine about whether other aspects of plans placed before them as part of licensing applications are operable and sufficient without testing same as part of its licensing process.

E. **Section 2.4.3 – Public Information Requirements**

The provisions listed in the Draft RegDoc are appropriate as far as they go. However there are many additional issues that should be included in the public education materials, including evacuation and transportation routes; host community information; information about expectations of the public in the case of a severe offsite accident (the current plans expect them to mainly find alternate accommodation and in some cases undertake decontamination themselves); where the radiation-accident equipped medical facilities are; what to do if they have senior residents, hospitalized residents or school age children

in other facilities at the time of an emergency and much else. In addition the expectations of the licensees as to what to communicate should be far more specific and should be tested in consultation with engaged and informed members of the public in the vicinity of the nuclear power plants such as those non-industry members of the public who have attended CNSC hearings and meetings or meetings of agencies such as the Durham Nuclear Health Committee. For example the limitations of sheltering in place must be clear, and the time sensitiveness of ingesting KI pills must also be explained clearly and broadly to the public.

F. **Section 2.4.4 – Testing the Implementation of Emergency Measures**

It is of course essential to test the emergency plans in a variety of way as outlined in the RegDoc. However, as far as CELA is aware none of the plans have so far included general members of the public and this is an essential aspect of emergency planning. Members of civil society and members of the public in the vicinity of the nuclear power plants should be included in the emergency measures planning testing and drills; both full scale and many smaller scale drills. In the case of the plants in Durham Region, this should include residents of the City of Toronto in addition to Durham Region.

We trust the foregoing is of assistance.

Yours very truly,



Theresa A. McClenaghan
Executive Director and Counsel
Canadian Environmental Law Association

A Fukushima-Level Nuclear Disaster at Pickering:

An Assessment of Effects



by Dr. Ian Fairlie
for Ontario Clean Air Alliance Research

March 2018

Foreword

by Jack Gibbons, Chair OCAA

This report considers what would happen if a serious nuclear accident, similar in extent to what took place in Fukushima, Japan in March 2011, were to occur at the Pickering Nuclear Station just east of Toronto. In other words, what would happen if similar levels of radiation and a similar fallout distribution pattern occurred after an accident at Pickering?

The answer is alarming. The modelling done by radiation expert Dr. Ian Fairlie finds that an estimated 26,000 cancer cases would arise over subsequent years, of which roughly half would be fatal. Large areas of the Greater Toronto Area, including potentially Pickering, Markham, Newmarket, Aurora and northern Scarborough, would need to be evacuated and would become uninhabitable in some cases for 100 years or more.

Major transportation links, including Highways 401, 404 and 407 and the CN / CP / GO Transit rail lines would now pass through heavily contaminated "no go" areas, probably requiring massively expensive re-routing or detours. Meanwhile, thousands of residents would essentially lose their homes with evacuation and no-entry periods ranging from 30 to more than 100 years affecting access to more than 154,000 homes. The economic losses of these uninsured housing losses (homeowner insurance does not cover nuclear accidents and Ontario Power Generation's liability is capped at $1 billion[1]) would exceed $125 billion. Of course, the economic consequences would extend far beyond these housing losses, with all economic activity grinding to a halt in a major part of the eastern Greater Toronto Area.

This report considers what would happen if a serious nuclear accident, similar in extent to what took place in Fukushima, were to occur at the Pickering Nuclear Station.

It is important to note that the exact chain of events that led to the Fukushima disaster does not have to be replicated to result in an accident of a similar scale here. Nuclear energy, by its very nature, presents extraordinarily high consequences for failure. Assurances that "it can never happen here" should be contrasted with the surprising regularity of nuclear accidents, with one major accident occurring roughly every 10 years worldwide.[2] This unfortunate history, of course, started with a major accident at the Chalk River reactor in Ontario in 1952.[3] (For a full list of the many accidents at nuclear plants around the world, see https://en.wikipedia.org/wiki/List_of_nuclear_power_accidents_by_country)

A common theme in these and many other high impact, low probability events (such as airplane crashes) is human error. For example, one study concerning the failure of valves in nuclear reactors reported that "human

error was responsible for 47.4% of the failures in Boiling Water Reactors and 45.7% in Pressurised Water Reactors. The main causes of failure were design and maintenance errors. Administration, fabrication, installation, and operator errors were the other human causes of valve failure."[4]

The Pickering Nuclear Station is the fourth oldest nuclear stations in North America and one of the largest.[5] It relies on systems – including computer systems – designed in the 1960s and '70s. Many experts have noted that the plant has fundamental design flaws that would be unacceptable in newer facilities, a positive void coefficient and a shared containment system for multiple reactors that leaves it prone to the kind of cascading failures that devastated Fukushima. (See http://www.cleanairalliance.org/pickering-safety/ for more on the plant's safety issues, including how its design could lead to a nuclear chain reaction dangerously speeding up when there is a loss of coolant accident).

The Pickering Station is surrounded by more people (within 30 km) than any other nuclear plant on the continent.

The Pickering Station is surrounded by more people (within 30 km) than any other nuclear plant on the continent.[6] It is also on the shores of Lake Ontario, an interconnected Great Lake that supplies millions of people with drinking water. It is highly questionable whether such a plant would ever be built in a location like this today. That is partly because we also understand the growing range of threats to such high-risk facilities, including cyberattacks. For example, the U.S. Department of Homeland Security issued an urgent report in July 2017 warning that hackers had targeted the Wolf Creek Nuclear Operating Corporation, which runs a nuclear power plant in Kansas.[7]

The Pickering Nuclear Station also has the highest operating costs of any nuclear plant in North America,[8] so the fundamental question becomes is it worth the risk of continuing to operate this aging plant? This question is especially pertinent given that demand for electricity in Ontario has been steadily dropping for the last decade – demand has fallen by the equivalent of the power needed to supply all the homes in the City of Toronto twice over since 2005.[9] Currently, roughly half of the power Pickering produces is exported out of province, often at a loss.[10]

Meanwhile, the Province of Quebec has made it very clear that it is interested in making a deal to supply Ontario with safe, waste-free water power. In the summer of 2017, it was reported that Hydro Quebec had offered Ontario power for 20 years at a cost of five cents a kilowatt hour (kWh).[11] This is roughly half of Pickering's current per kWh operating cost and roughly a third of what Ontario Power Generation (OPG) is seeking to be paid for power from rebuilt or extended-life reactors at Pickering and Darlington.

In January 2018, Hydro Quebec signed a deal to supply Massachusetts with power at a cost of 3 to 5.3 cents per kWh.[12] The CEO of Hydro Quebec stated at the time that the company would be pleased to make a similar deal with Ontario. Meanwhile costs for other sources of renewable energy continue to fall. The Province of Alberta, for example, recently received bids to supply wind power at a rock bottom cost of 3.7 cents per kWh.[13] This is even lower than the 6.3 cents Quebec agreed to pay in its last wind power auction, an example of the trend toward ever lower costs for solar and wind. In Ontario, meanwhile, the Independent Electricity System Operators reports that energy efficiency savings cost it 2.2 cents per kWh in 2016 and projects that there remains massive potential to increase efficiency.[14]

The consequences of a major accident at the Pickering would be severe. Safer and less expensive options for meeting our power needs are readily available. There seems little reason to continue operating a high-risk facility that has already surpassed its design life. It is time to stop risking lives and turn to safer alternatives.

The consequences of a major accident at the Pickering would be severe. Safer and less expensive options for meeting our power needs are readily available.

Endnotes

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About the Author

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Dr. Fairlie's doctoral studies at the Imperial College of Science Technology and Medicine in the UK and at Princeton University in the US examined nuclear waste technologies. He has been an employee of, and consultant to, UK government departments and UK environmental regulators for many years. He was also the scientific Secretary to the UK Government's Ministerial Committee Examining Radiation Risks of Internal Emitters (www.cerrie.org). In addition, Dr. Fairlie has acted as consultant to the European Parliament, World Health Organization, and local governments.

Dr. Fairlie's areas of expertise include the dosimetric impact of nuclear reactor emissions and he has written extensively on epidemiology studies of child leukemias near nuclear facilities, and the hazards of tritium. More information is available at www.ianfairlie.org.

Cover photo of Fukushima Station: Greenpeace International

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Executive Summary

This report examines what would happen if a serious nuclear accident, similar in extent to that at Fukushima, Japan in March 2011, were to occur at the Pickering Nuclear Station east of Toronto. In this report, we have modeled what would happen if similar amounts of radioactivity were released and a similar fallout distribution pattern occurred after an accident at Pickering.

Our models estimate that 26,000 cancer cases would arise over subsequent years, of which approximately half would be fatal. Large areas of the Greater Toronto Area, including Pickering, Markham, Newmarket, Aurora and northern Scarborough, would need to be evacuated and would become uninhabitable in some cases for 100 years or more.

We used very conservative assumptions in determining these estimates, for example excluding health impacts such as thyroid cancers and radiation-related strokes and cardiovascular illnesses for which widely accepted risk factors are not available. We also only partially accounted for the higher risks faced by women and did not factor in the higher risks for children and older people when exposed to radiation. We also assumed that areas with the highest exposures would remain effectively evacuated.

However, even with these conservative assumptions, our estimate of cancer cases is significantly higher than for Fukushima for the simple reason that the Pickering NGS is located in a large, densely populated urban area while Fukushima Prefecture is largely rural.

Fukushima also benefitted from winds that, at the time of the accident, were blowing out to sea. For Pickering, similar winds could blow radioactivity out across Lake Ontario, but the fallout for surrounding and cross-lake populations would still be dire. And given that 2.2 million people live within 30 kilometres of the plant, we can confidently say that there are likely no scenarios under which a Fukushima-scale accident would not have severe consequences.

As it is, our models also estimate that more than 154,000 houses would be affected by evacuation orders and re-entry prohibitions lasting from 30 to more than 100 years. Hundreds of thousands of residents would lose their homes. The economic value of single residence house losses alone is estimated to exceed $125 billion. Of course, the economic consequences would extend far beyond the loss of homes.

We conclude that the continued operation of the Pickering NGS creates a “hostage to fortune” situation for everyone in Ontario. The Ontario Government has the clear duty to protect its citizens from the very serious consequences that would arise if a Fukushima-level accident were to occur at the Pickering NGS.



Inspecting the remains of the Fukushima Nuclear Plant

1. Introduction

This report examines what would happen in Ontario should a Fukushima-level nuclear accident occur at the Pickering Nuclear Generating Station (PNGS). The six operating reactors at Pickering NGS have lengthy histories of accidents, serious leaks, poor performance, and high operating costs. Many concerns have been expressed that there are more people within 30 kilometres of the PNGS than any other nuclear station in North America. In fact, it lies within the Greater Toronto Area with a population exceeding 6 million people (Statistics Canada, 2017).

In 2014, the German Government's Strahlengschutzkommission (SSK – German Commission on Radiological Protection) called[1] for contingency planning for "accidents whose radiological effects mirror those of Fukushima." Accordingly, this report will discuss the consequences of a serious nuclear accident, similar to that at Fukushima, Japan in 2011, occurring at Pickering. In particular, it assumes that the same amounts of fallout that actually occurred in Japan would be distributed over the Greater Toronto Area (GTA).

It is reasonable to do this as the situations at Pickering and Fukushima have many features in common:

- The Fukushima nuclear power station had six reactors; Pickering has six operating reactors and two that have been idled and defueled. At Fukushima, three reactors were on line at the time of the accident. At Pickering NGS, all six operational reactors could be operating at any given time.
- The three Fukushima nuclear units that exploded had generating capacities of 440, 780 and 780 MW, for a total of 2,000 MW. The net in-service capacity of the Pickering Nuclear Generating Station currently is 3,094 MW[2]
- Located beside large bodies of water
- Located in areas with mainly flat topographies
- Large quantity of zirconium alloy cladding present (the cause of H_2 explosions)
- No protection against hydrogen detonations (as at Fukushima)
- Very old reactors past their design operating lifetimes, and
- Operating within a government nuclear culture and a closed management system that does not acknowledge high levels of nuclear risks.

The report assumes a major nuclear accident at Pickering would release the same quantity of radioactivity as the Fukushima accident in 2011. It assumes the same weather patterns that occurred in Japan and the same deposition patterns. Based on these parameters, we then superimposed the radioactive fallout pattern from Fukushima on Southern Ontario, centred on Pickering NGS, to map potential fallout areas here. Our maps are based on radioactive fallout maps created by independent Japanese scientists and by the Japanese Government from official Japanese fallout data.

[1] https://www.ssk.de/SharedDocs/Beratungsergebnisse_E/2014/Notfallmassnahmen_e.html

[2] Ontario Energy Board Docket No. EB-2016-0152, Exhibit A, Tab 4, Schedule 3, Page 2

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The use of maps to illustrate the effects of nuclear accidents is neither new nor unprecedented. For example, as we shall show below, many maps were published of the radioactive fallout at Fukushima. In addition the 2006 TORCH Report (cricket.biol.sc.edu/chernobyl/papers/TORCH.pdf) shows several official maps of the radioactive fallout from the Chernobyl nuclear catastrophe in 1986, which affected much of Europe and eventually travelled right around the world.

More recently, Professor Frank von Hippel, senior research physicist at Princeton University, Dr. Michael Schoeppner, former postdoctoral researcher at Princeton, and Dr. Edwin Lyman, senior scientist at the U.S. Union of Concerned Scientists co-authored a paper (www.sciencemag.org/news/2016/05/spent-fuel-fire-us-soil-could-dwarf-impact-fukushima) that modelled the serious effects of hypothetical radionuclide releases if an accident were to occur at U.S. nuclear fuel storage sites. This paper contained maps illustrating the radioactive plumes across northeast United States (www.tandfonline.com/doi/full/10.1080/08929882.2017.1318561).

Our report also estimates the collective doses and the numbers of cancer cases and fatal cancers arising from a Fukushima-style accident as if this had occurred at Pickering. It also estimates the time periods that heavily contaminated areas would need to be evacuated, and the losses in market values of single residence homes located in the long-term evacuation zones.

2. What Happened at Fukushima?

On March 11, 2011, the Great Tōhoku earthquake, with a magnitude of 9.0 - 9.1 on the Richter scale, occurred in the Pacific Ocean about 120 kilometres from the Fukushima Daiichi Nuclear Power Plant in Japan. This initiated huge tsunamis, about 15 metres high, which swamped the power station 40 minutes later.

Immediately after the earthquake, the three operating reactors were shut down, due to the cessation of electricity supplies to and from the Japanese grid as a result of the earthquake. However large amounts of heat continued to be generated by radioactive decay of the nuclear fuel. The following tsunami then flooded the basements of the reactor buildings, thereby disabling the emergency generators needed for powering the pumps to cool the reactors. From March 12th-15th, the insufficient cooling led to a series of hydrogen explosions,[3] large scale releases of radioactive aerosols, gases and other material, and nuclear meltdowns in Units 1, 2, and 3. Loss of cooling also caused the storage pool for spent fuel at Unit 4 to overheat on March 15th due to decay heat from its spent fuel rods.

In July 2012, the Japanese Parliament established the Fukushima Nuclear Accident Independent Investigation Commission,[4] which found that the causes of the accident had been foreseeable and that the plant operator, Tokyo Electric Power Company (TEPCO), had failed to meet basic safety requirements such as risk assessment, preparing for containing collateral damage, and developing evacuation plans.

In October 2012, TEPCO admitted that it had failed to take necessary measures for fear of inviting lawsuits or provoking protests against its nuclear plants. A large number of lawsuits against TEPCO and the Japanese Government are currently winding their way through the Japanese courts.

[3] The precise nature of these explosions remains a matter of debate.

[4] https://reliefweb.int/sites/reliefweb.int/files/resources/NAIIC_report_lo_res2.pdf



AIR PHOTO SERVICE

Destroyed reactors at Fukushima

Almost seven years later, the accident is continuing. TEPCO is still spraying cooling water on the destroyed reactors in order to avert further explosions. Neither TEPCO nor the Japanese Government knows the precise whereabouts or the conditions of most of the melted fuels inside or under the ruined reactors. TEPCO is still discharging contaminated cooling water into the Pacific Ocean.

The toll from the Fukushima nuclear disaster is high.

- Over 160,000 people[5] were evacuated from the most contaminated areas. The Japanese Government is currently trying to force evacuees to return to their contaminated homes by threatening financial penalties, albeit with little success.
- Many cases of post-traumatic stress disorder (PTSD), depression, anxiety disorders and suicides arose from the evacuations themselves.
- Approximately 12,000 workers[6] were exposed to high radiation levels.
- From UNSCEAR data[7], it can be estimated that approximately 5,000 fatal cancers will arise in future from radiation exposures, plus similarly high rates of radiogenic strokes, cardiovascular diseases and hereditary diseases.
- An as yet unquantified number of thyroid cancers is expected to arise.
- Official figures reveal that between 2011 and 2015 about 2,000 deaths occurred from the radiation-related evacuations due to ill-health and suicides, especially among elderly people.[8]
- 8% of Japan's land area (30,000 km^2), including parts of Tokyo, were contaminated.[9]
- Economic losses have been authoritatively estimated[10] at more than U.S. $188 billion.

Despite this high toll, Japan was actually lucky in terms of radiation exposures as over 80% of the radioactive emissions from the reactors were carried by prevailing winds out to sea: only 20% fell on land.[11] If 100% of the radioactive emissions had landed on the Japanese mainland, the toll would have been much greater.



Radioactive water storage tanks

[5] http://www.ianfairlie.org/wp-content/uploads/2015/08/Summing-up-the-Effects-of-the-Fukushima-Nuclear-Disaster-10.pdf

[6] Fukushima Nuclear Accident Independent Investigation Commission https://reliefweb.int/sites/reliefweb.int/files/resources/NAIIC_report_lo_res2.pdf

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[8] http://www.reconstruction.go.jp/topics/main-cat2/sub-cat2-1/20141226_kanrenshi.pdf

[9] http://www.unscear.org/docs/reports/2013/13-85418_Report_2013_Annex_A.pdf

[10] https://www.reuters.com/article/us-tepco-fukushima-costs/japan-nearly-doubles-fukushima-disaster-related-cost-to-188-billion-idUSKBN13Y047

[11] thereby contaminating the offshore U.S. aircraft carrier USS Ronald Reagan and its ~3,000 crew.

3. Radiation Exposures to the Japanese People

Japanese people were exposed to radiation in two separate time periods: during the first pass of the radioactive plumes; and over subsequent years from the radioactive fallout deposited on the ground.

During the First Pass

The first pass occurred when radioactive plumes[12] from the stricken reactors passed through populated areas. These plumes consisted of radioactive gases, vapours and volatilised solids such as tritium, carbon-14, cesium-137, etc. (see www.who.int/ionizing_radiation/a_e/fukushima/faqs-fukushima/en/).

People living in the paths of these plumes were exposed to radiation in a variety of ways:

- Via external radiation (gamma radiation, beta radiation)
- Direct radiation from the radioactive gases in the plume
- Direct radiation from fallout deposited on the ground (mainly Cs-134, Cs-137)
- Direct radiation from re-suspension and re-deposition of fallout
- Via internal radiation (mostly beta radiation)
- Inhalation of radioactive gases (e.g. H-3 [tritium], C-14, I-131, Xe-133, Xe-135, Kr-85) and vapours in the passing plume
- Inhalation of fallout re-suspended by natural and man-made processes
- Absorption of radioactivity through the skin (tritium and C-14)[13]
- Ingestion of radioactively contaminated food and water (tritium and C-14)[14]



KYOKO YOKOMA, EXPOSURE: TALES FROM FUKUSHIMA

Radiation monitoring station

During Subsequent Years

After the plumes have passed and deposited their fallouts, people can be exposed to continuing radiation mainly from Cs-137 and Cs-134 which have relatively long half-lives (30.1 and 2.06 years, respectively) and which were volatilised in large amounts during the Fukushima accident.

The main exposures are from the direct radiation emanating from the plume's fallout deposited on the ground, with smaller exposures from the inhalation of ground matter re-suspended by natural and man-made processes, and from the ingestion of food and water contaminated by re-suspended fallout.

[12] Contrary to what many people assume, the plumes resulted when the reactors were deliberately vented by TEPCO to avoid explosions, and not from the explosions themselves at the units.

[13] https://www.voanews.com/a/japan-fukushim-tritium-contaminated-water-into-pacific/3995414.html

[14] https://www.nature.com/articles/srep36947

Exposures also result from the many hundreds of poorly managed "bag farms" (see back cover photo), which contain radioactive topsoil, from radioactive waste sites, from municipal waste incinerator emissions, and from consumption of contaminated wild foods such as boar, mushrooms and fish.

These exposures can continue for years and even decades,[15] as discussed in section 9.

[15] http://www.ianfairlie.org/news/new-unscear-report-on-fukushima-collective-doses/#_ftn1

4. Could a Major Nuclear Accident Happen at Pickering?

The Fukushima catastrophe was due to the coincidence of two main factors. First, rare events of nature (i.e., a force 9.0 earthquake and its accompanying tsunami) and, second, the technical vulnerability of the Fukushima reactors to these events.

As regards to the first matter, possible events include earthquakes, extreme weather occurrences, malevolent (terrorist) attacks, airplane crashes, electromagnetic pulses from the sun, and electricity blackouts.

On plane crashes, in 2008 the Canadian Nuclear Safety Commission (CNSC, 2008) severely questioned Ontario Power Generation (OPG) on the matter. It "…asked OPG if it had considered the probability of an aircraft crash near the Pickering B nuclear plant. OPG answered that this type of question was not of public domain but added that this scenario and its impact were considered. To a second question from the Commission to find out if there was a no-fly zone over PNGS, OPG answered negatively. OPG added that the level of risk or frequency of an airplane accident did not require such a consideration."[16]

On seismic risks, in 2011, the CNSC acknowledged that potential seismic risks exist near Pickering and Darlington Nuclear Generating Stations and acknowledged that in recent years they had both experienced minor damage due to low magnitude earthquakes (CBC News, 2011).

Small earthquakes (below magnitude 3 on the Richter scale) occur regularly in Lake Ontario near the Pickering and Darlington nuclear stations. As stated above, according to the CNSC (CBC News 2011, 2013) larger earthquakes (above magnitude 3) have already caused noticeable damage to these stations. The St. Lawrence Rift Zone runs under Lake Ontario, and independent Ontario seismologists have stated that seismic hazards along the St. Lawrence Rift Zone are underestimated (Wallach et al 1998, p.763). CNSC and OPG claim that emergency plans exist for these earthquakes.

As regards to the second matter of reactor vulnerability, potential matters include human error, reactor design flaws, reactor malfunctions, the growing risk of cyberattacks and the old age (>40 years) of the reactors. If a nuclear accident or accidents were to occur at Pickering, the consequences would depend on the circumstances of the accident, the number of reactors online at the time of the accident, how long the reactors had been operating since they were last refuelled, and crucially, on the wind directions and strengths at the time of the accident and for days afterwards.

It is important to note however that this study does NOT make any assumptions or develop any scenarios regarding a specific possible accident at Pickering. Instead it uses actual Japanese fallout patterns, weather patterns and published dose contours and transplants these to Ontario, centred on Pickering.

[16] http://www.suretenucleaire.gc.ca/eng/the-commission/pdf/2008-12-10-Decision-PickeringB-e-Ed-ocs3330500.pdf see pp. 17; 75.



At 47 years old, the Pickering Nuclear Station is the 4th oldest in North America and the 7th oldest in the world. It has officially exceeded its "design life" and is surrounded by more people (within 30 kilometres) than any other nuclear plant in North America.

5. Maps of Radioactive Fallout

If a severe accident were to occur, fallout from the resulting radioactive plumes would be deposited downwind of the nuclear station. As stated earlier, fallout patterns are best visualised by maps, and many maps of Fukushima's radioactive fallout have been published.

On the following pages are two dose contour maps of Fukushima's radioactive fallout that have been superimposed on Southern Ontario. The first, Figure 1, shows the contours of lower (pale blue) doses and the second, Figure 2, the contours of much higher doses. The Japanese maps and the Ontario maps onto which these have been superimposed have identical scales and are similar in orientation.

Figure 1 is based on an original map of the contours of radiation doses from Cs-134 and Cs-137 fallout in March 2011 created by Professor Yukio Hayakawa, a vulcanologist at Gunma University in Japan. He is an acknowledged expert on the mapping of radioactive fallout from volcanic eruptions and is independent of the nuclear industry. His own map of Fukushima fallout can be found at kipuka.blog70.fc2.com/blog-entry-418.html. The Japanese map showing simplified dose contours (dark green and magenta) can be found at i.pinimg.com/originals/d6/67/0b/d6670b14b39f517832f355ffd38aa317.jpg

The radiation dose rate from fallout in the pale blue areas lies between 0.25 μSv/hour and 0.5 μSv/hour (radiation dose units are explained in the box on this page). The radiation dose unit here is microsieverts per hour, which is a millionth of a sievert (Sv) per hour. However, we need to multiply this by the 8,760 hours in one year to obtain the yearly exposure. When we do this, the doses in the pale blue areas lie between 2.5 and 5 mSv in the first year and in the magenta area greater than 5 mSv in the first year.

The range of estimated first year doses (2.5 to 5 mSv) used in this report is broadly consistent with the (1.0 to 7.5 mSv) range of first year doses estimated by UNSCEAR (2013) for non-evacuated areas of Fukushima Prefecture.

The fallout data sources from which Professor Hayakawa compiled his dose contour map are comprehensive and were obtained from the following sources:

- Fallout data from aerial monitoring maps from the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) (August 31, 2011 revised version)
- Map plots from the Japanese MEXT (www.nnistar.com/gmap/fukushima.html)
- The Hayakawa team's own detailed measurements in mountainous area (Gunma and Tochigi Prefectures)
- Horiba scintillator radioactivity measurements
- Local data from a number of individual sources

Radiation Dose Units

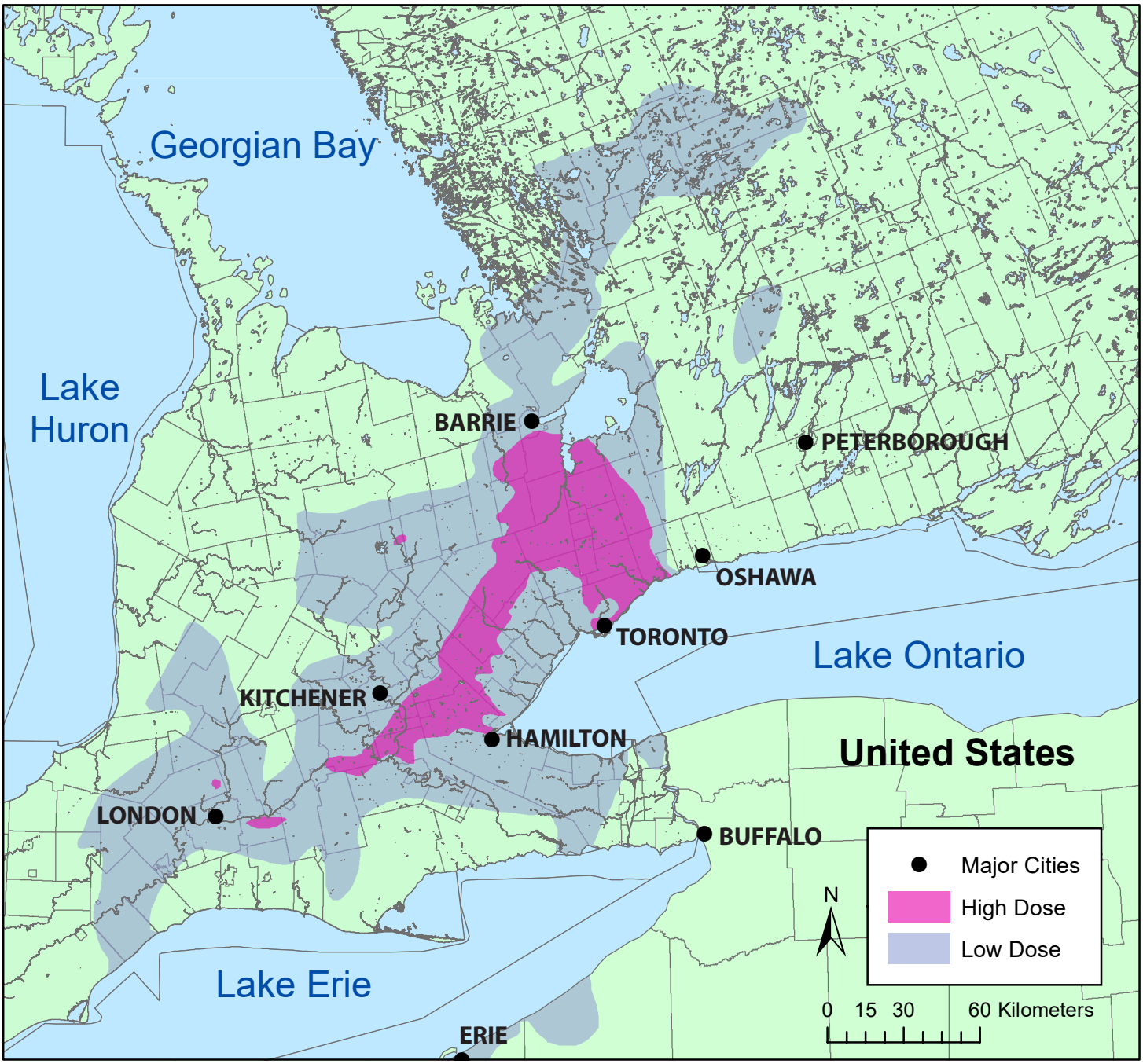
Exposures to radiation are usually measured in sieverts (Sv). In general terms, one Sv means that one joule of radiative energy has been absorbed in one kilogram of tissue. This is a very large amount of radiation. For example, 6 Sv is often considered a fatal radiation dose.

One millisievert (mSv) is equal to one thousandth of a sievert. One mSv is the annual public limit for radiation exposures in Canada.

Even this is often too large and a smaller unit is used. One millionth of a sievert is one microsievert (μSv) and there are 1,000 μSv in a mSv.

Their relationships are as follows: 1 Sv = 1,000 mSv = 1,000,000 μSv

Figure 1: Low Doses (light blue area)
Fukushima Fallout Centred on Pickering Superimposed on Southern Ontario

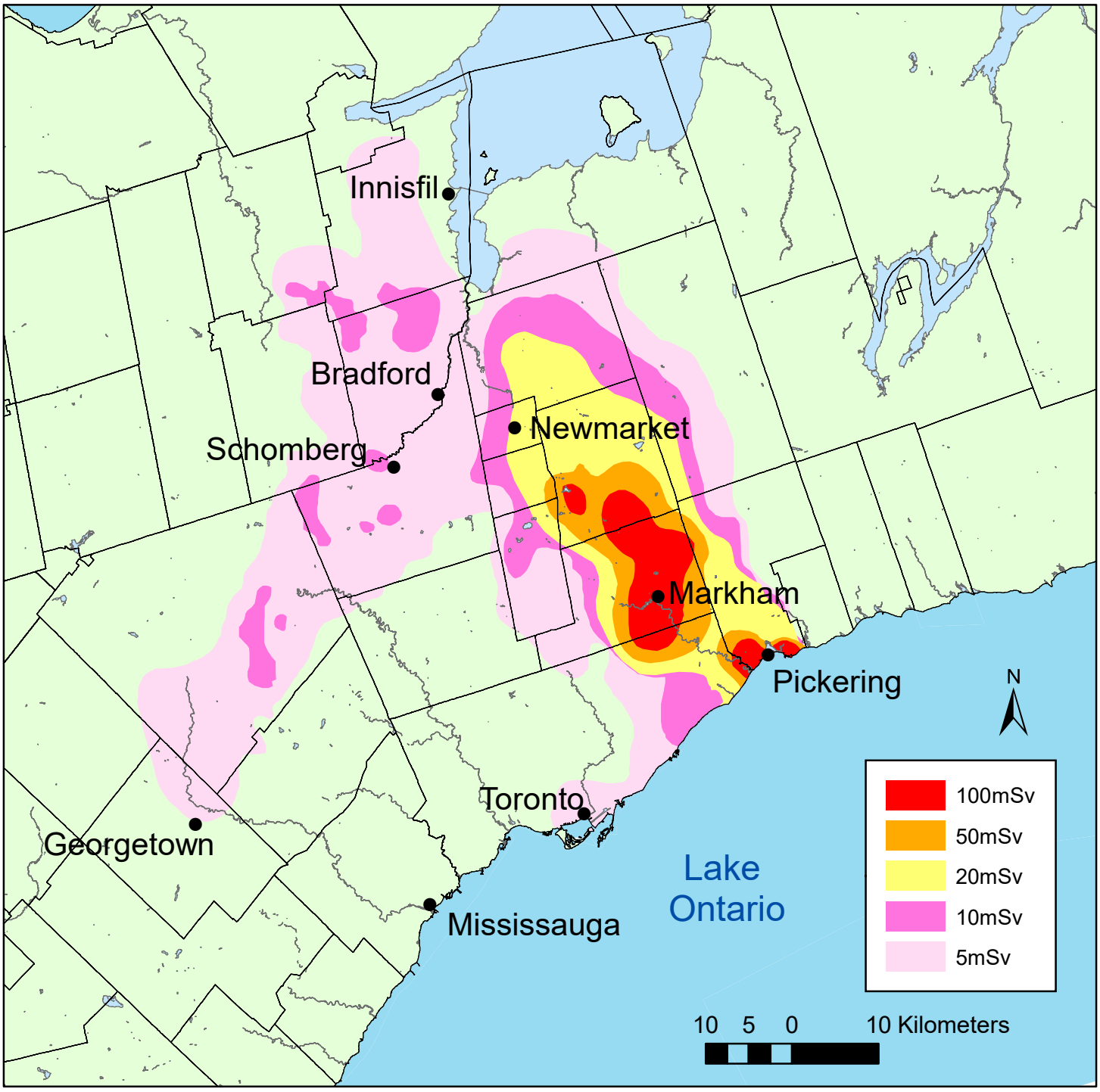


Credits: Dose contours as discussed in report. Contours reproduced with permission of Dr. Yukio Hayakawa, adapted by Edinburgh Energy and Environment Consultancy and Lynx Graphic Design.

Statistics Canada. Boundary Files. 2006. Statistics Canada Catalogue No. 92-160-X2006001. Published by Statistics Canada. http://www12.statcan.gc.ca/census-recensement/2011/geo/bound-limit/bound-limit-2006-eng.cfm Reproduced and distributed on an "as is" basis with the permission of Statistics Canada.

United States Census Bureau. TIGER/Line Shapefile, 2016, nation, U.S., Current County and Equivalent National Shapefile. 2016. Published by United States Census Bureau.

Figure 2: High Doses (red, orange and yellow areas)
Fukushima Fallout Centred on Pickering NGS Superimposed on Toronto and Surrounding Areas



Credits: Dose contours derived from Institut de Radioprotection et de Sûreté Nucléaire Report DRPH/2011-10 (IRSN, 2011) adapted by Edinburgh Energy and Environment Consultancy and Lynx Graphic Design.

Statistics Canada. Boundary Files. 2006. Statistics Canada Catalogue No. 92-160-X2006001. Published by Statistics Canada. http://www12.statcan.gc.ca/census-recensement/2011/geo/bound-limit/bound-limit-2006-eng.cfm Reproduced and distributed on an "as is" basis with the permission of Statistics Canada.

The Japanese map created by Professor Yukio Hayakawa reveals the widespread extent of fallout from Fukushima, including areas of greater Tokyo. This map is not used on official Japanese websites as it shows fallout in areas that Japanese authorities do not include in most of their own maps, especially areas in and near Greater Tokyo. The main reason for this exclusion is that Japanese radiation authorities prefer not to observe the Linear No Threshold model[17] of radiation's effects adhered to by all other radiation authorities around the world (i.e., UNSCEAR, WHO, IRSF, ICRP, BEIR VII and CNSC). For this reason, the Japanese Government's Ministry of Education, Culture, Sports, Science and Technology (MEXT) refrains from showing doses below 5 mSv per year in its maps. This practice is scientifically inaccurate. Such doses should be shown as radiation's adverse effects exist even at very low exposure levels. Accordingly, we have shown them in Figure 1.

Figure 2 is ultimately based on an official dose contour map produced during aerial monitoring by the U.S. Department of Energy and the Japanese Ministry of Education, Culture, Sports, Science and Technology (August 31/2011 revised version available at radioactivity.nsr.go.jp/en/contents/4000/3180/24/1304797_0506.pdf).

Unlike Figure 1, in Figure 2 it is reasonable to use official sources as these show doses down to 5 mSv per year. The colour legends indicate doses in the first year only. This map indicates that, if the Fukushima accident had occurred at Pickering NGS, very high radiation exposures would have occurred in Greater Toronto and its surrounding areas.

Assuming the same releases and weather patterns seen at Fukushima occur at Pickering, we can use these maps to assess average doses and population numbers affected and thereby estimate collective doses and expected numbers of future cancer cases and cancer deaths in Ontario. The detailed calculations are shown next.

[17] This assumes that radiogenic harm declines linearly with doses all the way to zero, without a threshold. In other words, there is no 'safe' dose of radiation.



Over 160,000 people were evacuated in the wake of the Fukushima disaster.

6. Estimated Collective Doses in the Toronto Region (First Year)

The average dose rate in the first year in the light blue areas in Figure 1 is the average of 0.25 + 0.5 μSv per hour = 0.375 μSv per hour. This equates to an average dose of 3.285 mSv per year (i.e., x 8,760 hours in a year[18]). To obtain collective doses we need to multiply this figure by the populations affected (listed in Appendix A). The total population in the light blue areas is currently 5,820,276.

Therefore, we can multiply average dose in the area bounded by light blue – 3.285 mSv – by 5,820,000 people to obtain a collective dose of 19,120 person Sv in the first year.

For Figure 2, it is necessary to estimate the populations in the red, orange, yellow, and pink areas. This was done by examining the dose contours in Figure 2 and matching them with the populations of affected municipalities from Statistics Canada (2017). The results are shown in Appendix B. It is acknowledged that this procedure will introduce uncertainties, as it is assumed that populations are homogenously distributed over all land areas. However, this is a routine assumption used in estimating collective doses.

As it is difficult to precisely differentiate the maroon from the pale blue areas in Figure 1, this procedure may involve some double counting of areas in Figures 1 and 2. However, considerable efforts were made to minimize this and there could also be small overlooked areas that would mitigate any double counting. The effect of any double counting on this report's final collective dose estimate would be small in any case. The average annual dose in Figure 1's pale blue area is small – only 3.75 mSv per year. So even in the unlikely event that 100,000 people were double counted, the resulting collective dose would only be 370 person Sv – about 2% of the original estimated collective dose.

Figure 2 shows dose contours (in red) of a first year dose of 100 mSv in four highly exposed areas – parts of Markham, Whitchurch/Stouffville, Richmond Hill and Pickering – with a total of 210,000 people. Assuming this to be an average dose (some people will have higher doses and some lower), then these highly exposed areas would receive a first year population dose of 210,000 x 100 mSv = 21,000 person Sv.

However, it is conservatively assumed that this area would be evacuated therefore lowering exposure. But because evacuations are unlikely to be fully effective, it is also assumed that a quarter of the first year dose will accrue, i.e., 5,250 person Sv. This estimate is based on the understanding that evacuations are only about 75% effective based on actual experience at Fukushima (information communicated orally to the author during study tours to Fukushima Prefecture in 2015 and 2016) and due to the following factors:

- residents who refuse to be evacuated
- residents who return
- emergency personnel who are exposed
- late evacuees who are contaminated with radioactivity
- the safety areas for evacuees may not be free of fallout, and
- it may take several months for all evacuations to take place.

[18] Several studies have shown that, as indoor Cs-137 concentrations are similar to outdoor concentrations, reductions to take into account that people live indoors are unconservative.

The map also gives a smaller dose area (orange) with an average first year dose of 50 mSv. Assuming a smaller population of 146,000 x 50 mSv x 0.25, we obtain a collective dose of 1,825 person Sv for this area.

For the yellow dose area of 20 mSv in the first year and a 297,000 population with 75% evacuating, we arrive at a collective dose of 297,000 x 20 mSv x 0.25 = 1,485 person Sv.

For the dark pink 10 mSv dose area in the first year, we take the population of 383,000 and arrive at a collective dose of 383,000 x 10 mSv = 3,830 person Sv. No reduction is applied here for evacuation as this only occurs for average doses greater than 20 mSv.

For the light pink 5 mSv dose area in the first year, we use the population of 1,818,000 to obtain a collective dose of 1,818,000 x 5 mSv = 9,100 person Sv.

These figures are set out in Table 1 below. In total, during the first year, the exposed areas of Figures 1 and 2 add to 40,610 person Sv, correct to two significant figures. (In view of the uncertainties here, only two significant figures are used in the estimated total.)

Table 1. Collective Doses from First Year Exposures

	Average Dose in First Year – mSv	Assumed Fraction Evacuated	Populations (see appendices A and B)	Collective Doses – Person Sv
Figure 1				
Pale Blue Area	3.285	not evacuated	5,820,000	19,120
Figure 2				
Red area (evacuated)	100	75%	210,000	5,250
Orange area (evacuated)	50	75%	146,000	1,825
Yellow area (evacuated)	20	75%	297,000	1,485
Dark Pink area	10	not evacuated	383,000	3,830
Light Pink area	5	not evacuated	1,818,000	9,100
TOTAL				**40,610**

7. Estimated Collective Doses (Years 2 to 10)

After the passage of the plumes, exposures will continue mostly from the plumes' fallout on the ground, initially mainly from Cs-134 (half-life = 2.06 years) and later from Cs-137 (half-life = 30.1 years).

In the past, it had been assumed that weathering would result in the relatively quick disappearance of radiocesiums from soil. However recent data on continuing high levels of Cs soil concentrations after Chernobyl (Drozdovitch et al, 2007) have indicated this is not the case and that Cs concentrations persist for decades. Drozdovitch et al tracked radioactivity beyond residence time on vegetation to include its migration into soil, using a weathering attenuation factor with two half-life time constants of 2.4 years and 38 years – both considerably longer than previous estimates (Beyea J, E Lyman and F von Hippel, 2013). As a practical example of this, in the U.K., persistently high Cs concentrations in soils in Cumbria and Wales from Chernobyl fallout lasted from 1986 until 2012. The result was that the U.K. Government had to issue food restriction orders prohibiting the sale of lamb from farms in these areas until 2012 (Fairlie, 2016).

It is therefore necessary to estimate the doses that occur over a longer time period than the first year. An additional nine years is chosen to make a 10-year period in total, as this is roughly the time period for which we have comparable experience (i.e., seven years since Fukushima in 2011). During this period, doses will decline in a similar fashion to that indicated in the graph below.

Graph 1: Dose Decline Curve



It is difficult to calculate accurately the average doses for years 2 to 10 as insufficient data are available, especially the initial ground concentrations of Cs-134 and Cs-137. For the first year, most of the dose will come from Cs-134 as it is considerably more radioactive[19] than Cs-137. On the other hand, Cs-134 decays more quickly than Cs-137, so that after about three years, the dose contribution from the latter exceeds the former.

Using the dose conversion factors and dose/surface concentration ratios published in Section E of the IAEA report on *Generic Procedures for Assessment and Response During a Radiological Emergency* (IAEA, 2000), it is possible to make the following estimates of the doses arising in years 2 to 10 inclusive. (See box opposite.)

For the pale blue areas in Figure 1, it is calculated that an average adult dose of 12.95 mSv will accrue over the years 2 to 10 after the accident – an approximately fourfold increase over the first year dose of 3.285 mSv. The total collective dose is 5,820,276 x 12.95 mSv = 75,370 person Sv.

For exposures in Figure 2, as doses will decline in the same way we can apply the same increase factor of four to the figures in Appendix B to obtain the collective doses set out in Table 2. No doses accrue in the red, orange and yellow areas as we conservatively presume that they remain evacuated.

Table 2. Collective Doses from Exposures in Years 2 to 10

	Average Dose Over 2-10 yrs	Population	Collective doses person Sv
Figure 1 Pale blue area	12.975 mSv	5,820,000	75,500
Figure 2 Dark pink area	10 x 4 = 40 mSv	383,000	15,320
Figure 3 Light pink area	5 x 4 = 20 mSv	1,818,000	36,360
TOTALS			**127,200**

The sums of the collective doses for the first year and years 2 to 10 from Figures 1 and 2 are set out in Table 3 below.

Table 3. Total Collective Doses

Exposures	Collective Doses Person Sv
First Year	40,610
Years 2- 10	127,200
TOTAL	**167,810**

In conclusion, it is estimated that the collective dose to Ontario from a Fukushima-level nuclear accident at Pickering would be 167,810 person Sv. As is conventional in scientific reports, rounding to two significant figures will be performed at the end of all calculations.

[19] The specific activity of Cs-134 is over 100 times greater than that of Cs-137

[23] Including the U.S. city of Erie, Pennsylvania, which was also affected

Calculations for External Doses from Cs Exposures for Years 2-10 after Fukushima

Assumptions Used

A. The first year average dose in Figure 1 pale blue areas = 3.285 mSv.

B. The initial soil Cs contamination from fallout is 50% from Cs-137 and 50% from Cs-134.[20]

C. Dose coefficients for Cs-137 = 6.5×10^{11} mSv/h per Bq/m^3 and Cs-134 = 17.0×10^{11} mSv/h per Bq/m^3: i.e. the Cs-134 dose coefficient is 2.615 times greater than the Cs-137 dose coefficient.

D. The dose coefficients (mSv/h per Bq/m^3) for external exposure are taken from IAEA data. (The values are based on homogeneous distribution in soil.)[11]

Methodology

Using a 50/50 mixture of Cs-134 and Cs-137, the dose contribution per Bq from Cs-134 = 2.615/2.615 + 1 = 72.3%

Therefore, in the first year, 72.3% of the average dose of 3.285 mSv = 2.375 mSv is from Cs-134. Similarly, in the first year, 27.7% of 3.285 mSv = 0.910 mSv is from Cs-137.

The table below indicates annual doses from both Cs-134 and Cs-137 as estimated by the radioactivity decay program www.radprocalculator.com/Decay.aspx

Year	Dose from Cs-134 mSv	Dose from Cs-137 mSv	Totals mSv
1	2.375	0.910	3.285
2	1.697	0.889	
3	1.213	0.869	
4	0.867	0.849	
5	0.620	0.830	
6	0.443	0.811	
7	0.317	0.793	
8	0.227	0.775	
9	0.162	0.757	
10	0.116	0.740	
TOTALS	**5.662**	**7.313**	**Years 2-10 = 12.975**

Therefore, the ratio of dose from years 2-10 to that from the first year = 12.975/ 3.285 = 3.95.

The ratio of 4.0 (to two significant figures) is consistent with other estimates produced using different assumptions and methodologies. For example, Ishikawa (2016) and Nagataki et al (2016) discuss the UNSCEAR (2013) ranges of estimated doses and cite a ratio of 3.3 for 10- year to first-year doses.

In addition, a ratio of 4 for the ratio of first year dose to the dose for years 2-10 is estimated by Tsuneki (2013) (in Japanese). [22]

[20] This is a reasonable assumption for two reasons. First, the UNSCEAR report on Fukushima (2013) stated on page 41 of Annex A that almost equal amounts of Cs-134 (9.0 PBq) and Cs-137 (8.8 PBq) were emitted at Fukushima. Second, Japanese MEXT data for 2011 as reproduced by Tsuneki (2013) indicate equal surface contributions of the two nuclides in 2011 in Japanese areas affected by fallout. See table 5.1 page 107 labelled Cesium 134 and 137 Fallout concentrations in Japanese cities in 2011. From MEXT Ministry of Education, Culture, Sports, Science and Technology "Results of environmental radiation level survey (monthly)."

[21] http://www.iaea.org/inis/collection/NCLCollectionStore/_Public/37/101/37101600.pdf Reproduced from table 5.1.

[22] See Table 5.3 of on page 123 of the pdf version. Title of table - "Approximate estimate of annual dose when outdoor radiation dose rate from cesium was 1 μSv/h as of March 2012". http://www.gakushuin.ac.jp/~881791/radbookbasic/rbb20130117.pdf





GREENPEACE INTERNATIONAL

Farm produce remains contaminated by Fukushima's fallout and radiation levels remain unsafe in many areas of Fukushima Prefecture.

8. Estimated Numbers of Cancer Cases and Cancer Deaths in Ontario

We now need to estimate the likely numbers of (a) cancer cases and (b) fatal cancers expected to arise from this collective dose. Some official reports consider only fatal cancers but since the number of survivable cancer cases is usually double the number of fatal cancers, we need to consider these as well.

We shall use the latest official radiation risk estimates published in 2006 by the U.S. National Academy of Sciences in its report on the *Biological Effects of Ionizing Radiation - Part 2 BEIR VII* (US NAS, 2006). Table ES-1 (page 15) of the BEIR VII report contains the BEIR Committee's preferred estimates of the lifetime attributable of incidence (i.e., cases) and mortality (i.e., deaths) for all solid cancers. The U.S. report contains separate figures for males and females,[24] but these have been averaged here to simplify matters. The risks are presented in BEIR VII per 0.1 Sv but these have been presented per Sv here again to make matters clearer.

Finally, it is necessary to explain that the BEIR Committee's risks in 2006 were estimated using a Dose and Dose Rate Effectiveness Factor (DDREF). This reduced the Committee's preferred risks by a factor of 1.5. However, since the BEIR report's publication in 2006, new evidence has emerged showing that DDREFs should no longer be used. For example, neither the UNSCEAR (2013) nor the WHO (2012, 2013) reports on Fukushima used DDREFs in deriving their Fukushima risk estimates.

The WHO Report (WHO, 2013) on page 32 explained why as follows:

"Based on the findings of the two meta-analyses discussed above (74,92), which showed similar risks for protracted and acute exposures, the WHO- HRA Expert Group considered it prudent to base risk calculations on models derived from the atomic bomb survivors cohort without applying any modification factor for low dose or low dose rate. This decision, which represents a departure from standard practice in radiation risk assessment, was not unanimous as two members {out of 13} expressed a dissenting opinion."

This decision has been followed by the UNSCEAR (2013) report and by other reports since then.

Table 4. Absolute Radiogenic Risks of Cancer Cases and Fatal Cancers from Table ES-1 of BEIR VII (Risks to Males and Females Averaged)

Effect	Numbers per 100,000 People Exposed to 1 Sv	Radiation Risk	Radiation Risk Without DREF of 1.5
Cancer Cases (fatal and non-fatal)	10,500	10.5% per Sv	15.75% per Sv
Fatal Cancers	5,100	5.1% per Sv	7.65% per Sv

[24] It should be noted that these estimates are for risks to adults. Radiogenic risks to babies, infants, children, adolescents and to pregnant women are higher.

This report will therefore estimate the numbers of cancer cases and fatal cancers in Ontario as shown in Tables 5 and 6. The central estimates, correct to two significant figures, are that 26,000 cancer cases would arise, of which 13,000 (approximately half) would be fatal.

Table 5. Estimated Numbers of Cancers Cases in Ontario[25]

Collective Dose Person Sv	Risk of (Fatal and Non-fatal) Cancer Cases	Number
167,810	15.75%	26,430

Table 6. Estimated Numbers of Fatal Cancers in Ontario[25]

Collective Dose Person Sv	Risk of Fatal Cancer	Number
167,810	7.65%	12,840

[25] including Erie PA, US

9. Estimated Time Periods of Evacuations

Estimates can be made of time periods that the red, orange and yellow zones in Figure 2 would need to remain evacuated. These estimates were made using the online software at www.radprocalculator.com using the following assumptions:

- Cs-137 concentrations on contaminated land decline exponentially in line with Cs-137 radioactive decay with a half-life of 30.1 years
- linearity between Cs-137 concentrations and dose, and
- no external factors such as clean-ups, forest fires, and flash floods.

Ten mSv/a is the Ontario Government's recommended[20] "lower level" above which evacuations "should be applied unless valid reasons exist for deferring action." Such reasons are not defined in the emergency response plan.

In the yellow (20 mSv/a) zone, it is calculated that it would take about 30 years for the average dose rate to decline from 20 to 10 mSv/a, at which time it would be permissible to lift the evacuation orders. Similarly, in the orange zone, it would take about 70 years for the dose rate to decline from 50 to 10 mSv/a. And in the red zone, it would take about 100 years for the dose rate to decline from 100 to 10 mSv/a.

It therefore can be seen in Figure 3, that the red, orange and yellow zones of the Greater Toronto Area (GTA) may need to remain evacuated for about 100, 70 and 30 years respectively.

Some uncertainty would exist with these time estimates, as there is limited experience to draw upon. But they are in line with the situation at Chernobyl, where the ~3,000 km^2 evacuation zone remains in force with no prospect of being lifted despite it being more than 30 years since the accident. At Fukushima, about seven years after the accident, most of the evacuation zones are still in force with little prospect of major changes. In a few areas where average doses are now estimated by the Japanese Government to have fallen below 20 mSv/a (the Japanese threshold[27]), the government is attempting to compel[28] evacuees to return with limited success. (The author has visited Fukushima Prefecture twice in recent years during study tours to Japan, and it is apparent that many Fukushima citizens no longer trust their government or TEPCO and remain reluctant to return to their former homes.)

It is recognised that the above are simple estimations with large uncertainty ranges. However, they give an approximate indication of the time periods required for evacuations after a Fukushima-level disaster at Pickering.

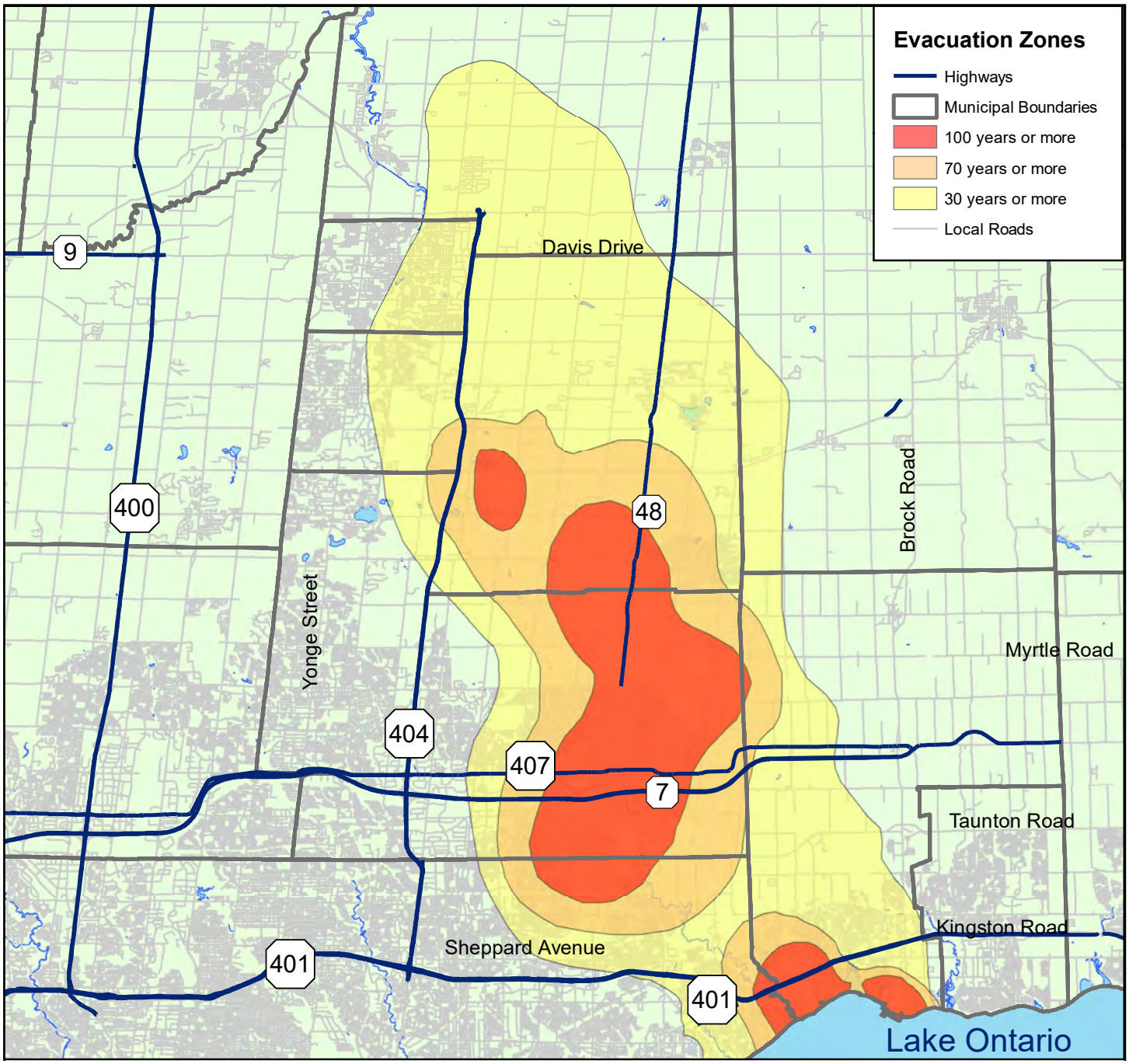
[26] Provincial Nuclear Emergency Response Plan. Ontario Government. See Annex E – Protection Action Levels. https://www.emergencymanagementontario.ca/english/beprepared/ontariohazards/nuclear/provincial_nuclear_emergency_response_plan.html#P2618_168284

[27] Fukushima Nuclear Accident Independent Investigation Commission https://reliefweb.int/sites/reliefweb.int/files/resources/NAIIC_report_lo_res2.pdf

[28] by ceasing state compensation payments to evacuated residents

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Figure 3: Time Periods of Evacuations



Source: Statistics Canada. Boundary Files. 2017. Statistics Canada Catalogue No. 92-160-X2016002. Published by Statistics Canada. http://www12.statcan.gc.ca/census-recensement/2011/geo/RNF-FRR/index-2011-eng.cfm?year=16 Reproduced and distributed on an "as is" basis with the permission of Statistics Canada.

Statistics Canada. Road Network File. 2017. Statistics Canada Catalogue No. 92-500-X2017001. Published by Statistics Canada. http://www12.statcan.gc.ca/census-recensement/2011/geo/RNF-FRR/index-2011-eng.cfm?year=16 Reproduced and distributed on an "as is" basis with the permission of Statistics Canada

ArcGIS for Desktop: 10.1.5, [Computer software]. (2017). Redlands, CA: ESRI.

10. Conservative Dose Estimation

In this report, significant efforts were made to avoid the overestimation of radiation doses. As a result, the dose estimates in this report should be viewed as underestimates rather than overestimates for the following reasons:

- A 10-year cut-off is used for collective doses, even though UNSCEAR and the EU use 70 years. This is because of the uncertainty about actual doses accruing in future years due to possible clean-up efforts, forest fires (which re-suspend radionuclides) and possible people movements into and out of affected zones.
- It is assumed that large-scale evacuations would take place for areas where average dose levels exceed 10 mSv (Ontario threshold for evacuations[29]) and will continue until they fall below this level.
- Doses from the plume overhead in the first year are not estimated because it is not possible to reconstruct them from the available data.
- Adult risk factors for fatal and non-fatal cancers are used: higher risk factors could have been used to take into account the increased radiogenic risks to babies, children, old people and the risks of genetic effects. This would have approximately doubled the risk factors.
- Risk factors were averages of the rates for both males and females. Women's risks from radiation exposures are about 50% greater than men's risks.
- Deaths from radiogenic cardiovascular disease, including strokes, have not been added. This would have approximately doubled the estimated number of deaths. The reason is that the existence of this risk and its risk factor are still not widely acknowledged even though the evidence for them is robust and from statistically significant Japanese bomb survivor data (Shimizu et al, 2010).
- A major source of conservatism is that this report assumes Fukushima levels of radioactive emissions in Ontario, which were due to explosions at three reactors with a total capacity of 2,000 MW. Pickering NGS currently has six operating reactors with a total capacity of 3,094 MW. If all six were assumed to explode (due to a common mode accident, e.g., earthquake and tsunami), it would be reasonable to assume that the radioactive releases would be approximately 50% greater than at Fukushima.

[29] Provincial Nuclear Emergency Response Plan. See https://www.emergencymanagementontario.ca/english/beprepared/ontariohazards/nuclear/provincial_nuclear_emergency_response_plan.html#P2618_168284



Mandatory long-term evacuations could result in the loss of $125 billion in assets for residents.

11. Economic Losses: House Value Loss

In Appendix C, we outline just one aspect of the economic price Ontario would pay for a Fukushima-scale accident at Pickering: housing value loss as a result of long-term evacuations and no re-entry orders. The estimated loss of $125 billion in housing value for homes within evacuation zones is in line with the estimates of economic losses at Fukushima of U.S.$ 188 billion (Can$ 236 billion). Home insurance policies routinely exclude coverage of nuclear accidents and OPG's total liability in the event of a nuclear accident is capped at $1 billion,[30] meaning homeowners would have no ready source of compensation for losses.

Of course, the loss of businesses, schools, hospitals and other infrastructure within the evacuation areas would rapidly inflate this loss figure further. Additionally, 26,000 cancer cases (half fatal) would also present an enormous economic and logistical strain on the health care system.

12. Conclusions

Cancer and Other Health Effects

This report estimates that, if a Fukushima-level nuclear accident were to happen at Pickering NGS, 26,000 cancer cases would arise of which 13,000 (approximately half) would be fatal (correct to two significant figures). This is a very large number compared, for example, to the 668 deaths estimated to arise each year if coal-fired power stations were permitted to continue operating in Ontario (DSS, 2005).

The kinds of cancer that could arise include cancers of the bone, lung, skin, intestine and other soft tissues. Blood cancers (e.g., leukemias and lymphomas) would also occur.

Thyroid cancers (TC) would be expected to arise similar to the epidemics of thyroid cancers after the Chernobyl nuclear disaster in 1986 (Fairlie, 2016). These are usually considered separately as they depend mainly upon specific thyroid exposures to radioiodine intakes. Stable iodine is an effective prophylactic and the Ontario Government has already pre-issued stable iodine (KI) tablets to residents within 10 kilometres of Pickering and will also send them to other residents who request them. However, it is hard to estimate how many people would actually ingest KI tablets in the event of an accident. Therefore, in this report the likely number of thyroid cancer cases which would arise has not been estimated.

Other radiation effects not considered here are long-term genetic (i.e., hereditary) effects, teratogenic effects (from doses to embryos and fetuses), eye cataracts, and cardiovascular disease plus stroke. The main reason for these exclusions is that there are, as yet, few internationally agreed risk factors for these effects.

[30] http://nuclearsafety.gc.ca/eng/acts-and-regulations/acts/nuclear-liability-and-compensation-act.cfm

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It is recognized that the cancer estimates derived in this report will have uncertainty ranges. It is difficult to assign numerical limits to these uncertainties. This is the reason the two WHO (2012, 2013) and UNSCEAR (2013) reports on Fukushima cited earlier do not include uncertainty ranges in any of their estimates. Nevertheless, this report's estimates indicate the likely scale of the cancer effects if a Fukushima-level disaster were to occur at Pickering NGS.

In comparison, at Fukushima, UNSCEAR (2013) estimated a collective dose of 48,000 person Sv from which it can be estimated that about 5,000 fatal cancers would arise in future.[31] The reason why the effects in Ontario would be greater than those in Japan is that Southern Ontario is considerably more populated than Fukushima Prefecture, which is a largely rural area.

Long Term Evacuations and No Re-entry Zones

The report also shows that, if a Fukushima-level accident were to occur at Pickering, many thousands of people in the Greater Toronto Area could be exposed to high levels of radiation – over 100 mSv per year. Millions of Greater Toronto residents and workers could need to be evacuated for long periods of 30, 70 or 100 years as indicated in Figure 3. In other words, parts of Greater Toronto could become uninhabitable for several decades or longer.

Economic Losses

Finally, this report estimates that losses of home property values would exceed $125 billion. However, this is a partial estimate as similar losses would also have occurred in business, industrial, commercial, governmental and municipal properties, and in apartment and condominium values as well.

It is difficult to contemplate or internalize such huge consequences. In sum, the continued operation of the Pickering NGS creates a hostage to fortune for everyone living in the Province of Ontario.

Over 2,000 years ago Cicero, the Roman orator and lawyer, wrote "*Salus populi suprema lex esto*" – the health of the people is the highest law. By this standard, the Ontario Government has the clear duty to protect its citizens from the very serious consequences that would arise if a Fukushima-level accident were to occur at the Pickering NGS.

[31] See http://www.ianfairlie.org/news/assessing-long-term-health-effects-from-fukushimas-radioactive-fallout/



AIR PHOTO SERVICE

The explosions at three reactors at the Fukushima Daiichi Nuclear Station had devastating consequences for the people of Japan.



The Fukushima accident is estimated to have resulted in $236 billion in economic losses for Japan.

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Appendix A: Populations in Contaminated Areas in Figure 1

Populations in pale blue areas in Figure 1 (average dose = 3.285 mSv/a)

Toronto City (50%)	1,365,786
Mississauga	721,599
Brampton	593,638
Hamilton	536,917
Kitchener-Cambridge-Waterloo	523,894
London	494,069
St. Catharines	406,074
Barrie	197,059
Oakville	193,832
Guelph	131,794
Markham (35%)	115,138
Halton Hills	61,161
Brantford (50%)	49,360
Woodstock	40,902
Stratford	31,465
Orangeville	30,734
Vaughan (10%)	30,623
Grimsby	27,314
Dundas	24,285
Fergus	20,767
Bracebridge	16,010
West Lincoln	14,500
Strathroy	14,401
Ingersoll	12,757
Gravenhurst	12,311
Elmira	11,988
Norwich	11,001
Caledonia	9,674
EastZorra-Tavistock	7,129
St. Marys	7,265
Huntsville	6,482
Komoka	1,754
Erie PA (US*)	98,593
Total	**5,820,276**

All data from Statistics Canada (2017)
(*from United States Census Bureau)

Appendix B: Populations in Contaminated Areas in Figure 2

Estimates of Affected Populations in Municipalities

Municipality	Estimated Percent of Land Area That Is Contaminated	Estimated Affected Population
100 mSv areas		
Pickering	100%	92,000
Markham	25%	82,000
Richmond Hill	6%	13,000
Whitchurch-Stouffville	50%	23,000
Sub Total		**210,000**
50 mSv areas		
Markham	12%	42,000
Richmond Hill	15%	30,000
Whitchurch-Stouffville	25%	11,000
Scarborough	10%	63,000
Sub Total		**146,000**
20 mSv areas		
Newmarket	50%	42,000
Markham	12%	7,000
Richmond Hill	10%	20,000
Whitchurch-Stouffville	25%	11,000
East Gwillimbury	90%	22,000
Ballantrae	100%	3,000
Pleasantville	100%	7,000
Aurora	50%	27,000
Scarborough	25%	158,000
Sub Total		**297,000**

continued next page

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Municipality	Estimated Percent of Land Area That Is Contaminated	Estimated Affected Population
10 mSv areas		
Newmarket	25%	21,000
East Gwillimbury	10%	2,000
Schomberg	40%	1,000
Markham	6%	3,000
Richmond Hill	6%	12,000
Scarborough	40%	253,000
Mt. Albert	50%	2,000
Newmarket	25%	21,000
Markham	12%	7,000
Aurora	50%	27,000
Bradford - West Gwillimbury	20%	7,000
Caledon	40%	27,000
Sub Total 10 mSv		**383,000**
5 mSv areas		
Newmarket	25%	21,000
Markham	37%	123,000
Richmond Hill	50%	98,000
Scarborough	25%	158,000
Schomberg	40%	1,000
Mt. Albert	50%	2,000
Brampton	25%	148,000
North York	25%	163,000
Vaughan	25%	77,000
Toronto	30%	820,000
Nobleton	100%	5,000
Bradford -West Gwillimbury	80%	28,000
Innisfil Heights	100%	37,000
Thornton	100%	137,000
Sub Total 5 mSv		**1,818,000**
Grand Total		**2,854,000**

Population data from Statistics Canada (2017)

Appendix C: Estimates of House Values Lost in Each Municipality

We have used data from the Municipal Property Assessment Corporation (2016) to calculate house values that would be lost if the Pickering Nuclear Station were to suffer a Fukushima-level accident and long-term evacuation and no re-entry orders were issued.

The values were determined by first estimating the average value of houses in each Ontario municipality (for City of Toronto in the case of Scarborough). This estimate was based on residential housing value assessments[32] made by the Municipal Property Assessment Corporation (MPAC) in 2016. Average values for single-detached, semi-detached, row house or any other single-attached dwellings were determined. (Values of apartments in apartment blocks were not included.)

These average house values were multiplied by the number of houses estimated to be lost from such an accident. The three evacuation zones areas of 30 years, 70 years and 100 years (see Figure 3) were digitized over a shapefile (GIS geographic file) map of the Greater Toronto Area. Based on the boundaries of the evacuation zones in Figure 3, the number of houses were counted within each zone based on the count for single-detached, semi-detached, row house or any other single-attached house dwelling for each of the census tracts of Greater Toronto Area municipalities (the census tracts were based on data collected from the 2016 Canadian Census).

For census tracts that were partially located inside the evacuation zones, estimates of how many dwellings would be affected were determined by examining how much of the local street network was located within each evacuation zone. The detailed calculations for each municipality are set out in the following table.

The main conclusion here is that estimated losses of house property values would exceed $125 billion. However, this is very much a partial estimate as greater losses would likely have occurred in business, industrial, commercial, governmental and municipal properties, and in apartment values as well.

These very large losses are commensurate with the estimates of economic losses at Fukushima of U.S.$ 188 billion (Can$ 236 billion).

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[32] housing value assessment for East Gwillimbury from a report by Canadian Real Estate Wealth (2016)

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Residence Values in Ontario Municipalities

All Areas	**Total Estimated Loss**
Estimated Dwelling Count (Based on figures from 2016 Canadian census)	153,969
Multiplied by each municipality's average housing value (According to 2016 MPAC assessment and Canada Real Estate Wealth)	$125,642,400,000
Pickering	**Estimated Loss**
Estimated Dwelling Count (Based on figures from 2016 Canadian Census)	23,037
Multiplied by **$563,000** (According to 2016 MPAC assessment)	$12,969,831,000
Scarborough	**Estimated Loss**
Estimated Dwelling Count (Based on figures from 2016 Canadian Census)	39,508
Multiplied by **$770,000** (According to 2016 MPAC assessment)	$30,421,160,000
Markham	**Estimated Loss**
Estimated Dwelling Count (Based on figures from 2016 Canadian Census)	59,487
Multiplied by **$991,000** (According to 2016 MPAC assessment)	$58,951,617,000
Whitchurch-Stouffville	**Estimated Loss**
Estimated Dwelling Count (Based on figures from 2016 Canadian Census)	14,085
Multiplied by **$741,000** (According to 2016 MPAC assessment)	$10,436,985,000
Newmarket	**Estimated Loss**
Estimated Dwelling Count (Based on figures from 2016 Canadian Census)	9,857
Multiplied by **$655,000** (According to 2016 MPAC assessment)	$6,456,335,000
Richmond Hill	**Estimated Loss**
Estimated Dwelling Count (Based on figures from 2016 Canadian Census)	188
Multiplied by **$1,028,000** (According to 2016 MPAC assessment)	$193,264,000
East Gwillimbury	**Estimated Loss**
Estimated Dwelling Count (Based on figures from 2016 Canadian Census)	1,571
Multiplied by **$921,450** (According to 2016 report from Canadian Real Estate Wealth)	$1,447,597,950
Aurora	**Estimated Loss**
Estimated Dwelling Count (Based on figures from 2016 Canadian Census)	6,079
Multiplied by **$770,000** (According to 2016 MPAC assessment)	$4,680,830,000
Uxbridge	**Estimated Loss**
Estimated Dwelling Count (Based on figures from 2016 Canadian Census)	157
Multiplied by **$540,000** (According to 2016 MPAC assessment)	$84,780,000

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Radioactively contaminated topsoil and debris is stockpiled throughout Fukushima Prefecture.

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Canada’s nuclear regulator overlooked dubious data when renewing Pickering plant’s licence, documents show

In 2018, the CNSC extended Ontario Power Generation’s licence for its Pickering Nuclear Generating Station for 10 years, and in doing so, lifted key regulatory roadblocks that would have forced OPG to replace aging pressure tubes

https://www.theglobeandmail.com/canada/article-canadas-nuclear-regulator-overlooked-dubious-data-when-renewing/

Matthew McClearn
Published March 23, 2021 Updated March 23, 2021



The Pickering Nuclear Generating Station is shown in January of 2020, a year and a half after the Canadian Nuclear Safety Commission renewed its operating license. - Frank Gunn/The Canadian Press

When it renewed the operating licence for Canada’s oldest nuclear power plant, the Canadian Nuclear Safety Commission overlooked perplexing results from inspections of the station’s pressure tubes that nobody could explain – a decision critics say is part of a larger pattern of placing the industry’s interests over those of the public.

In August, 2018, the CNSC extended Ontario Power Generation’s licence for its Pickering Nuclear Generating Station for 10 years – the longest term it had ever received. In doing so, the CNSC lifted key regulatory roadblocks that would have forced OPG to replace aging pressure tubes – six-metre-long rods that contain fuel bundles of uranium – at great expense.

The tubes – often referred to as the heart of CANDUs, the reactor design found in Canada's nuclear power plants – deteriorate as they age. If one ruptures, coolant could be lost, which could trigger a range of scenarios from a relatively minor incident that's contained by the plant's safety systems but results in costly damage, to a catastrophe in which fuel overheats. Each of Pickering's reactors contains 380 pressure tubes; Pickering Station has six operational reactors.

In a worst-case scenario, a ruptured tube could lead to a series of "cascading failures not unlike what happened at Fukushima," says Sunil Nijhawan, a nuclear engineer and consultant who once worked for OPG and specializes in accident and safety assessments. He was referring to the 2011 accident at the Fukushima Daiichi Nuclear Power Plant following an earthquake and tsunami, in which the loss of coolant led to three reactor meltdowns, hydrogen explosions and radioactive releases. That scenario is of "low probability," he added, but "the consequences to the nation would be very high."



Smoke rises from Unit 3 of Japan's Fukushima Dai-ichi nuclear plant on March 21, 2011, after an earthquake and tsunami caused a disaster. TEPCO via Kyodo News/AP

Documents obtained under the federal Access to Information Act by Ottawa researcher Ken Rubin, and provided to The Globe, show that since 2017, CNSC staffers had grown increasingly concerned about unreliable data arising from OPG's inspections of pressure tubes.

In December, 2019, Alexandre Viktorov, regulatory program director for CNSC's Pickering Regulatory Program Division, sent a letter to OPG detailing numerous concerns about results from those inspections, some of which appeared to defy the laws of physics. A 32-page appendix warned that inspections data were used extensively in predictive models used to determine how

much longer Pickering's tubes should operate before requiring replacement. (These predictions inform what the industry calls "fitness for service" assessments.) The letter described the resulting uncertainty around fitness for service as "potentially one of the biggest issues currently faced by the Industry."

The original design life of Pickering Station's pressure tubes was 30 years, a limit they began passing around 2014. (Its oldest tubes date from 1982). The station was built half a century ago during the nuclear industry's heyday, during which dozens of new reactors entered service worldwide each year. But that era is a distant memory, leaving owners and regulators with difficult decisions about how much longer aging plants should continue operating.

With Pickering Station there's an additional consideration: located just 30 km from downtown Toronto, it's one of very few nuclear plants within a major global city.

In interviews and statements, the CNSC said the inaccurate data – which OPG attributed to improper calibration of measurement equipment by an outside vendor – is being corrected, a process that will be complete by the end of this year.

"There was never an immediate safety concern," a CNSC spokesperson wrote in an e-mail to The Globe. "The CNSC is satisfied with the corrective measures put in place … no future actions are required."

Critics disagreed on all counts.

Former OPG employee Frank Greening, who worked in the company's pressure tube group for the last decade of his career before retiring in 2000, said the letter shows that OPG was unable to demonstrate to its regulator that the station's pressure tubes were fit for service.

"At the time they were approving this licence, they knew about this problem," Mr. Greening said. "So I can't help but use the word 'cover up' at that point. The CNSC had the audacity to go public and say, 'Everything's fine. There's your licence.' "

Gordon Edwards, president of the Canadian Coalition for Nuclear Responsibility, is a long-time anti-nuclear activist and consultant. He said the inability to resolve the data problems until late 2021 shows that the industry is currently running blind.

"Whether they admit it or not, they know they are taking a risk," he said.

"We're running these reactors without any real confidence that we're doing the right thing."

Pickering Nuclear Generating Station is located in a densely populated area
The Ontario Clean Air Alliance, which has called for the plant's prompt dismantling, says more people live within a 30 km radius of it than any other nuclear power plant in North America



MURAT YÜKSELIR / THE GLOBE AND MAIL, SOURCE: TILEZEN; OPENSTREETMAP CONTRIBUTORS; MICROSOFT; STATISTICS CANADA

Heart of the Reactor

Pressure tubes, the major life-limiting component of CANDUs, inhabit a hostile environment. They're bombarded with neutrons as nuclear fission takes place within. While most of these neutrons travel through the material, some are absorbed: pressure tubes gradually pick up deuterium (an isotope of hydrogen) through a corrosion process known as deuterium ingress.

In combination with other aging processes, deuterium ingress causes tubes to grow in length and diameter (known as creep), which allows more coolant to bypass the fuel bundles, lowering the margin of safety. Meanwhile their walls thin and the metal embrittles, and tubes begin to sag.

Eventually tubes can become so brittle that they can fracture. Several CANDU tubes failed in the 1970s and 1980s, but these incidents were of low severity and plant safety systems were able to cope: there has been no reported tube ruptures since 1986.

The original design life for pressure tubes was approximately 30 years – or 210,000 effective full power hours (EFPH). When the tubes in Hydro Quebec's CANDU station east of Trois Rivières reached that limit, it closed the plant, called Gentilly-2. Thierry Vandal, chief executive at the time, testified before Quebec's national assembly that he considered 210,000 EFPH "the extreme limit" beyond which his management team dared not go.

"I would no more operate Gentilly-2 beyond 210,000 hours than I would climb onto an airplane that does not have its permits and that does not meet the standards," he said, according to a translated transcript.

The decision to operate Pickering's tubes longer was informed, in part, by data from inspections and predictive models showing tubes could remain fit for service well beyond original expectations. In 2014, as Pickering's oldest pressure tubes neared 210,000 EFPH, OPG officials told the CNSC that limit had been arbitrary.

"It wasn't based on technical knowledge or experience of the day," testified Bryce Phillips, senior vice-president of the Pickering Station, at a hearing. "No one had run a CANDU reactor for any significant period of time back then. We know a lot more now than we did then."

The CNSC raised the limit to 247,000 EFPH (in 2014) and then to 295,000 EFPH (in 2018). It deems the new limit to be safe. During a meeting in January, CNSC technical specialist Blair Carroll told commissioners that licensees had shown that tubes deteriorated less than expected, so "additional operating margins were available."

Even as it eased the age limits, however, the CNSC beefed up inspection requirements.

OPG shuts down reactors for inspections every two or three years, during planned outages. It can take between five and 10 days to get the reactor powered down and depressurized. OPG uses a cutting tool to scrape off tiny metal samples (about a millimetre thick) from select tubes and drops them into flasks. They're called scrape measurements, and they're typically conducted on 10 or more tubes. The highly radioactive samples are sent to a lab for analysis, to measure how much deuterium they've picked up.

All this is expensive. Each day a reactor is out of service costs up to $1-million. Whereas in years past planned outages lasted about 60 days, now they're taking up to twice as long. OPG figured that the incremental costs for additional inspections would be as much as $236-million for the four years leading up to 2020.

OPG can't inspect all 380 tubes in each reactor – there's simply too many. Instead, it feeds data from the small number of inspected tubes into mathematical models used to predict how long the rest can safely remain in service. (More than two-thirds of tubes will never be inspected.) One model predicts how quickly tubes will accumulate deuterium. Others estimate how much they

will weaken as they accumulate deuterium, and are known as material fracture toughness models.

But internal CNSC documents make it abundantly clear that modelling is not an exact science. Models are frequently revised because they don't square with data obtained during inspections.

Dr. Greening, the retired expert, said deuterium ingress is bafflingly complex. Generally, it occurs more rapidly in parts of the tube subjected to higher water temperatures; concentrations tend to be higher at the tube's outlet end where coolant water exits at about 300 C. They're also higher at a part of the tube known as the rolled joint. For reasons that aren't fully understood, tubes near one another in the reactor sometimes pick up deuterium at different rates.

"Deuterium pickup does not follow a nice simple law," he said. "So to predict it is a nightmare."

Making accurate predictions isn't the only challenge: scraping inspections have been known to produce unreliable data since the 1990s. The latest problems surfaced in 2017 when data from one of Pickering Station's reactors showed a "relatively large" reduction in deuterium levels. It wasn't an isolated incident: In August, 2018, OPG submitted 20 scrapes from tubes in another reactor. After analysis, 12 of them showed decreased or unchanged deuterium levels.

These readings distressed CNSC staff for one simple reason: There is no known way that deuterium can diffuse out of pressure tubes. It always accumulates over time, so falling levels suggested the data was corrupt. The whole method by which operators assessed fitness for service of pressure tubes had been called into question.

"The continuous challenges and the overall lack of understanding is very worrisome," CNSC staff wrote.

And there was yet another problem.

In addition to inspecting in-service tubes, OPG periodically removes one from each reactor and sends it to a lab for destructive testing. A crack is introduced into a section of the tube, and then it's pressurized until it bursts. The results help the nuclear industry gauge how long tubes can remain in service before they become dangerously brittle.

During a burst test in 2017 known as BT-29, a segment of tube burst at a pressure below what the mathematical models predicted. OPG told the Commission that the testing conditions "were more severe than conditions expected for pressure tubes in

Units" and that the facility's tubes remained fit for service.

Nevertheless, the CNSC imposed restrictions on use of that model; according to the CNSC, industry subsequently conducted nine more burst tests, none of which exhibited the same weakness.

‘Numerically corrected’

The CNSC said the BT-29 test had no impact on its assessment of the safe operation of pressure tubes, and it has also moved on from the concerns expressed in the Dec. 2019 letter.

In e-mailed responses to questions, a Commission spokesperson explained that subsequently, an investigation determined that a contractor hired by OPG to measure deuterium concentrations in scrape samples had miscalibrated a measuring tool known as a Thermal Desorption Mass Spectrometer. The data is now being “numerically corrected to account for the calibration error.”

In an interview, Dr. Viktorov acknowledged that some of the concerns identified in his Dec. 2019 letter remain unresolved. But he said that they relate to the predictive models, not the condition of tubes. “What the present condition is right now, we know this through inspections.” OPG complied with its licensing requirements at all times, he added.

Dr. Greening found the Commission’s explanation unsatisfactory.

“That opens a huge can of worms in my mind,” he said. “Well, why was [the equipment] not calibrated? Don’t you guys do these measurements all the time? Don’t you have protocols and procedures? How could you miss that?

“They are in violation of their own standard,” he added. “Their license requirement is they do these tests, get this data and show that everything’s fine. And right now they’re not in a position to do that.”

Responding to questions from The Globe, CNSC president Rumina Velshi said it would be inappropriate to comment on the Commission’s decisions beyond what the CNSC had already published.

“Pickering Nuclear Generating Station pressure tube fitness for service was confirmed through various evaluation methods and continues to be evaluated regularly by Ontario Power Generation and reviewed by our staff,” a CNSC spokesperson wrote.

The CNSC reports to Parliament through the Minister of Natural Resources, Seamus O’Regan.

His press secretary, Ian Cameron, wrote in a statement: “The health and safety of Canadians is always our top priority. All Canadian nuclear power facilities are licensed and monitored by Canada’s independent regulator – the Canadian Nuclear Safety Commission (CNSC) – which makes science-based, objective decisions, and regularly undergoes peer-reviews from world-renowned organizations.”

Critics often accuse the CNSC of serving the industry’s interests. The documents obtained through the Access to Information Act appear to tell a more complicated story. Read in one light, Dr. Viktorov emerges as a diligent, thorough regulator, a man not easily satisfied by what he regarded as unsatisfactory responses from regulated companies. (The CNSC rejected OPG’s

early explanations for the wonky data, and subsequent developments suggest that skepticism was warranted.)

Yet neither Dr. Viktorov nor anybody else from the CNSC raised concerns about erroneous inspections data at the 2018 hearings. (Rather, he assured the Commission that OPG's continuing work "will continue demonstrating that the fuel channels are fit for service" beyond 40 years of age.) The Commission extended the license for 10 years.

"This issue was not raised during the Pickering relicensing hearing because the questionable data was never used," the CNSC said in a statement. "Relicensing decisions were only based on valid data." In contrast, the Dec. 2019 letter repeatedly emphasized how bad inspections data could compromise predictive models.

Dr. Nijhawan said what troubled him most about the letter was how quickly the CNSC declared that the industry had resolved problems identified by staff.

"In most cases they turn obvious mistakes and violations into non-issues, and where they cannot they accept garbage science," he wrote.

At the time of the licence renewal, OPG's stated intent was that commercial operations would cease at the end of 2024. Since then, however, OPG has said it wants to run the reactors for an additional year. A hearing date before the CNSC hasn't been set.

Dr. Nijhawan said pressure tubes are but one of many CANDU reactor components that have aged to the point where they present a hazard to public safety.

"Pickering has 100 other issues with it," he said. "You cannot run these reactors to that age."

Dr. Greening said that the CANDU design is clever, and Canadians should be proud of it. But he says the industry cannot accept that its reactors have aged past the point of obsolescence.

"They don't want to give up and they want to keep pushing this CANDU to the absolute limit," he said. "And my concern is that one of these days, they'll exceed that limit, and we will have a potentially very nasty accident at one of these stations.

"I think they're playing Russian Roulette with the Canadian public."

Editor's note: The Canadian Nuclear Safety Commission reports to Parliament through the Minister of Natural Resources. Incorrect information appeared in a previous version of this story.

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Advertisement



Pickering

Country: Canada
Continent: North America

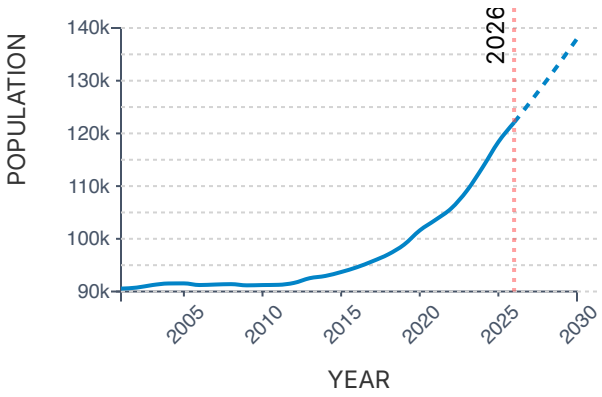
Pickering's 2026 population is now estimated at **122,059**.In 2001, the population of Pickering was **90,552**.Pickering has grown by 3,681 in the last year, which represents a 3.11% annual change.These population values and projections come from Statistics Canada Table 17-10-0155-01: Population estimates, July 1, by census subdivision, 2021 boundaries and World Population Review Internal Projections.

122.1K	3.7K 3.11%
Total Population	Growth

Capital of Canada?

Pickering Population

All 10Y 25Y



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CITY	2026 POP. ↓	GROWTH
Toronto	3,358,275	2.64%
Montreal	1,943,903	1.49%
Calgary	1,678,073	4.04%
Edmonton	1,284,480	3.73%
Ottawa	1,218,903	2.59%
Winnipeg	870,032	2.33%
Brampton	801,732	3.08%
Mississauga	768,794	0.55%
Vancouver	751,644	1.51%
Surrey	731,630	3.99%
Hamilton	652,266	1.84%

Halifax	532,856	3.1%
London	508,883	2.85%
Laval	466,247	1.03%

Sources

1. Statistics Canada Table 17-10-0155-01: Population estimates, July 1, by census subdivision, 2021 boundaries
2. World Population Review Internal Projections

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Selling a home near the nuclear plant? That false alarm just reminded everyone of the risks

Haider-Moranis Bulletin: Those thinking they might be getting a deal, and that prices in the vicinity of such a facility will normalize, should beware

By **Murtaza Haider and Stephen Moranis, Haider-Moranis Bulletin**
Published Jan 14, 2020 3 minute read Join the conversation

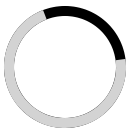
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The Pickering Nuclear Generating Station in PIckering, Ont. PHOTO BY AARON LYNETT/NATIONAL POST FILES

On Sunday, 15 million Ontarians were jolted out an early morning slumber by an emergency alert issued by the provincial government, warning about an incident at the Pickering Nuclear Generating Station just east of Toronto.

While the alert said emergency staff were responding to the situation, it thankfully noted there had been “no abnormal release of radioactivity” and that no action was required on the part of local residents. It explicitly indicated the alert was directed at residents within 10 km of the nuclear facility.



STORY CONTINUES BELOW

The good news, for those living in the vicinity of the plant, is that it turns out the alert was a false alarm, sent in error apparently during a training exercise. The bad news is that it reminded everyone that buying a home within that 10 km band comes with an added element of risk.

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Properties located adjacent to certain kinds of facilities or infrastructure deemed undesirable — such as waste treatment plants, power lines, or nuclear power plants — are often impacted by negative effects because of real or perceived health or amenity risks. Visual encumbrance can be a problem, too.

Those living near the plant, which became fully operational in 1971, no doubt have been aware of these issues when they bought their properties.

But Sunday's false alarm may give prospective buyers pause — at least in the short term.

The Pickering power plant is located approximately 33 km west of downtown Toronto fronting on Lake Ontario. According to the 2016 Census, almost 300,000 people live within a 10-km radius of the plant. A much larger population of about 1.13 million lives with a 20-km radius.

STORY CONTINUES BELOW

The plant has been an essential contributor to the province's electricity grid for decades — it generates 3,100 megawatts of electricity, representing almost 15 per cent of the province's supply. But the plant is also getting old. The provincial government intends to continue operating the plant beyond 2020 to at least 2024, something that for many residents was not welcome news.

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While Canada has never experienced a major nuclear disaster, awareness about the possible safety risks from nuclear power plants came to the fore after a March 2011 earthquake in Japan, resulting in a meltdown at the Fukushima Daiichi nuclear power plant. The ripple effects of the Fukushima accident were felt far and wide.

In Germany, for instance, the anti-nuclear protests after the Japan earthquake forced the German government to close eight of its 17 nuclear power plants. The government also committed to phasing out the remaining plants by 2022.

A paper published in 2017 in the Journal of Urban Economics also found that housing prices near still-operating plants in Germany

were negatively affected by Fukushima, declining by 4.9 per cent.

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Housing prices near German plants that were shut down after the accident in Japan fell even further — by 9.8 per cent. Even though the perceived safety risks are mitigated near the decommissioned sites, the economic fallout resulting from plant employees losing their jobs can exacerbate the price declines.

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Homeowners near such sites usually are out of luck when it comes to compensation.

Most infrastructure facilities predate the residential neighbourhoods that fill in around them. While homeowners benefit from lower values when they buy their homes, they will have a hard time attracting top dollar in a subsequent sale.

Those thinking they might be getting a deal, and that prices in the vicinity of such a facility will normalize, should beware. The impact of undesirable facilities or outcomes can last for a long time. A forthcoming paper in the journal American Economic Review showed that differences in housing prices in neighbourhoods in London that were impacted by cholera persisted for over 160 years.

Ontario's solicitor general, Sylvia Jones, has already apologized for the Pickering alert, which she stated was "issued in error to the public."

For those trying to sell their homes in the vicinity of plant, that may be of little comfort.

Murtaza Haider is a professor of Real Estate Management at Ryerson University. Stephen Moranis is a real estate industry veteran. They can be reached at www.hmbulletin.com.

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Population estimates, July 1, by census metropolitan area and census agglomeration, 2021 boundaries[1, 2, 3, 4, 5, 6, 7]

Frequency: Annual

Table: 17-10-0148-01

Release date: 2026-01-14

Geography: Canada, Census metropolitan area, Census agglomeration, Census metropolitan area part, Census agglomeration part

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Gender :

Total - gender

Age group : [8]

All ages

Reference period

From:

2021

To:

2025

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Gender	Total - gender				
Age group[8]	All ages				
Geography	2021	2022	2023	2024	2025
	Persons				

Gender	Total - gender				
Age group[8]	All ages				
Geography	2021	2022	2023	2024	2025
Canada (map)	38,239,864	38,950,132	40,049,088	41,262,329	41,651,653
All census metropolitan areas and census agglomerations, Canada	32,089,899	32,734,767	33,776,803	34,926,482	35,272,005
All census metropolitan areas, Canada	28,222,191	28,815,714	29,789,257	30,859,870	31,169,100
St. John's (CMA), Newfoundland and Labrador (map)	220,052	224,707	232,536	240,428	243,478
Halifax (CMA), Nova Scotia (map)	482,144	498,222	515,453	536,372	544,834
Moncton (CMA), New Brunswick (map)	161,376	168,356	178,208	190,477	196,143
Saint John (CMA), New Brunswick (map)	133,140	135,443	138,854	142,905	144,543
Fredericton (CMA), New Brunswick (map)	111,017	114,480	118,659	123,308	125,303
Saguenay (CMA), Quebec (map)	162,376	164,244	166,557	169,247	170,192
Québec (CMA), Quebec (map)	844,774	857,697	875,108	894,691	903,607
Sherbrooke (CMA), Quebec (map)	229,294	233,354	237,466	242,136	243,911
Trois-Rivières (CMA), Quebec (map)	162,531	165,780	168,438	172,585	174,316
Drummondville (CMA), Quebec (map)	102,356	103,827	105,919	107,895	109,151
Montréal (CMA), Quebec (map)	4,330,143	4,372,296	4,465,221	4,572,813	4,597,837
Ottawa - Gatineau (CMA), Ontario/Quebec (map)	1,540,340	1,568,982	1,610,010	1,661,966	1,700,014
Ottawa - Gatineau (CMA), Ontario part, Ontario (map)	1,184,369	1,209,897	1,246,173	1,291,272	1,325,788
Ottawa - Gatineau (CMA), Quebec part, Quebec (map)	355,971	359,085	363,837	370,694	374,226
Kingston (CMA), Ontario (map)	179,707	184,150	188,354	192,395	193,466
Belleville - Quinte West (CMA), Ontario (map)	115,493	118,545	121,069	123,720	124,978
Peterborough (CMA), Ontario (map)	133,661	137,058	141,740	148,630	149,938
Oshawa (CMA), Ontario (map)	433,529	447,894	464,288	482,076	493,441
Toronto (CMA), Ontario (map)	6,472,951	6,591,642	6,840,723	7,109,866	7,108,874
Hamilton (CMA), Ontario (map)	817,777	827,480	843,066	862,679	871,143

Gender	Total - gender				
Age group[8]	All ages				
Geography	2021	2022	2023	2024	2025
St. Catharines - Niagara (CMA), Ontario (map)	450,926	462,224	477,863	493,608	503,670
Kitchener - Cambridge - Waterloo (CMA), Ontario (map)	602,303	627,929	664,490	699,402	701,568
Brantford (CMA), Ontario (map)	156,714	161,449	167,206	173,380	176,307
Guelph (CMA), Ontario (map)	172,876	176,523	179,894	182,615	183,134
London (CMA), Ontario (map)	567,539	586,473	607,654	626,875	633,002
Windsor (CMA), Ontario (map)	439,473	453,224	469,673	484,698	488,738
Barrie (CMA), Ontario (map)	222,065	230,302	238,309	247,098	252,446
Greater Sudbury (CMA), Ontario (map)	177,415	180,295	185,364	192,688	194,278
Thunder Bay (CMA), Ontario (map)	128,040	129,009	131,123	133,305	133,765
Winnipeg (CMA), Manitoba (map)	860,237	877,045	909,657	940,010	951,758
Regina (CMA), Saskatchewan (map)	257,368	260,689	271,896	285,039	291,187
Saskatoon (CMA), Saskatchewan (map)	328,256	336,168	352,851	369,766	378,475
Lethbridge (CMA), Alberta (map)	128,503	130,818	134,883	140,181	143,143
Calgary (CMA), Alberta (map)	1,540,242	1,587,723	1,680,332	1,783,661	1,836,012
Red Deer (CMA), Alberta (map)	104,429	105,653	108,971	112,959	115,273
Edmonton (CMA), Alberta (map)	1,472,402	1,500,864	1,560,830	1,641,668	1,692,385
Kelowna (CMA), British Columbia (map)	232,150	239,880	246,046	251,648	254,605
Kamloops (CMA), British Columbia (map)	119,049	122,129	125,303	127,457	127,198
Chilliwack (CMA), British Columbia (map)	118,634	121,511	123,690	127,026	130,283
Abbotsford - Mission (CMA), British Columbia (map)	204,670	207,467	213,548	220,638	223,828
Vancouver (CMA), British Columbia (map)	2,771,430	2,855,205	2,970,008	3,081,713	3,088,036
Victoria (CMA), British Columbia (map)	414,596	426,033	432,684	441,961	445,090
Nanaimo (CMA), British Columbia (map)	120,213	122,944	125,313	128,285	129,750
All census agglomerations, Canada	3,867,708	3,919,053	3,987,546	4,066,612	4,102,905

Gender	Total - gender				
Age group[8]	All ages				
Geography	2021	2022	2023	2024	2025
Grand Falls-Windsor (CA), Newfoundland and Labrador (map)	14,294	14,366	14,480	14,516	14,549
Gander (CA), Newfoundland and Labrador (map)	13,817	13,838	14,102	14,266	14,389
Corner Brook (CA), Newfoundland and Labrador (map)	30,827	30,985	31,009	31,379	31,880
Charlottetown (CA), Prince Edward Island (map)	83,104	86,395	90,602	94,906	96,516
Summerside (CA), Prince Edward Island (map)	19,051	19,344	19,964	20,619	21,017
Kentville (CA), Nova Scotia (map)	27,776	28,283	28,731	29,283	29,559
Truro (CA), Nova Scotia (map)	48,077	48,762	49,579	50,650	51,166
New Glasgow (CA), Nova Scotia (map)	35,345	35,739	36,109	36,493	36,677
Cape Breton (CA), Nova Scotia (map)	100,754	102,830	108,760	112,078	111,889
Bathurst (CA), New Brunswick (map)	31,876	32,177	32,624	33,326	33,467
Miramichi (CA), New Brunswick (map)	28,085	28,620	29,287	30,047	30,218
Edmundston (CA), New Brunswick (map)	22,514	22,634	23,275	24,174	24,655
Campbellton (CA), New Brunswick/Quebec (map)	15,206	15,096	15,185	15,450	15,554
Campbellton (CA), New Brunswick part, New Brunswick (map)	12,204	12,134	12,202	12,483	12,587
Campbellton (CA), Quebec part, Quebec (map)	3,002	2,962	2,983	2,967	2,967
Matane (CA), Quebec (map)	18,494	18,782	18,839	18,722	18,724
Rimouski (CA), Quebec (map)	54,209	54,651	55,319	56,542	56,959
Rivière-du-Loup (CA), Quebec (map)	30,134	30,259	30,573	30,849	30,925
Baie-Comeau (CA), Quebec (map)	26,730	26,652	26,556	26,530	26,446
Alma (CA), Quebec (map)	30,418	30,496	30,685	30,813	30,682
Dolbeau-Mistassini (CA), Quebec (map)	15,295	15,283	15,298	15,276	15,213
Sept-Îles (CA), Quebec (map)	27,892	27,813	27,791	27,858	27,853
Sainte-Marie (CA), Quebec (map)	13,199	13,343	13,468	13,706	13,933

Gender	Total - gender				
Age group[8]	All ages				
Geography	2021	2022	2023	2024	2025
Saint-Georges (CA), Quebec (map)	34,970	35,215	35,620	35,973	36,067
Thetford Mines (CA), Quebec (map)	28,332	28,485	28,925	29,251	29,602
Cowansville (CA), Quebec (map)	15,377	15,908	16,230	16,578	17,011
Victoriaville (CA), Quebec (map)	53,099	53,589	54,152	54,866	55,053
Shawinigan (CA), Quebec (map)	49,892	50,678	51,113	51,604	51,734
Granby (CA), Quebec (map)	91,440	92,605	93,764	95,061	95,867
Saint-Hyacinthe (CA), Quebec (map)	60,306	61,224	62,124	63,137	63,565
Sorel-Tracy (CA), Quebec (map)	42,124	42,525	42,629	43,112	43,478
Joliette (CA), Quebec (map)	53,023	53,706	54,504	55,347	56,044
Salaberry-de-Valleyfield (CA), Quebec (map)	43,177	43,880	44,787	45,935	46,892
Sainte-Agathe-des-Monts (CA), Quebec (map)	20,013	20,241	20,658	20,862	21,208
Lachute (CA), Quebec (map)	14,226	14,828	14,994	15,177	15,364
Val-d'Or (CA), Quebec (map)	34,234	34,279	34,393	34,759	34,862
Amos (CA), Quebec (map)	18,958	18,939	18,934	18,962	18,862
Rouyn-Noranda (CA), Quebec (map)	42,565	42,696	42,771	43,190	43,281
Hawkesbury (CA), Ontario/Quebec (map)	12,333	12,428	12,515	12,717	13,134
Hawkesbury (CA), Ontario part, Ontario (map)	10,506	10,561	10,596	10,821	11,196
Hawkesbury (CA), Quebec part, Quebec (map)	1,827	1,867	1,919	1,896	1,938
Cornwall (CA), Ontario (map)	63,680	64,435	66,346	67,926	68,503
Brockville (CA), Ontario (map)	32,768	33,255	33,509	33,778	33,946
Pembroke (CA), Ontario (map)	24,701	24,802	24,838	24,677	24,465
Petawawa (CA), Ontario (map)	19,131	19,309	19,671	20,266	20,890
Cobourg (CA), Ontario (map)	21,159	20,968	21,045	21,041	21,028
Port Hope (CA), Ontario (map)	17,915	18,331	18,484	18,620	18,565
Kawartha Lakes (CA), Ontario (map)	82,147	83,694	84,273	84,802	85,223
Centre Wellington (CA), Ontario (map)	32,336	33,138	33,662	34,743	35,736

Gender	Total - gender				
Age group[8]	All ages				
Geography	2021	2022	2023	2024	2025
Ingersoll (CA), Ontario (map)	14,335	14,451	14,739	14,843	15,042
Woodstock (CA), Ontario (map)	48,777	50,084	51,172	52,584	53,801
Tillsonburg (CA), Ontario (map)	18,700	19,052	19,535	19,938	20,575
Norfolk (CA), Ontario (map)	70,300	72,233	73,373	74,384	75,773
Stratford (CA), Ontario (map)	34,522	34,835	35,171	35,505	35,702
Chatham-Kent (CA), Ontario (map)	108,243	109,418	110,453	111,679	112,977
Sarnia (CA), Ontario (map)	101,251	104,006	106,249	108,798	108,986
Essa (CA), Ontario (map)	24,039	24,611	24,863	25,361	25,868
Wasaga Beach (CA), Ontario (map)	25,780	26,606	27,194	28,098	29,039
Owen Sound (CA), Ontario (map)	33,887	34,365	34,747	35,176	35,534
Collingwood (CA), Ontario (map)	25,714	26,286	26,821	27,092	27,266
Orillia (CA), Ontario (map)	34,732	35,483	36,186	36,945	37,477
Midland (CA), Ontario (map)	28,955	29,470	29,734	29,937	30,087
North Bay (CA), Ontario (map)	74,521	76,924	80,138	84,475	84,834
Elliot Lake (CA), Ontario (map)	11,711	11,914	11,917	11,894	11,901
Timmins (CA), Ontario (map)	42,763	43,147	44,922	45,935	45,983
Sault Ste. Marie (CA), Ontario (map)	80,202	81,955	84,916	88,334	88,307
Kenora (CA), Ontario (map)	15,599	15,566	15,423	15,404	15,370
Winkler (CA), Manitoba (map)	33,640	34,326	35,734	37,007	37,719
Steinbach (CA), Manitoba (map)	18,282	18,570	19,156	19,666	20,081
Portage la Prairie (CA), Manitoba (map)	13,813	13,782	13,789	13,765	13,921
Brandon (CA), Manitoba (map)	55,877	57,004	59,119	61,665	62,723
Thompson (CA), Manitoba (map)	13,459	13,435	13,282	13,138	13,065
Yorkton (CA), Saskatchewan (map)	20,385	20,339	20,637	21,230	21,562
Moose Jaw (CA), Saskatchewan (map)	35,791	35,997	36,773	37,500	37,434
Swift Current (CA), Saskatchewan (map)	19,279	19,390	19,577	20,037	20,312
North Battleford (CA), Saskatchewan (map)	19,886	19,836	19,850	20,340	20,772

Gender	Total - gender				
Age group[8]	All ages				
Geography	2021	2022	2023	2024	2025
Prince Albert (CA), Saskatchewan (map)	47,084	46,934	47,229	48,306	48,655
Estevan (CA), Saskatchewan (map)	13,163	13,000	13,069	13,239	13,266
Weyburn (CA), Saskatchewan (map)	12,597	12,574	12,653	12,937	13,100
Lloydminster (CA), Alberta/Saskatchewan (map)	37,779	37,661	38,192	39,191	39,806
Lloydminster (CA), Alberta part, Alberta (map)	20,403	20,345	20,746	21,244	21,324
Lloydminster (CA), Saskatchewan part, Saskatchewan (map)	17,376	17,316	17,446	17,947	18,482
Medicine Hat (CA), Alberta (map)	78,780	79,057	80,073	82,024	82,880
Brooks (CA), Alberta (map)	15,420	15,407	15,813	16,409	16,698
Okotoks (CA), Alberta (map)	31,362	31,467	32,099	32,654	32,992
High River (CA), Alberta (map)	14,732	14,820	15,272	15,416	15,514
Strathmore (CA), Alberta (map)	14,781	14,802	15,095	15,378	15,589
Canmore (CA), Alberta (map)	16,617	17,091	17,623	18,056	17,897
Sylvan Lake (CA), Alberta (map)	17,144	17,456	17,916	18,477	18,953
Lacombe (CA), Alberta (map)	13,789	13,622	13,594	13,625	13,657
Camrose (CA), Alberta (map)	19,344	19,387	19,607	19,908	20,071
Grande Prairie (CA), Alberta (map)	66,628	66,029	67,727	70,308	72,120
Wood Buffalo (CA), Alberta (map)	76,888	76,748	78,538	82,425	83,376
Wetaskiwin (CA), Alberta (map)	12,963	12,807	12,799	12,932	13,032
Cranbrook (CA), British Columbia (map)	28,197	28,613	29,248	29,660	29,713
Nelson (CA), British Columbia (map)	19,877	20,002	20,230	20,227	20,182
Trail (CA), British Columbia (map)	15,114	15,175	15,133	15,162	15,149
Penticton (CA), British Columbia (map)	48,924	49,408	49,489	49,736	49,807
Vernon (CA), British Columbia (map)	69,482	70,959	72,291	73,143	73,500
Salmon Arm (CA), British Columbia (map)	20,357	20,640	20,892	21,070	21,216
Squamish (CA), British Columbia (map)	25,538	27,661	28,564	29,381	29,752

Gender	Total - gender				
Age group[8]	All ages				
Geography	2021	2022	2023	2024	2025
Ladysmith (CA), British Columbia (map)	16,009	16,337	16,404	16,547	16,679
Duncan (CA), British Columbia (map)	49,241	49,934	50,161	50,730	51,122
Parksville (CA), British Columbia (map)	31,767	32,097	32,282	32,452	32,525
Port Alberni (CA), British Columbia (map)	26,726	27,088	27,308	27,528	27,672
Courtenay (CA), British Columbia (map)	65,519	66,804	68,181	69,564	70,323
Campbell River (CA), British Columbia (map)	42,231	43,176	43,390	43,784	43,999
Powell River (CA), British Columbia (map)	18,381	18,650	18,824	18,895	18,966
Williams Lake (CA), British Columbia (map)	24,532	24,872	25,007	25,017	25,061
Quesnel (CA), British Columbia (map)	24,000	23,953	24,066	24,170	24,222
Prince Rupert (CA), British Columbia (map)	14,181	14,112	14,101	14,138	14,052
Terrace (CA), British Columbia (map)	20,496	20,724	21,147	21,754	21,934
Prince George (CA), British Columbia (map)	93,542	94,810	96,859	99,007	100,127
Dawson Creek (CA), British Columbia (map)	18,724	19,096	19,615	20,179	20,264
Fort St. John (CA), British Columbia (map)	30,216	30,111	30,285	30,613	30,862
Whitehorse (CA), Yukon (map)	34,233	35,213	36,702	38,823	39,584
Yellowknife (CA), Northwest Territories (map)	21,904	22,165	22,421	23,150	23,826
All areas outside census metropolitan areas and census agglomerations, Canada	6,149,965	6,215,365	6,272,285	6,335,847	6,379,648
Area outside census metropolitan areas and census agglomerations, Newfoundland and Labrador	248,066	247,361	246,662	246,280	245,615
Area outside census metropolitan areas and census agglomerations, Prince Edward Island	59,978	61,461	63,168	64,184	65,124
Area outside census metropolitan areas and census agglomerations, Nova Scotia	305,812	310,198	314,373	317,893	319,120

Gender	Total - gender				
Age group[8]	All ages				
Geography	2021	2022	2023	2024	2025
Area outside census metropolitan areas and census agglomerations, New Brunswick	290,590	295,025	297,994	301,573	302,766
Area outside census metropolitan areas and census agglomerations, Quebec	1,561,639	1,582,774	1,600,121	1,616,440	1,630,527
Area outside census metropolitan areas and census agglomerations, Ontario	1,489,276	1,512,843	1,525,515	1,537,434	1,549,650
Area outside census metropolitan areas and census agglomerations, Manitoba	396,616	399,336	402,465	406,893	410,435
Area outside census metropolitan areas and census agglomerations, Saskatchewan	396,526	396,553	398,276	401,527	403,714
Area outside census metropolitan areas and census agglomerations, Alberta	787,104	788,635	796,658	811,705	818,430
Area outside census metropolitan areas and census agglomerations, British Columbia	542,869	549,454	555,227	559,629	561,619
Area outside census metropolitan areas and census agglomerations, Yukon	8,728	8,656	8,717	8,772	8,694
Area outside census metropolitan areas and census agglomerations, Northwest Territories	22,675	22,466	22,193	22,107	22,124
Area outside census metropolitan areas and census agglomerations, Nunavut	40,086	40,603	40,916	41,410	41,830
All census metropolitan areas and census agglomerations, Newfoundland and Labrador	278,990	283,896	292,127	300,589	304,296
All census metropolitan areas, Newfoundland and Labrador	220,052	224,707	232,536	240,428	243,478
All census agglomerations, Newfoundland and Labrador	58,938	59,189	59,591	60,161	60,818

Gender	Total - gender				
Age group[8]	All ages				
Geography	2021	2022	2023	2024	2025
All census metropolitan areas and census agglomerations, Prince Edward Island	102,155	105,739	110,566	115,525	117,533
All census agglomerations, Prince Edward Island	102,155	105,739	110,566	115,525	117,533
All census metropolitan areas and census agglomerations, Nova Scotia	694,096	713,836	738,632	764,876	774,125
All census metropolitan areas, Nova Scotia	482,144	498,222	515,453	536,372	544,834
All census agglomerations, Nova Scotia	211,952	215,614	223,179	228,504	229,291
All census metropolitan areas and census agglomerations, New Brunswick	500,212	513,844	533,109	556,720	566,916
All census metropolitan areas, New Brunswick	405,533	418,279	435,721	456,690	465,989
All census agglomerations, New Brunswick	94,679	95,565	97,388	100,030	100,927
All census metropolitan areas and census agglomerations, Quebec	7,010,381	7,087,189	7,221,575	7,379,034	7,427,770
All census metropolitan areas, Quebec	6,187,445	6,256,283	6,382,546	6,530,061	6,573,240
All census agglomerations, Quebec	822,936	830,906	839,029	848,973	854,530
All census metropolitan areas and census agglomerations, Ontario	13,353,212	13,642,993	14,106,966	14,607,363	14,708,610
All census metropolitan areas, Ontario	12,254,838	12,524,094	12,966,989	13,444,307	13,534,536
All census agglomerations, Ontario	1,098,374	1,118,899	1,139,977	1,163,056	1,174,074
All census metropolitan areas and census agglomerations, Manitoba	995,308	1,014,162	1,050,737	1,085,251	1,099,267
All census metropolitan areas, Manitoba	860,237	877,045	909,657	940,010	951,758
All census agglomerations, Manitoba	135,071	137,117	141,080	145,241	147,509
All census metropolitan areas and census agglomerations, Saskatchewan	771,185	782,243	811,981	846,341	863,245
All census metropolitan areas, Saskatchewan	585,624	596,857	624,747	654,805	669,662
All census agglomerations, Saskatchewan	185,561	185,386	187,234	191,536	193,583

Gender	Total - gender				
Age group[8]	All ages				
Geography	2021	2022	2023	2024	2025
All census metropolitan areas and census agglomerations, Alberta	3,644,427	3,724,096	3,891,918	4,097,325	4,210,916
All census metropolitan areas, Alberta	3,245,576	3,325,058	3,485,016	3,678,469	3,786,813
All census agglomerations, Alberta	398,851	399,038	406,902	418,856	424,103
All census metropolitan areas and census agglomerations, British Columbia	4,683,796	4,809,391	4,960,069	5,111,485	5,135,917
All census metropolitan areas, British Columbia	3,980,742	4,095,169	4,236,592	4,378,728	4,398,790
All census agglomerations, British Columbia	703,054	714,222	723,477	732,757	737,127
All census metropolitan areas and census agglomerations, Yukon	34,233	35,213	36,702	38,823	39,584
All census agglomerations, Yukon	34,233	35,213	36,702	38,823	39,584
All census metropolitan areas and census agglomerations, Northwest Territories	21,904	22,165	22,421	23,150	23,826
All census agglomerations, Northwest Territories	21,904	22,165	22,421	23,150	23,826

How to cite: Statistics Canada. Table 17-10-0148-01 Population estimates, July 1, by census metropolitan area and census agglomeration, 2021 boundaries
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Related information

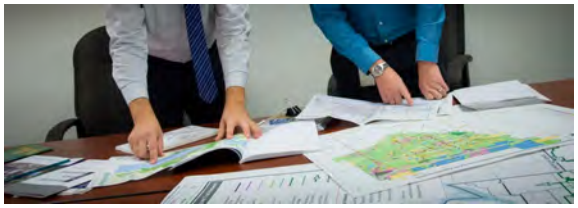
▶ Replaces

▶ Source (Surveys and statistical programs)

▶ Related products

▶ Subjects and keywords

Date modified:



Planning for Growth

Section Menu

The Regional Municipality of Durham is one of the fastest-growing regions in Canada.

Our population increased on average 2.55% per year from 2021 to 2025. At the end of 2025, it is estimated that over 815,000 people are living in the region. Our population is expected to grow to 1.3 million by 2051.

With proper community planning, growth enhances our quality of life.

Growth Management (#collapse_79268ae2-23bb-4974-8e80-84623c221f14_1)

Directing more growth to our built-up areas means:

- Different types of housing availability - click here (/living-here/comparing-housing-form-by-density-ty to view housing forms by density type.
- Appealing public spaces and walkable communities.
- Communities accessible by transit.
- Better protection for our natural systems.

Planning Benefits (#collapse_79268ae2-23bb-4974-8e80-84623c221f14_2)

There are many benefits to planning for growth in Durham:

- Jobs
- Local services
- Public facilities
- Housing options

These benefits of planning improve the quality of people of all ages.

Planning means that we can:

- Plan for healthy and complete communities.
- Protect farmland and green spaces.
- Reduce traffic jams.
- Refresh downtowns.
- Support long-term economic growth.

Monitoring (#collapse_79268ae2-23bb-4974-8e80-84623c221f14_3)

The Community Growth Division monitors population and household data.

Growth Trends

The **2025 Commissioner's Report 93** (/media/bd0pidpt/2025-info-93-monitoring-of-growth-trends.pdf) has semi-annual population and household estimates. It also has short-term population and household estimates.

The 2026 Commissioner's Report 031 (/media/iluljb3b/2026-info-031-monitoring-of-growth-trends.pdf) details semi-annual population and household estimates.

Development Activity (#collapse_79268ae2-23bb-4974-8e80-84623c221f14_4)

The Community Growth Division provides a yearly update on subdivision and condominium activity.

Annual Subdivision/Condominium Activity

- Report 2026-INFO-032 (/media/pcyffqhh/2026-info-032-annual-subdivision-condominium-activity-report-for-2025.pdf) focuses on applications that have reached major goals in 2025.
- Report 2025-INFO-26 (/media/mh1nbqsg/2025-info-26-annual-subdivision-condominium-activity-re for-2024.pdf) focuses on applications that have reached major goals in 2024.
- Report 2024-INFO-20 (/media/jqnd30vn/2024-info-20-annual-subdivision-condominium-activity-rep for-2023.pdf) focuses on applications that have reached major goals in 2023.
- Report 2023-INFO-37 (/media/ldshyzca/2023-info-37-annual-subdivision-condominium-activity-rep for-2022.pdf) focuses on applications that have reached major goals in 2022.
- Report 2022-INFO-58 (/media/gm3l4axm/2022-info-58-annual-subdivision-condominium-activity-re for-2021.pdf) focuses on applications that have reached major goals in 2021.
- Report 2021-INFO-33 (/media/s51bjclz/2021-info-33-annual-subdivision-condominium-activity-repo for-2020.pdf) focuses on applications that have reached major goals in 2020.
- Report 2020-INFO-68 (/media/qrxbhvz4/2020-info-68-annual-subdivision-condominium-activity-rep for-2019.pdf) focuses on applications that have reached major goals in 2019.
- Report 2019-P-17 (/media/l4tp23io/2019-p-17.pdf) focuses on applications that have reached major go 2018.
- Report 2018-INFO-60 (/media/iyyby3rr/2018-info-60-annual-subdivision-condominium-activity-repo for-2017.pdf) focuses on applications that have reached major goals in 2017.
- Report 2017-INFO-51 (/media/oewlep0p/2017-info-51-annual-subdivision-condominium-activity-rep for-2016.pdf) focuses on applications that have reached major goals in 2016.

Building Activity

Building activity shows us:

- Housing activity.
- Employment activity.
- Investment.
- Economic performance.

The 2025 Annual Building Activity Review (/media/vc5lqmuu/2026-info-54-2025-annual-building-activity-review.pdf) summarizes the key results of the 2025 Annual Building Activity Review, including an infographic summary, as well as appendix tables which include background data and analysis used to formulate the report.

Historical Annual Building Activity Reviews

2024 – Report and Appendix (Combined) (/media/k2hfxesn/2025-info-57-2024-annual-building-activity-review.pdf)
2023 – Report (/media/kcpp341c/2023-annual-building-activity-review.pdf) and Appendix (/media/wclfsyh4/2023-annual-building-activity-review-data-tables.pdf)
2022 – Report (/media/r3cp5h01/2022-annual-building-activity-review.pdf) and Appendix (/media/xfxg2kxb/2022-annual-building-activity-review-data-tables.pdf)
2021 – Report (/media/exzl1azu/2021-annual-building-activity-review.pdf) and Appendix (/media/df3jhxqq/2021-annual-building-activity-review-data-tables.pdf)
2020 – Report (/media/m5pfoznv/2020-annual-building-activity-review.pdf) and Appendix (/media/fiybcpoo/2020-annual-building-activity-review-data-tables-attachment-2.pdf)
2019 – Report (/media/pmzcrjfk/2019-annual-building-activity-review-final-accessible.pdf) and Appendix (/media/tojkwqaz/2019-annual-building-activity-review-data-tables.pdf)
2018 – Report (/media/4dseeqt3/2018-annual-building-activity-review.pdf) and Appendix (/media/3wuj014j/2018-building-activity-review-appendix-2.pdf)
2017 – Report (/media/lkfntiww/2017-annual-building-activity-review-accessible-revised.pdf) and Appendix (/media/1ldn3wid/2017-building-activity-review-appendix-2.pdf)

Statistics (#collapse_79268ae2-23bb-4974-8e80-84623c221f14_5)

The Census of Population is our main source of demographic data. Statistics Canada conducts the censu every five years.

Census Data

- The 2022 Commissioner's Report 31 (/media/xf1hsipe/2022-info-31.pdf) recaps the 2021 Census of Population first release on population and dwelling counts.
- The 2022 Commissioner's Report 77 (/media/sjnpp5bp/2022-info-77.pdf) recaps the 2021 Census of Population second release on age, sex at birth, gender and dwelling type.
- The 2022 Commissioner's Report 79 (/media/lh5pts1f/2022-info-79.pdf) recaps the 2021 Census of Population third release on families, households, marital status and income.
- The 2022 Commissioner's Report 80 (/media/dmzfg4jh/2022-info-80.pdf) recaps the 2021 Census of Population fourth release on language.
- The 2022 Commissioner's Report 98 (/media/d4hgpw3t/2022-info-98-2021-census-of-population-indigenous-peoples-and-housing-portrait-release-5.pdf) recaps the 2021 Census of Population fifth release on Indigenous peoples and the housing portrait.
- The 2022 Commissioner's Report 102 (/media/4m4lp553/2022-info-102.pdf) recaps the 2021 Census c Population sixth release on citizenship, immigration, ethnocultural characteristics, religion, mobility, and

migration.
- The 2023 Commissioner's Report 4 (/media/2hjdcj3v/2023-info-4.pdf) recaps the 2021 Census of Population seventh release on education and employment.

Durham Region Profile

The Durham Region Profile is a complete set of demographic and socio-economic data.

- The **2024 Commissioner's Report 15** (/media/we0hrjca/2024-p-15-durham-region-profile-demograp and-socio-economic-data.pdf) summarizes highlights from the Durham Region Profile.
- Our Online Dashboard (https://durham.ca/durhamprofile) makes demographic and community data m accessible, visual and usable.
- Our **Infographic** (/media/azjolwfi/attachment-1-durhamprofile_final-infographic_accessible.pdf) is visual summary of the information from the profile.
- Our **Technical Report** (/media/bvldv1t3/attachment-2-drp-technical-report-and-appendices.pdf) is a complete, detailed report with more than 100 tables of data.

Employment, Business and Land Inventory (#collapse_79268ae2-23bb-4974-8e80-84623c221f14_6)

Every year, we count the number of businesses and employees in Durham Region.

Business Count

Durham Region Business Count Highlights 2025 (/media/c53jaj5j/2025-business-count-highlights.pdf) (/media/osjnmd2p/2024-business-count-highlights.pdf) includes basic information about businesses such as:

- Type and nature of business.
- Number of employees.
- Floor space.

Employment Lands Inventory

We keep track of the supply of employment lands (2018):

- Employment areas - Region of Durham (/media/53wfn40e/employment-areas-region-of-durham.pdf)
- Employment areas - Ajax (/media/waujl0uc/ea-servicing-ajax.pdf)
- Employment areas - Brock (/media/diim0fuu/ea-servicing-brock.pdf)
- Employment areas - Clarington (/media/3ddbqiwy/ea-servicing-clarington.pdf)
- Employment areas - Oshawa (/media/jrcdm2by/ea-servicing-oshawa.pdf)
- Employment areas - Pickering (/media/ttmj0dqf/ea-servicing-pickering.pdf)
- Employment areas - Scugog (/media/uvaeb0b0/ea-servicing-scugog.pdf)
- Employment areas - Uxbridge (/media/i2xgp1n0/ea-servicing-uxbridge.pdf)
- Employment areas - Whitby (/media/vinphnob/ea-servicing-whitby.pdf)
- Rural employment areas - Brock and Uxbridge (/media/qrbhsjrd/ea-servicing-ruralareas_brockuxbridge.pdf)

The results of the previous Employment Lands Inventory are also available:

- Employment areas - Region of Durham (2014) (/media/eral2rip/employment-areas-region-of-durham-2014.pdf)

Living Here (/living-here/)

Planning for Growth (/living-here/planning-for-growth/)

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Contact Us

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Contact us

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Demographics and Statistics

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Kawartha Lakes Could Be the Right Fit - Backed by Data

Businesses considering relocation to Kawartha Lakes benefit from dedicated support through the Kawartha Lakes Economic Development team, who can help assess whether the region aligns with your specific needs and goals.

The Kawartha Lakes Situational and Community Analysis offers a helpful starting point, providing a snapshot of the community's demographics, workforce, and economy. From there, our team offers ongoing, hands-on support, including connections to workforce training, funding opportunities, and government incentives tailored to your business.

Key Statistics and Demographics

Population Growth

Kawartha Lakes has **83,000** residents (2023), with growth expected to reach **117,000** by **2051**.

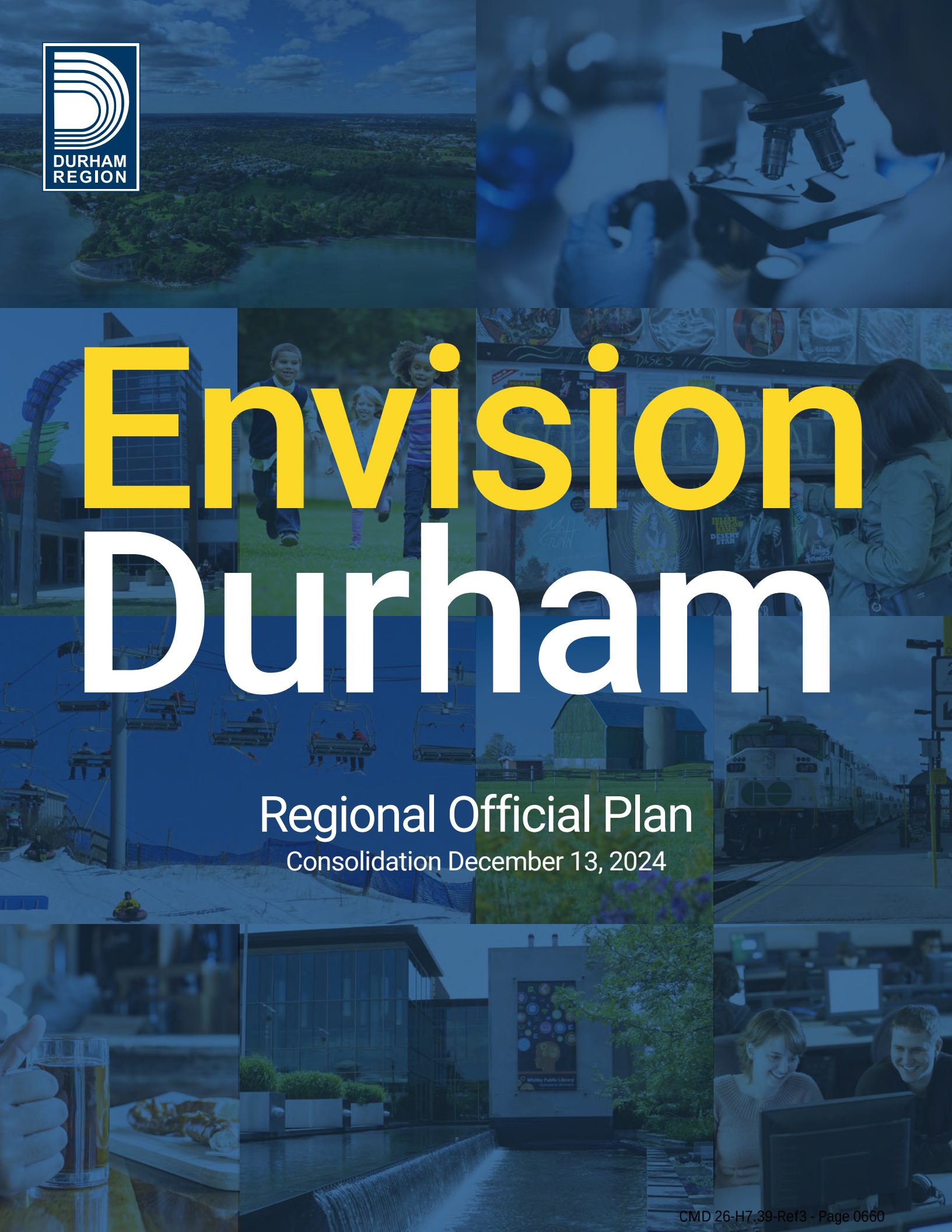
Workforce Participation

The labour force totals **41,613** people.

Education Levels

57% of adults aged 25–64 have post-secondary education, primarily **college diplomas or trades certificates** (54%).

Community Profile



Envision Durham

Regional Official Plan

Consolidation December 13, 2024

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Prologue



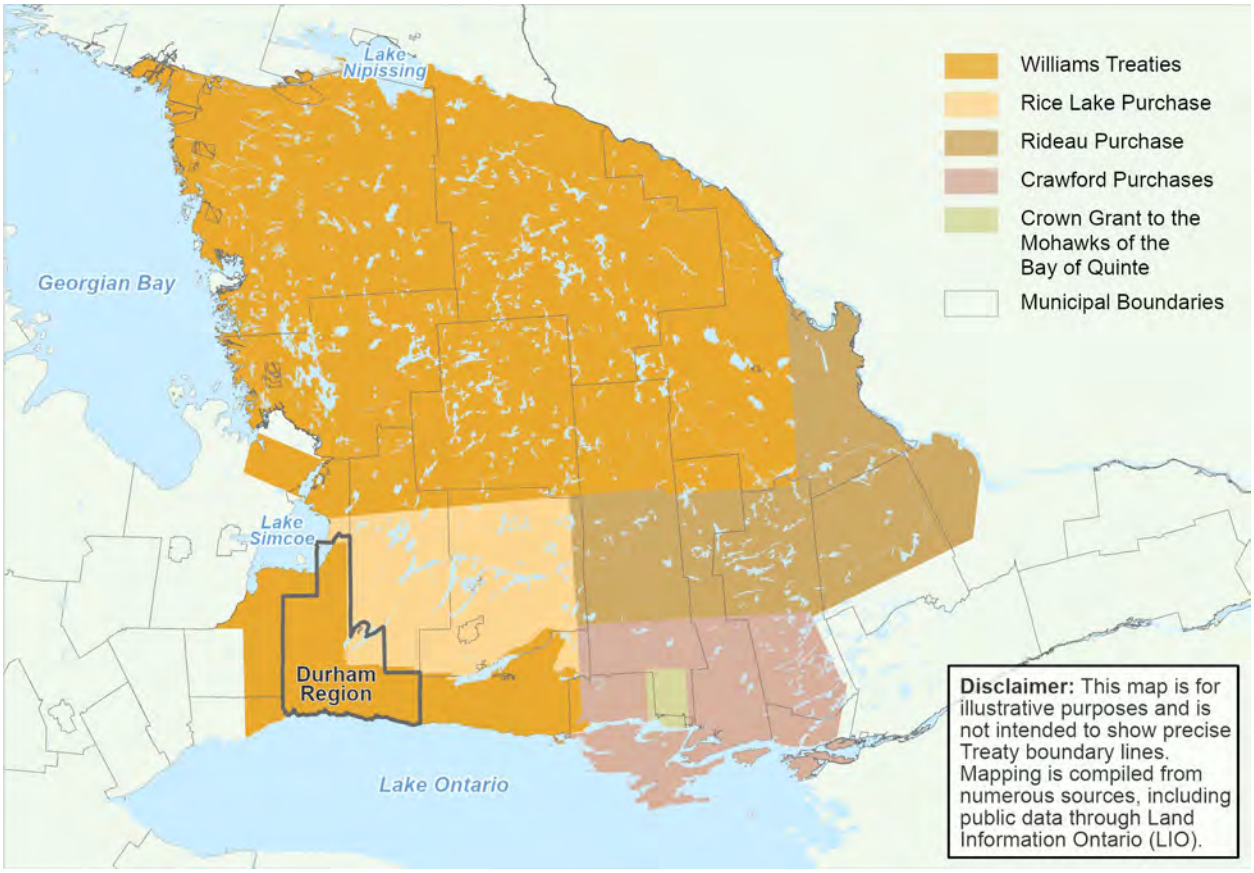
Traditional Territory Acknowledgement

The Durham Regional Official Plan aims to guide long-term planning and infrastructure while recognizing and respecting First Nations Peoples and their stewardship of lands and waters from time immemorial to the present day.

Durham Region spans a portion of the territories covered by the Williams Treaties signed by the Alderville First Nation, the Beausoleil First Nation, the Chippewas of Rama First Nation, the Chippewas of Georgina Island First Nation, the Curve Lake First Nation, the Hiawatha First Nation, and the Mississaugas of Scugog Island First Nation.

Reconciliation and strengthening relationships with Williams Treaties First Nations is a key priority for the Region, as is supporting Métis communities, Inuit communities, and other Indigenous groups within Durham.

Figure i. – Shared Traditional Territories of the Mississauga Signatories to the 1923 Williams Treaties:





Durham Region – The Place to Live, Learn & Thrive

Durham Region, a community of communities, has a distinct history tied to its geologic past, natural resources, ancestral heritage, routes of travel and trade, farming, industrial development and global events.

The Oak Ridges Moraine formed following the last glacial retreat to become the primary water source for many rivers, streams, wetlands and other recharge areas. Early Indigenous hunter-gatherers settled after the retreat of the glacier. Durham was home to the Iroquois, the Ojibway and by the 15th century, the Wendat Peoples. The Wendat, devastated by disease and conflict, abandoned their ancestral villages and agricultural areas. The first Mississauga people resettled the Lake Scugog basin around 1700, wherein this territory remains home to the Mississaugas of Scugog Island First Nation to this day.

Early French and English explorers and settlers that began to colonize the region realized the importance that rivers and streams – like the Ganaraska River, Bowmanville Creek, Oshawa Creek and Duffins Creek – represented as sources for clean water and locations for new settlement. By the late 1700s surveying activity commenced. While some roads, like Brock Road and Simcoe Street followed preexisting Indigenous trails, others like Kingston Road became routes where villages such as Bowmanville, Oshawa, Whitby and Pickering would grow. Early immigrants established farms, mills and logging operations throughout the region. Manufacturing of farm implements, construction goods, carriages, sleighs and other goods were shipped to other parts of Canada, the United States and further abroad.

Small settlements would dot the region, many with post offices in places like Duffins Creek, Brougham, Uxbridge, Beaverton, Newcastle, Kinsale, Liverpool Market and elsewhere. The emergence of the railway connecting Toronto with Montreal would result in stations at Whitby and Oshawa, while stations on other rail lines would emerge in Cannington, Sunderland, Beaverton, Uxbridge, Goodwood and Port Perry.

Through the 1900s, major industries and installations became an important part of the Durham story. Robert McLaughlin's carriage works relocated to Oshawa to become the home of General Motors of Canada – a vast industrial complex with a proud legacy of automobile manufacturing.

During the Second World War, Whitby housed Camp X, a British paramilitary installation for training covert agents. Ajax was established as the location for Defence Industries Limited – the largest shell filling plant in the British empire – where a townsite would later grow. In Clarington, the now national historic site of Camp 30, a former Boys Training School, was converted to a prisoner-of-war camp during the Second World War. An Elementary Flying Training School opened in 1941 at RCAF Station Oshawa would later become the Oshawa Executive Airport.

In 1971, the Pickering Nuclear Generating Station (NGS) opened (now Canada's third largest) producing about 15% of Ontario's power and employing 3,000 workers. The Darlington NGS (Canada's second largest) opened in 1990 and now provides about 20% of Ontario's electricity needs – enough to serve a city of two million people. Ontario Tech University was founded in 2002 as a centre of research and innovation with an emphasis on science and technology.

Durham Region continues to be a place where bold plans are realized.

This Plan envisions Durham's growth and development for 1.3 million residents and 460,000 jobs by 2051. Seaton – an emerging community in central Pickering – will be a place where 70,000 people will call home and where 35,000 jobs will be provided. A second international airport serving Toronto and the surrounding region is proposed in central Pickering as a major new hub for jobs, passenger travel and cargo. A network of highways – the 401, 407, 412 and 418 – is complete and mobility will continue to be enhanced through rapid transit expansions, innovations in technology, improvements in personal mobility, and a reimagined and connected cycling network.

Durham will flourish as an inspiring, welcoming, healthy, inclusive and walkable community. Durham's downtowns will grow and thrive. New transit stations will be the focus for vibrant pedestrian-oriented places. Durham's industries, educational institutions and agricultural sector will continue to lead through innovation.

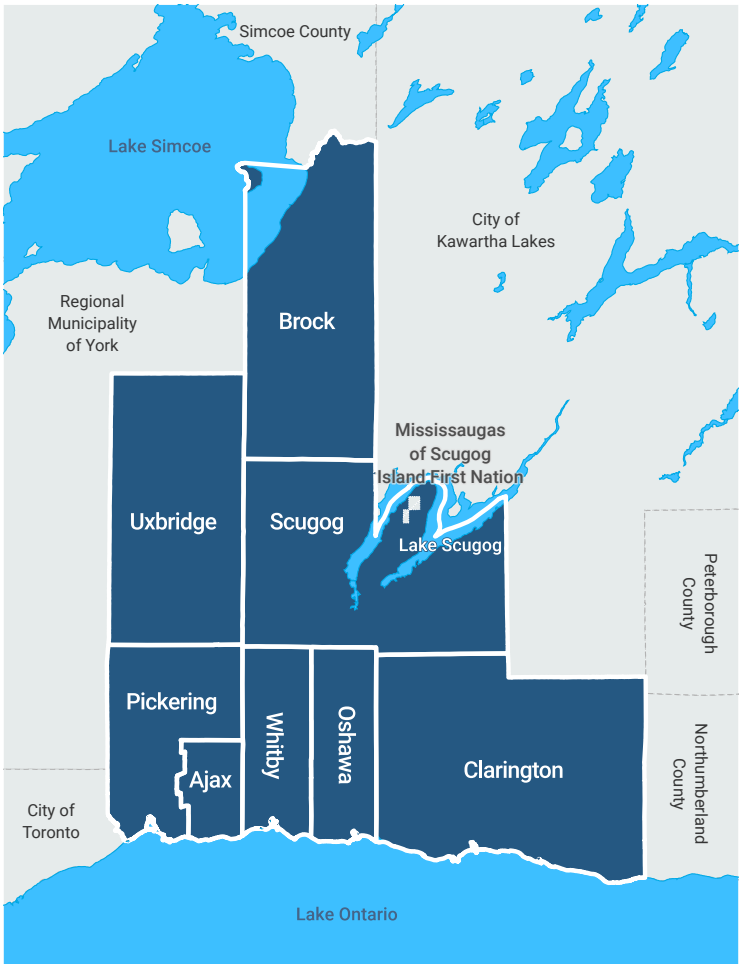
The effects of human-caused climate change are being felt around the world, and the pace of change is accelerating. Durham will make great strides to improve climate resilience and will take action toward a cleaner and greener environment. Key environmental features will be protected, and our tree canopy will grow. The Oak Ridges Moraine, the Rouge National Urban Park, shorelines, rivers and creeks will be protected, connected and accessible for the enjoyment of all residents.

In 2051, Durham's reputation as a complete, healthy, sustainable, diverse and welcoming community of communities will be known worldwide as the place to live, learn and thrive.

Over the timeframe of this Plan, the Region will experience significant growth and change. The Region is forecast to accommodate a population of 1.3 million residents and 460,000 jobs, representing an almost doubling of the Region's 2021 population of nearly 725,000 and more than double its nearly 197,000 jobs. Along with accommodating forecasted growth, this Plan provides policies and direction that will further strengthen our communities by:

- Accommodating the needs of an aging, growing and diverse population;
- Meeting our shared obligations to address the impacts of a changing climate and protect the natural environment;
- Satisfying a growing demand for sustainable alternatives to the personal vehicle for mobility, such as active transportation and public transit options;
- Using land efficiently, optimizing services and infrastructure, and focusing efforts on intensification within existing communities;
- Providing measures to improve the viability of Rural Settlements;
- Taking strides to further support the agricultural sector; and
- Facilitating the development of high-quality job opportunities.

Figure ii. – Map of Durham Region:



The elements cherished by Durham residents – natural areas, waterfronts, clean air, an abundance of recreational opportunities, protected farmlands, historic downtowns and more – while managing the growth to strengthen our communities – have shaped the policies of this Plan.

This Plan provides Regional Council with an integrated long-term policy framework that will guide decision-making on land use, growth management, development, delivery of infrastructure, services and related matters.

This Plan has been prepared in conformity with provincial plans and is consistent with the Provincial Policy Statement.

The Plan



Chapter 1

Regional Structure

The Plan

Chapter 1. Regional Structure

This Plan emphasizes a structural framework that forms the underlying basis for the long-term evolution of the region beyond the timeframe of the Plan.

Durham Region's land use structure is comprised of four systems:

- Urban System;
- Rural System;
- Greenlands System; and
- Transportation System.

The Urban System is comprised of emerging centres, established and developing neighbourhoods and Employment Areas. South Durham has more compact built form, while more modest densities predominate in north Durham, with historic downtowns supporting the surrounding rural areas. The Urban System accommodates the majority of the region's existing population and employment, and is where most of the future growth is directed.

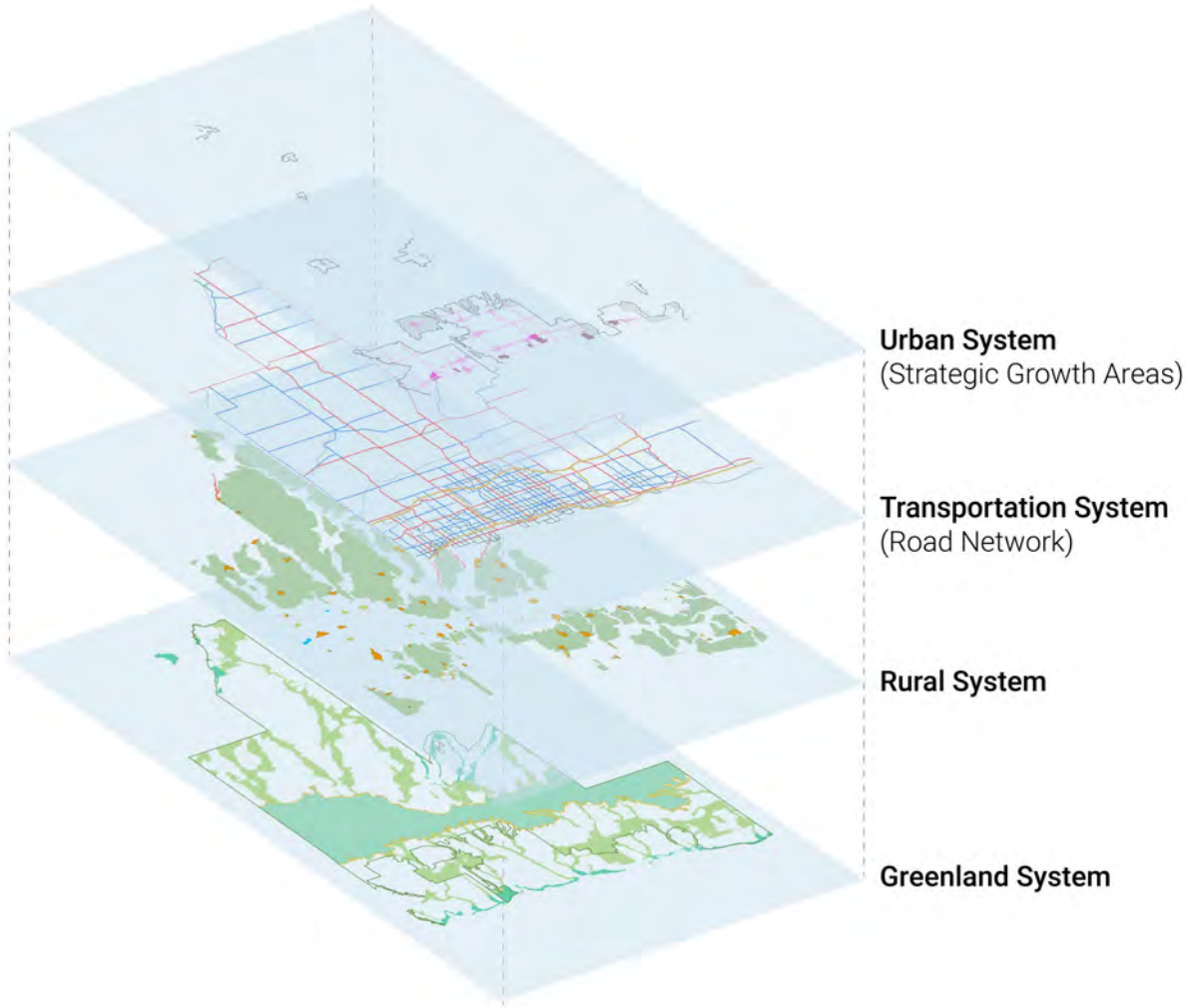
The Rural System supports and protects areas of the region with existing rural character, largely identified by the continuous and productive Agricultural System land base. The Rural System includes traditional rural industries such as farming and aggregate extraction, as well as Rural Settlements and Regional Nodes.

The Greenlands System follows natural features and functions, weaving through and between the Urban and Rural Systems. Lands within the Greenlands System are generally meant to be preserved for their ecological and environmental benefits, while providing urban separations and opportunities for recreational activities where appropriate. The Greenlands System encompasses the Oak Ridges Moraine, waterfronts, and key natural heritage and key hydrological features and areas.

The Transportation System provides access and connections across the region – through and between the Urban and Rural Systems. The Transportation System is comprised of roads, active transportation networks (including pedestrian paths, cycle paths and trails), transit priority networks, strategic goods networks, and other transportation related infrastructure such as airports, railways and ports.

These four systems with supportive infrastructure support a prosperous economy and healthy communities.

Figure 1. – Illustration of the systems that comprise the Regional Structure:



Goal:

I. Plan for a Regional Structure that accommodates forecasted growth in Urban Areas and Rural Settlements, supported by required services and infrastructure while reinforcing underlying natural systems.

1.1 General Regional Structure Policies

Objective:

i. Promote the distinction between the Urban System and the Rural System, while minimizing conflicts between the various Systems and their underlying components.

Policies:

It is the policy of Council to:

1.1.1 Designate the Regional Structure, including the Urban System, Rural System, Greenlands System and Transportation System on Map 1. Further delineations of the various systems and their underlying components are designated on Maps 1, 2 and 3.

1.1.2 Recognize the distinction between the Urban and Rural System is a fundamental principle of land use planning, growth management and the efficient use of infrastructure.

1.1.3 Direct population and employment growth to the Urban System with limited growth permitted within the Rural System, including Rural Settlements, where it is appropriate and compatible with surrounding uses, in accordance with Section 6.5.

1.1.4 Plan for a balance of residential growth with increased employment growth to achieve the population and employment forecasts outlined in this Plan, while aspiring to achieve a more balanced job to population ratio of 50% (one job for every two residents).

1.1.5 Ensure that necessary regional services and infrastructure are in place to accommodate the provincial population and employment forecasts within the Regional Structure by 2051:

a) 1,300,000 people; and

b) 460,000 jobs.

1.1.6 Plan for and implement services and infrastructure to enable the achievement of a minimum 50% annual rate of intensification region-wide.

1.1.7 Plan for the required services and infrastructure in accordance with the following minimum population, employment and household allocations by area municipality:

Figure 2. – Population. employment and household allocations table:

Municipality	2021	2026	2031	2036	2041	2046	2051
Ajax							
Urban:	130,510	140,000	150,570	161,940	173,370	185,590	198,160
Rural:	960	960	960	960	950	950	950
Total Population:	**131,470**	**140,960**	**151,530**	**162,900**	**174,320**	**186,540**	**199,110**
Households:	39,490	44,080	49,070	54,420	60,010	65,790	71,640
Employment:	**37,040**	**40,240**	**44,190**	**48,280**	**52,400**	**57,070**	**61,910**
Brock							
Urban:	8,100	8,850	9,700	10,630	11,770	13,130	14,620
Rural:	4,940	5,210	5,480	5,710	5,900	6,100	6,310
Total Population:	**13,040**	**14,060**	**15,180**	**16,340**	**17,670**	**19,230**	**20,930**
Households:	4,790	5,170	5,580	6,010	6,520	7,100	7,720
Employment:	**3,710**	**4,200**	**4,720**	**5,250**	**5,840**	**6,570**	**7,370**
Clarington							
Urban:	89,960	108,330	128,460	147,040	164,620	184,790	205,250
Rural:	15,310	15,400	15,510	15,600	15,360	15,690	15,770
Total Population:	**105,270**	**123,730**	**143,970**	**162,640**	**180,250**	**200,480**	**221,020**
Households:	35,970	42,840	50,450	57,540	64,380	72,240	80,160
Employment:	**29,920**	**35,040**	**40,900**	**46,330**	**52,150**	**60,590**	**70,320**
Oshawa							
Urban:	180,980	199,230	218,930	238,320	256,880	276,800	297,450
Rural:	1,040	1,050	1,060	1,070	1,070	1,080	1,090
Total Population:	**182,020**	**200,280**	**219,990**	**239,390**	**257,950**	**277,880**	**298,540**
Households:	66,640	73,800	81,450	89,060	96,680	104,710	112,970
Employment:	**63,740**	**70,600**	**78,070**	**85,250**	**92,110**	**99,670**	**107,280**
Pickering							
Urban:	98,360	121,220	147,000	171,710	195,670	223,330	251,600
Rural:	4,580	4,610	4,650	4,690	4,710	4,740	4,770
Total Population:	**102,940**	**125,830**	**151,650**	**176,400**	**200,380**	**228,070**	**256,370**
Households:	33,430	41,310	50,360	59,230	68,010	78,200	88,590
Employment:	**39,310**	**47,000**	**55,260**	**62,840**	**71,080**	**81,860**	**93,790**
Scugog							
Urban:	11,370	12,100	12,940	13,830	14,800	16,190	17,740
Rural:	11,030	11,130	11,250	11,350	11,400	11,480	11,570
Total Population:	**22,400**	**23,230**	**24,190**	**25,180**	**26,200**	**27,670**	**29,310**
Households:	8,250	8,610	9,000	9,400	9,850	10,470	11,140
Employment:	**9,680**	**10,030**	**10,410**	**10,800**	**11,210**	**11,760**	**12,350**

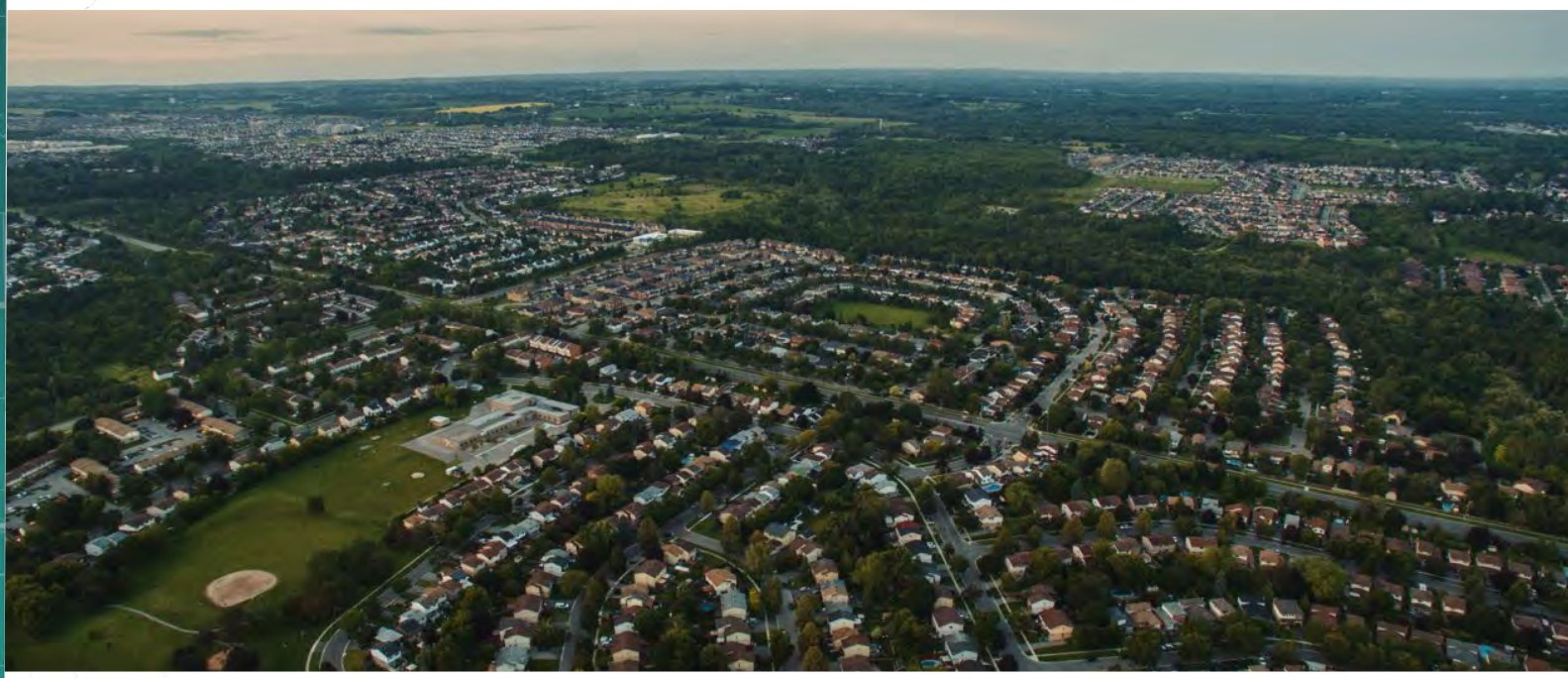
Municipality	2021	2026	2031	2036	2041	2046	2051
Uxbridge							
Urban:	12,520	13,260	14,170	15,190	16,280	17,570	19,000
Rural:	9,860	10,050	10,250	10,420	10,540	10,680	10,830
Total Population:	**22,380**	**23,310**	**24,420**	**25,610**	**26,820**	**28,250**	**29,830**
Households:	8,020	8,400	8,830	9,290	9,780	10,340	10,940
Employment:	**9,530**	**9,820**	**10,120**	**10,440**	**10,810**	**11,270**	**11,770**
Whitby							
Urban:	141,600	157,270	174,170	190,890	206,930	224,590	242,650
Rural:	2,150	2,170	2,190	2,200	2,210	2,220	2,240
Total Population:	**143,750**	**159,440**	**176,360**	**193,090**	**209,140**	**226,810**	**244,890**
Households:	46,450	52,330	58,670	65,060	71,480	78,510	85,710
Employment:	**48,730**	**55,950**	**63,760**	**71,480**	**78,910**	**87,020**	**95,210**
Durham							
Urban:	673,400	760,260	855,940	949,550	1,040,320	1,141,990	1,246,470
Rural:	49,870	50,580	51,350	52,000	52,410	52,940	53,530
Total Population:	**723,270**	**810,840**	**907,290**	**1,001,550**	**1,092,730**	**1,194,930**	**1,300,000**
Households:	243,040	276,540	313,410	350,010	386,710	427,360	468,870
Employment:	**241,660**	**272,880**	**307,430**	**340,670**	**374,510**	**415,810**	**460,000**

Notes:

Numbers may not add precisely due to rounding.

Population figures include undercount.

These forecasts do not assign population, households or employment to the provincial Greenbelt removals in Pickering, Ajax and Clarington.





Chapter 2

A Prosperous Region

Chapter 2. A Prosperous Region

Durham Region offers a diversity of places to live, work, play and visit. Framed by active and distinct waterfronts, Durham Region includes thriving farms, historic settlements, diverse employment areas, growing downtowns and a variety of mixed-use and walkable communities. Natural areas and trails cross and connect the region, often following streams and forests. Connected yet distinct, each of Durham's eight area municipalities are unique in their built form and heritage. This diversity and quality of place is a defining characteristic that underpins the strength of Durham Region.

Building and maintaining a strong and resilient economy is one of Council's key objectives. In support of a diverse industrial sector and a growing and dynamic knowledge-based economy, the Region will embrace technology, innovation and infrastructure development to support economic growth. The diversification of the Region's economic base is also supported through continued growth in tourism, sports, agri-business, entrepreneurship, arts and culture, and related enterprises.

Working in concert with Economic Development strategies and action plans, this Plan provides policies that are intended to guide the advancement, diversification, development and strengthening of the Region's economy. Its policies serve to encourage investment, provide necessary infrastructure, leverage partnerships and promote innovation.

Goals:

I. **Support the development of a strong, resilient and prosperous economy that maximizes opportunities for business and employment growth, innovation and partnerships.**

II. **Develop the Region to its fullest economic potential while respecting the environmental and social well-being of the region.**



2.1 General Economic Development Policies

Objectives:

i. **Ensure that regional services and infrastructure are provided while recognizing that investment and expansion in services and infrastructure is also required by area municipalities, utility providers and others, to facilitate economic growth and job creation.**

ii. **Support the expansion of knowledge-based industries and leading-edge technologies, including high-speed broadband infrastructure, throughout the region to enable businesses, residents, institutions and visitors to participate in modern society and the digital economy.**

iii. **Support the creation of complete communities and efforts to further improve the balance of growth in jobs to population growth by implementing the policies and achieving the forecasts of this Plan.**

iv. **Support the continued growth and the broadening diversity of a highly skilled regional labour force.**

v. **Support and promote the expansion of the Region's key economic sectors strengths.**

vi. **Support a transition towards a net-zero carbon economy by promoting collaboration and partnerships.**

vii. Encourage improvements to the transportation network that support improved mobility, goods movement, active transportation, transit-oriented development and tourism.

viii. Support measures to enhance the image and profile of the Region.

ix. Support the development of an airport on the federal lands in Pickering.

Policies:

It is the policy of Council to:

2.1.1 Prepare, update and implement an Economic Development Strategy and Action Plan in conformity with the policies of this Plan.

2.1.2 Develop and implement a marketing plan to promote the Region and its area municipalities as an attractive location to live, learn and thrive.

2.1.3 Encourage the formation of key sector development advisory groups comprised of Regional, area municipal, labour, education and industry representatives for knowledge sharing and capacity development.

2.1.4 Ensure that changes and trends in the growth, distribution and composition of the Region's employment base are continuously monitored and reported on, in accordance with Policy 11.5.3, so that the Region's progress in achieving its employment forecast, and its jobs-to-population ratio is well understood.

2.1.5 Encourage and recognize economic reconciliation for Indigenous communities and support collaboration towards improving their economic wellbeing.

Investment-ready Infrastructure

It is the policy of Council to:

2.1.6 Support the delivery of broadband infrastructure to underserved areas through the implementation of the Durham Region Broadband Strategy, including through partnerships.

2.1.7 Support the establishment of a Regional Broadband Network and continue to engage area municipal partners, Indigenous communities and service providers.

2.1.8 Ensure an appropriate supply of land within Employment Areas, with access to municipal water and sewage services to ensure the Region's investment readiness and competitiveness. The supply and development of such lands will be regularly monitored.

2.1.9 Advance the provision of adequate regional infrastructure to Strategic Growth Areas identified in Section 5.2, to support the growth and development of complete communities, where people and jobs are within proximity and have convenient access to transit and other community amenities.

2.1.10 Support improvements to the transportation network in the region including:

a) supporting the extension of all day, two-way passenger rail service along the Lakeshore East GO Rail line to Bowmanville and planned intercity passenger rail projects that cross the region including the VIA High Frequency Rail initiative;

b) supporting and promoting the ongoing development of an efficient, continuous and connected Strategic Goods Movement Network;

c) supporting targeted and effective use of existing special intermodal facilities, such as the Oshawa Executive Airport and the Port of Oshawa;

d) encouraging investments in active transportation infrastructure; and

e) supporting a new airport on the federal lands in Pickering.

2.1.11 Encourage the province to invest in highway and rapid transit infrastructure to support regional economic growth and employment opportunities through measures including:

a. provincial investment in priority transit infrastructure that supports the Region's planned urban structure and regional economic growth;

b. provincial advancement of freeway and highway projects identified in Policy 8.4.9;

c. expansion of Commuter Rail projects within the region, particularly the GO Lakeshore East Extension to Bowmanville and the GO Seaton line; and

d. supporting implementation of Rapid Transit Spines on the Highway 2 and Simcoe Street corridors, in accordance with Section 5.2.

Diversified Economic Base

It is the policy of Council to:

2.1.12 Encourage knowledge-based institutions, businesses and enterprises to locate and expand within the region by:

a) supporting the development of new and expanded post-secondary education facilities or campuses in the region;

b) encouraging the establishment and expansion of innovation hubs within the region;

c) encouraging provincial and federal government offices to locate to the region; and

d) encouraging provincial and federal governments to provide access to their infrastructure for co-location opportunities, as well as by providing funding programs to aid projects that expand broadband services to the region's underserved areas.

2.1.13 Encourage greater diversification of the Region's economic base with a range of high-quality employment opportunities by:

a) ensuring the preparation and implementation of a Tourist Development Strategy in cooperation with area municipalities and the industry to increase visitation in key segments that include sport tourism, business events, group travel and leisure travel;

b) supporting the development of Strategic Growth Areas as attractive locations for high-density, mixed-use development, including major offices, major institutional development, and other business and economic activities, supported by transit and other community amenities, in accordance with Sections 5.2 and 8.1;

c) supporting and promoting the rejuvenation, redevelopment and renewal of Strategic Growth Areas and brownfield sites, which may include deep energy retrofits of existing buildings;

d) ensuring on-going collaboration with area municipalities and others to implement the Regional Cycling Plan and the Regional Trail Network;

e) supporting the beautification of development along major transportation corridors, in particular the redevelopment and intensification of existing Employment Areas abutting Highway 401;

f) ensuring housing strategies provide for the development of a full range of housing options, sizes and tenure that are attainable and accessible for residents of all ages, ability and stages of life to meet the needs of a diverse labour force;

g) supporting collaboration with educational institutions and the business community, in programs that create and maintain a highly skilled regional labour force;



h) supporting the development of strong and prosperous rural communities, while protecting and enhancing Durham's rural character;

i) supporting the continued growth of the rural economy, including the agricultural and agri-food sector along with secondary and compatible on-farm diversified uses, tourism and recreational uses, to provide job opportunities for current and future generations;

j) encouraging participation in research and development opportunities that diversify agricultural operations and develop potential for growth in the agricultural sector;

k) encouraging entry-level farmers to participate in knowledge sharing for operational excellence and succession planning;

l) supporting development and investment that advances Durham Region's profile as the province's premiere energy cluster;

m) supporting the development of local low and zero carbon energy systems, including renewable energy and district energy projects, leveraging public and private partnerships where feasible; and

n) supporting, implementing and showcasing innovative technologies and infrastructure that enable fuel switching from fossil fuels to low carbon electricity in the transportation sector, such as the use of electric and autonomous vehicles, and through measures within the building sector.

2.1.14 Encourage economic growth in strategic locations by considering the acquisition, development, servicing and marketing of land in accordance with the intent of this Plan and the Municipal Act.

2.1.15 Encourage the province to review rate structures for such services as trucking, rail freight, energy, telecommunications and aggregate levies and disbursements affecting the Region's economic growth with the intent of implementing changes that will ensure the Region's competitiveness.

2.1.16 Support efforts by private industry, utility providers and others to lower greenhouse gas (GHG) emissions and approaches to reduce their carbon footprint through measures, in accordance with Section 4.3.

2.1.17 Seek opportunities to implement and showcase innovative technology approaches at regional facilities, as appropriate.

Future Airport on Federal Lands in Pickering

It is the policy of Council to:

2.1.18 Request the federal government for a firm commitment to the construction of an airport on the federal lands in Pickering.

2.1.19 Ensure that required services and infrastructure are planned to support and serve an airport, upon commitments being made to construct an airport in Pickering by the federal government.

2.1.20 Support the development of a transportation-based, multi-modal employment hub in the vicinity of the federal lands in Pickering to maximize the economic benefit of a future airport.

2.1.21 Support the establishment of a new multi-modal transportation network serving a future airport in Pickering, and once an announcement is made by the federal government, develop a plan to implement new highway connections, roads and new rapid transit infrastructure.



Chapter 3

Healthy Communities

Chapter 3. Healthy Communities

In order to accommodate the needs of a growing region, complete, healthy, well-designed and resilient communities should be prioritized for existing and future generations. Healthy Communities must provide a full range of housing options to support existing and future residents of all ages and abilities, with available services and amenities that form complete communities.

Supporting complete communities is key to building resiliency and achieving net-zero emissions in the region. Important considerations include energy efficient and low impact climate-resilient development that incorporates nature-based solutions, and supports climate adaptation and mitigation.

High-quality built environments, connected by multiple transportation modes, with access to community health and services, and built and cultural heritage such as historic and cultural downtowns add to the unique character and sense of place of Durham's urban and rural communities.

Goals:

I. **Provide a wide range of diverse housing options by type, size and tenure, including affordable and special needs housing.**

II. **Prepare built and natural environments to be low carbon and climate-resilient.**

III. **Plan for complete communities that improve the quality of life for residents.**

IV. **Enhance community health, safety and well-being by planning for sufficient community services.**

V. **Recognize the diversity of Durham's population and ensure residents have access to healthy built, social, economic and natural environments that enable opportunities to live to their fullest potential, regardless of race, ethnicity, gender, income, age and ability.**

3.1 Diverse & Available Supply of Housing

Housing is the foundation of complete and healthy communities. The housing spectrum ranges from homelessness to rental housing and market ownership. It includes housing options that are appropriate for residents at various stages in their life cycle and ability.

The Region supports increasing the range and mix of diverse housing opportunities, including affordable and special needs housing, and prioritizes the availability of housing options that are appropriate for households in various socioeconomic conditions and for people of all ages and abilities.

Objectives:

i. Ensure an adequate supply of housing units and land to accommodate growth in Durham.

ii. Support the provision of an appropriate range and mix of housing options, including special needs housing, affordable housing and additional residential units.

iii. Promote residential growth in the region by prioritizing intensification of existing residential areas.

iv. Support efforts to prevent the loss of affordable and rental housing.

v. Monitor housing need, demand and trends in the housing market.

vi. Support area municipalities in assessing the financial viability and implementation of inclusionary zoning.

Policies:

Housing Supply

This section addresses existing housing supply, residential growth, intensification, housing options, affordable housing, rental housing and monitoring to meet projected housing needs of current and future residents.

It is the policy of Council to:

3.1.1 Develop and implement a housing and homelessness plan that supports the goals of ending homelessness, providing affordable rent for everyone, greater housing choice, and strong and vibrant neighbourhoods through the following actions:

a) increase the privately funded affordable rental housing supply;

b) increase government-funded affordable rental housing supply;

c) diversify housing options by type, size and tenure;

d) preserve the private rental housing stock;

e) strengthen the social housing sector; and

f) support an energy efficient, environmentally sustainable purpose-built rental housing stock.

3.1.2 Provide a minimum of 15-year supply of land through residential intensification, redevelopment, on lands designated and available within Settlement Areas for residential development and through Urban Area Boundary expansions, in accordance with Section 5.7, if necessary.

3.1.3 Support opportunities to ensure that a wide range of affordable and market-based housing options are provided in Urban Areas. Outside of Urban Areas, housing options shall be locally appropriate and consistent with the character of the area.

3.1.4 Support opportunities to increase the supply of housing in Urban Areas to reflect market demand through intensification, considering the adequacy of municipal services and the physical potential of the housing stock.

3.1.5 Encourage the development of microhomes where appropriate.

3.1.6 Require microhomes to comply with the health and safety requirements of Ontario's Building Code, area municipal zoning and other local by-laws.

3.1.7 Ensure that permission for additional residential units are consistent with provincial regulations.

3.1.8 Support the conversion and adaptive reuse within Community Areas, where feasible, of former industrial or commercial buildings, or portions thereof, into residential units.

3.1.9 Encourage creation of residential units above commercial uses, which efficiently use land, resources, infrastructure and public service facilities.

3.1.10 Support the creation of new residential units on vacant or underdeveloped lands through infilling in Urban Areas.

3.1.11 Prioritize transit-supportive development, including potential air rights development, in proximity to transit, including Regional Corridors and Protected Major Transit Station Areas.

3.1.12 Undertake a Regional housing assessment, in consultation with the area municipalities, to review the current range and mix of housing options and evaluate projected needs for housing including affordable and special needs housing.

3.1.13 Encourage area municipalities to develop local housing strategies and to increase the supply of affordable, special needs and appropriate housing of all types, sizes, densities and tenures to households in various socioeconomic conditions and for people of all ages and abilities within their communities.

Housing Options

There is a need to accommodate an appropriate range and mix of housing, including additional residential units, affordable, special needs, seniors' and rental housing. This Plan supports a diverse mix of housing options, especially for housing needs that are not generally met by the housing market.

It is the policy of Council to:

3.1.14 Require area municipalities to adopt policies and zoning by-law provisions that permit additional residential units in new and existing residential development, redevelopment and intensification, including:

a) the use of three residential units in a detached house, semi-detached house or townhouse, where feasible;

b) the use of an additional residential unit in a building or structure ancillary to a detached house, semi-detached house or townhouse, including properties where the primary dwelling may already contain an additional residential unit;

c) allowing more opportunities for additional residential units by not applying minimum unit sizes and not requiring more than one parking space per unit; and

d) encouraging municipalities to remove parking space requirements for additional residential units in areas intended to support existing and planned higher order transit service, including Protected Major Transit Station Areas and other Strategic Growth Areas.

3.1.15 Ensure the adequacy of water and wastewater servicing capacity for all additional residential units in consultation with the Region, either by municipal or private servicing.

3.1.16 Encourage the development of new affordable rental and ownership housing options, including shared living arrangements, such as co-ownership housing.

3.1.17 Support the development of new special needs and supportive housing that include accessibility features, in areas that have access to community services, amenities and health care.

3.1.18 Require an Affordability and Accessibility Analysis as part of a Planning Justification Report for all major residential development applications, which include 100 units or more, that:

a) justifies how the development application will contribute to achieving affordable housing targets;

b) identifies opportunities to include a variety of special needs housing options to accommodate seniors and persons with disabilities; and

c) identifies how residents would be able to access health care, social services and other amenities in their community.

3.1.19 Apply for federal and/or provincial programs for the provision of assisted housing for special needs groups, seniors, singles, and families as opportunities arise.

Affordable Housing

The availability of affordable housing for low and moderate income households is critical for supporting complete communities. The Region encourages the development of less expensive types of housing, and to identify and remove barriers to create more affordable forms of housing, regardless of tenure.

It is the policy of Council to:

3.1.20 Require that at least 25% of all new residential units produced throughout the region to be affordable to low and moderate income households.

3.1.21 Require that at least 35% of all new residential units created in Strategic Growth Areas to be affordable to low and moderate income households.

3.1.22 Encourage affordable housing, including additional residential units, microhomes, and medium and high-density apartments in areas that are well served by local amenities including transit, schools and parks.

3.1.23 Encourage reduced parking standards to support the delivery of affordable housing, including purpose-built rental housing.

3.1.24 Support aging in place by encouraging affordable housing units for older adults that consider:

a) a broad mix of housing types, unit sizes and tenures, including additional residential units, mid and low-rise apartments, shared living and multigenerational housing; and

b) proximity to community hubs and Strategic Growth Areas that include retail, amenities, greenspaces, transit and social and health services that support physical and mental well-being.

3.1.25 Support municipalities that choose to implement inclusionary zoning policies within Protected Major Transit Station Areas, including the completion of a Regional housing assessment report.

3.1.26 Encourage new and innovative affordable housing options and the means by which affordable housing may be supplied, regardless of tenure.

Rental Housing

The creation and maintenance of rental housing as part of a healthy housing mix contributes to a broad housing spectrum that addresses the needs of Durham residents.

It is the policy of Council to:

3.1.27 Prioritize an appropriate balance between rental and private ownership so that housing can be provided to meet the various needs of residents.

3.1.28 Encourage the retention of rental units and only allow the conversion of existing rental housing to condominium tenure subject to the regulations as set out under the Planning Act, and only if the following conditions are satisfied:

a) the rental vacancy rate for the whole of the Region is 3% or higher for at least one year, as determined in the annual rental vacancy survey undertaken by the Canada Mortgage and Housing Corporation (CMHC), or by a survey prepared by the Region's Planning Division in the absence of CMHC figures;

b) the rental vacancy rate for the respective conversion application's area municipality is 3% or higher for at least one year, as determined by the CMHC annual rental vacancy survey, or by the Region's Planning Division in the absence of CMHC figures; and

c) the approval of such conversions to condominium tenure does not result in the reduction of the vacancy rate below 3%, in accordance with a) and b) above.

3.1.29 Require applications for the conversion of rental housing to condominium tenure to be accompanied by an analysis indicating that the provisions of Policy 3.1.28 have been met. The area municipality shall circulate all such applications to the Region for comment.

3.1.30 Require an amendment to the Regional and area municipal official plan, for the conversion of existing rental housing units to condominium tenure affecting six or more units, supported by information that demonstrates the following:

a) there is a net benefit for housing in Durham that will advance the goals of the area municipal and Regional 10-year housing and homelessness plans;

b) the proponent shall prepare a tenant relocation plan for all existing residents to find suitable and affordable housing in proximity to site. The plan shall include but not be limited to the following:

i) a plan to consult with existing residents of the rental property;

ii) a strategy outlining how existing tenants will be temporarily relocated within proximity of the existing site;

c) documentation demonstrating that existing tenants shall have the right of first refusal to purchase a replacement unit; and

d) confirmation that the area municipality shall require the applicants to enter into agreements with the Region to satisfy the Region's requirements, financial and otherwise.

3.1.31 Encourage area municipalities to protect rental housing by prohibiting the demolition of rental housing where warranted by local conditions. Exemptions may be considered for proposals that satisfy the following criteria:

a) the redevelopment maintaining at least the same number of rental housing units;

b) tenants being provided the first rights to occupy one rental housing unit on the redeveloped property once final building permit occupancy is granted by the area municipality;

c) where rental housing is not replaced, a Rental Housing Feasibility Analysis is provided within a Planning Justification Report which describes:

i) why rental housing is not a viable option for redevelopment;

ii) how the development will create opportunities to accommodate affordable housing and/or special needs housing;

iii) where public health and safety are affected as a result of the building or site's conditions, the conversion must be justified to the satisfaction of the area municipality and the Region (e.g. the completion of building renovations and/or retrofits; the submission of detailed inspection reports prepared by a Qualified Architect or Engineer on the physical condition of the site; etc.); and

iv) any additional criteria required by the area municipality.

3.1.32 Support area municipal protection of existing rental housing through condominium conversion policies and demolition control by-laws.

3.1.33 Encourage area municipalities to enact zoning by-laws to regulate and license short-term rentals if and where they are determined to be appropriate.

Monitoring Housing Supply & Affordability

It is the policy of Council to:

3.1.34 Regularly monitor, evaluate and report on housing supply and affordability as a component of housing need, including:

a) the Region's supply of residential units available on lands suitably zoned to facilitate intensification and redevelopment, through site plans, and in draft approved and registered plans of subdivision and condominium;

b) the range of housing types produced on new residential lands and through the intensification of previously developed, serviced lands;

c) the availability of water and wastewater servicing capacity for additional residential units in new development, redevelopment and intensification;

d) house prices and rents by housing type, relative to the distribution of income within the region;

e) the proportion of new residential units across the region that are affordable for low and moderate income households compared to the minimum target of 25%;

f) the proportion of new residential units in Strategic Growth Areas that are affordable for low and moderate income households to compared to the minimum target of 35%;

g) the supply of special needs housing; and

h) monitoring the impact of short-term rentals by type (room or entire home) relative to the broader rental housing market.

3.2 Climate Change & Sustainability

Durham Region is committed to climate change adaption and mitigation and supports building resilient, healthy and sustainable communities for future generations.

Durham's future climate will be warmer, wetter and wilder with increasing incidents of extreme weather events like heat waves and storms that bring high winds and intense precipitation. Preparing for the impacts of a changing climate requires building resilience into the region's infrastructure and land use system. Addressing climate change also means making deep reductions in GHG emissions across Durham Region, growing in a way that brings key services and amenities together, supporting alternative modes of transportation and improving air quality. Climate resilient development that incorporates energy efficiency, low impact development, sustainable building design and retrofits, and nature-based climate solutions to protect and enhance biodiversity and contribute to a cleaner, healthier and more resilient region.

Objectives:

i. Promote a culture of conservation across the region's natural and built environments.

ii. Ensure reduction of overall GHG emissions and other air pollutants generated by the Region's own corporate activities and functions striving towards a net-zero corporate carbon footprint.

iii. Promote improved air quality through active and alternative transportation modes, energy efficiency measures, through the protection and enhancement of the natural environment and through intensification

iv. Promote resilient and sustainable communities that support climate change adaptation and mitigation in collaboration with area municipalities, conservation authorities and stakeholders.

v. **Promote increased tree canopy coverage by working collaboratively with the area municipalities, conservation authorities and other stakeholders.**

vi. **Support new development that provides an attractive, well-designed, comfortable and sustainable public realm that incorporates natural landscapes and features.**

Policies:

Reducing Greenhouse Gases (GHG) and Improving Air Quality

Integrating GHG reduction measures into the planning and management of growth is key to building resiliency, and being adaptive and resilient to the impacts of a changing climate.

The Region declared a climate emergency on January 29, 2020, and has committed to implementing programs to build more resilient infrastructure, communities, and natural systems to reduce the impacts of a changing climate; and reducing GHG emissions in an effort to achieve carbon neutral communities.

The **Durham Region Climate Emergency Declaration**, approved by Council in 2020, is an overall strategy to reduce GHG emissions and build adaptive capacity against extreme weather events. The Region has completed climate action and resilience plan and risk assessments in partnership with the area municipalities and other key stakeholders to guide the transition to a low-carbon and climate-resilient Region while realizing significant benefits to the community and local economy.

It is the policy of Council to:

3.2.1 Establish policies and undertake programs that support the Low Carbon Pathway, target reducing annual GHG emission by 30% over 2019 levels by 2030, and achieve net-zero by 2050.

3.2.2 Work with local area municipalities, academic institutions and other partners to annually assess progress towards Council's endorsed GHG reduction targets, and identify shared priorities to accelerate progress towards net-zero by 2050.

The **Climate Change Local Action Plan** identifies the Region's GHG emission reduction targets, suggests programs and highlights the roles that the Region, area municipalities, and community partners play in reducing emissions.

The **Climate Adaptation Plan** identifies climate adaptation programs across various sectors, including: building, electrical, flooding, human health, roads, natural environment, and food security. Food security refers to a situation in which all community residents obtain a safe, culturally acceptable, nutritionally adequate diet through a sustainable food system that maximizes community self-reliance and social justice, and the ability of the agricultural community to support this system.

The **Regional Community Energy Plan** focuses on improving sustainable energy production and efficiency, and reducing GHG emissions through various approaches including building retrofits, electric vehicle infrastructure, alternative energy, and education and outreach.

It is the policy of Council to:

3.2.3 Reduce GHG emissions, improve air quality, encourage sustainability, and adapt and mitigate impacts of a changing climate by encouraging the following measures through development, redevelopment and infrastructure projects:

a) green infrastructure, including low impact development and stormwater management systems, planting of native species, green roofs, bird-friendly design and other sustainable design practices, in accordance with the policies of this section and Section 4.1;

b) increasing the tree canopy by promoting tree planting, naturalizing priority areas and reducing energy use through sheltering and shading, in accordance with Policy 3.2.22;

c) protecting and enhancing the natural environment, in accordance with the policies in Chapter 7;

d) energy efficient construction and green building design, including net-zero and net-zero ready development, in accordance with the policies of this section;

e) energy conservation and production, including the development and use of renewable and/or district energy systems and technologies and including infrastructure that encourages the use of zero-emission vehicles, in accordance with Section 4.3;

f) integrated solid waste management that preserves the natural environment, in accordance with Section 4.2;

g) designing and constructing infrastructure projects to be more resilient to the effects of climate change;

h) community design that promotes intensification, walkable communities and compact built form, and prioritizes active transportation, supports public transit and transportation demand management, reduces single occupancy vehicle use, and supports measures to balance jobs and population growth to reduce long-distance single occupancy vehicle trips to reduce GHG emissions caused by vehicles, in accordance with Sections 8.1, 8.2 and 8.3;

i) partnerships with area municipalities, agencies and stakeholders to develop and implement programs identified within the Low Carbon Pathway in the Durham Community Energy Plan; and

j) complementary programs from other levels of government, agencies and stakeholders that address the impacts of a changing climate, community planning and public health considerations.

3.2.4 Encourage area municipalities to:

a) develop and implement community-wide GHG reduction and monitoring programs, policies and standards in collaboration with the Region, energy utilities and other key stakeholders;

b) develop GHG reduction targets for their corporate operations that demonstrate municipal sector leadership in the community-wide effort to reach net-zero emissions by 2050;

c) provide policies, programs and standards to support the achievement of their corporate GHG reduction targets and monitor progress, including the reduction of GHG emissions from municipal operations; and

d) work in collaboration with the Region and the province to regularly assess and report on regional air quality.

3.2.5 Encourage collaboration between the Region, area municipalities, waste collection providers and waste producers to reduce emissions from waste management services, in accordance with Section 4.2.

3.2.6 Promote the uptake of zero-emission, hybrid or alternative fuel vehicles through:

a) the pre-installation of electric vehicle charging conduits and/or the provision of public charging infrastructure on Regional and area municipal owned properties;

b) the delivery of education and awareness initiatives; and

c) demonstrating leadership in adopting the use of zero-emission fleet vehicles for Regional and area municipal operations, where appropriate, in accordance with Policy 3.2.17.

3.2.7 Require the submission of an Air Quality study as part of a complete application where air quality is a potential concern between facilities and sensitive land uses.

3.2.8 Reduce GHG emissions from vehicle use by:

a) implementing transportation demand management measures, in accordance with Section 8.3;

b) enhancing opportunities for active transportation, including walking, cycling, taking public transit and carpooling through built form, including the co-location of public facilities, amenities and retail uses, in accordance with Section 8.2; and

c) ensuring communities are designed for all road users, while prioritizing the safety of pedestrians and cyclists.

Resilient Development

Achieving climate resilience requires cooperation from all levels of government, conservation authorities, and the development community.

It is the policy of Council to:

3.2.9 Promote a wide range of sustainable and green design standards and techniques in the natural environment, including:

a) providing drought-tolerant, landscaped open spaces that are designed to maximize infiltration of surface water runoff;

b) implementing green infrastructure and other low impact development measures such as permeable surfaces, in accordance with Policies 4.1.15 to 4.1.19;

c) planting of native or non-invasive species of trees and plants; and

d) incorporating biophilic design concepts, where appropriate.

3.2.10 Promote the use of sustainable design principles and green building design in the planning and construction of buildings, including:

a) orienting and designing buildings to maximize solar access and minimize energy loss from prevailing winds;

b) passive building design;

c) adaptive reuse, and energy efficient building materials and designs;

d) bird-friendly building design measures to mitigate bird collisions with buildings;

e) green or high albedo (cool) roofing to reduce urban heat island effect; and

f) energy conservation measures in the rehabilitation and upgrading of existing buildings and underutilized sites, including building retrofits.

3.2.11 Encourage new development to:

a) include electric vehicle charging facilities, or at a minimum, pre-install conduits and other infrastructure to support future charging facilities;

b) be net-zero or net-zero ready upon construction;

c) support alternative, renewable energy sources and energy storage, including district energy and green technology, in accordance with Section 4.3;

d) support active transportation by providing safe and sheltered bicycle parking and storage;

e) incorporate sustainable and green design principles, identified in Policy 3.2.10; and

f) include measures which provide for water conservation and reuse through greywater systems, rain barrels, low flow taps and toilets, and drought-tolerant native plantings and trees.

3.2.12 Implement building retrofit programs informed by finance, utility programs and contractors.

3.2.13 Implement incentive programs and explore funding opportunities to improve the energy, water and stormwater management performance of new construction, in collaboration with all levels of government, conservation authorities, utilities, the building industry and other stakeholders.

3.2.14 Encourage the application of green development standards and practices across area municipalities with a focus on stormwater management, energy efficiency, renewable energy opportunities including district energy, and innovation in planning for green spaces.

3.2.15 Request that the province update the Ontario Building Code to require improvements to standards of residential construction that improve resilience to the impacts of a changing climate and improved sustainability.

3.2.16 Promote water conservation and efficiency strategies through demand management, water recycling, green infrastructure and low impact development, in accordance with Policies 4.1.15 to 4.1.19.

3.2.17 Prioritize corporate leadership and environmental sustainability on the path to net-zero by designing and operating Regional buildings, land, equipment and facilities to incorporate:

a) energy efficient design and green building practices, including low carbon, net-zero and net-zero ready development, green infrastructure, and energy conservation, where feasible, in accordance with Sections 3.2 and 4.1;

b) use of, charging and parking for zero-emission fleet vehicles, in accordance with Policy 3.2.6;

c) sustainable and accessible design that provides pedestrian, cyclist and transit access, and applies universal accessibility design principles, in accordance with Policies 3.3.3 and 3.3.14;

d) adaptive reuse and promotion of cultural heritage resources and recycled building materials; and

e) partnerships with private enterprises to support a vibrant public realm.

3.2.18 Encourage area municipalities to:

a) require supporting information from proponents that addresses green infrastructure, net-zero ready development, district energy readiness and proposed building practices, where appropriate; and request that proponents demonstrate how development or redevelopment would support the relevant policies of this section;

b) include sustainable design elements, exterior sustainable design, landscaping, permeable paving materials, bicycle parking, bird-friendly design, electric vehicle charging and street furniture through the site plan approval process.

c) establish and incorporate passive building design and low carbon, net-zero or net-zero ready development policies within their official plans;

d) establish guidelines, practices and incentive programs to improve energy, water and stormwater management and waste diversion performance of new construction in collaboration with the Region; and

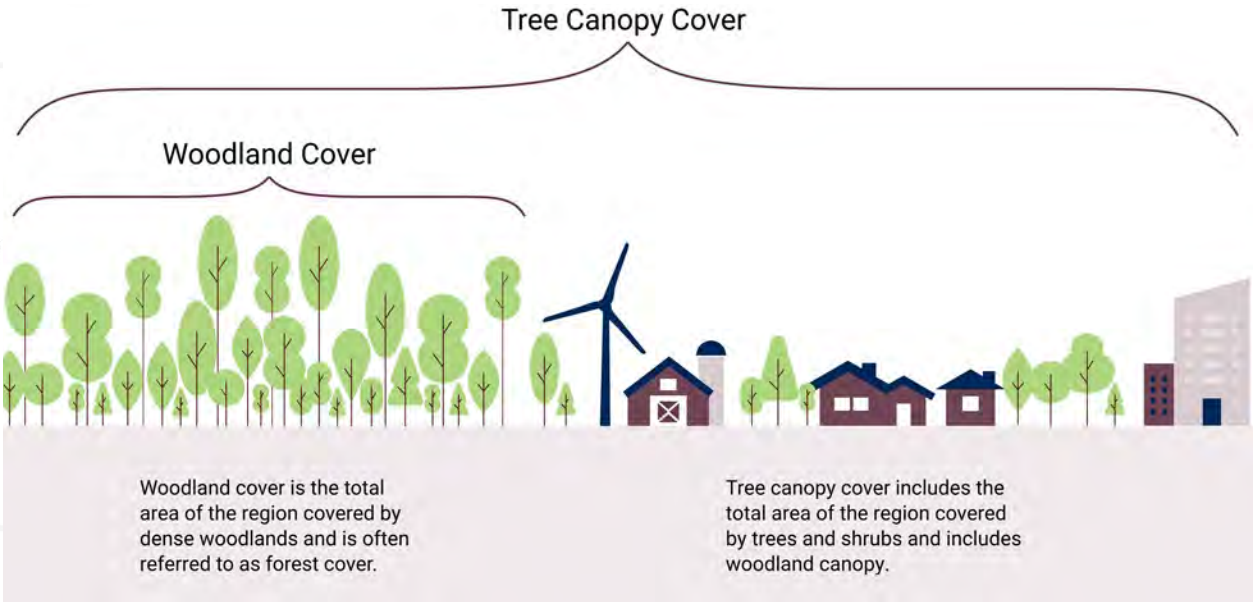
e) include local green development practices and sustainability guidelines, including water conservation measures in collaboration with the Region.

Nature-Based Climate Solutions

Nature-based solutions help to combat the impacts of a changing climate. These solutions include tree planting, preserving tree canopies, protecting and restoring wetlands, encouraging native species, invasive species management and urban agriculture.

Increasing the region's tree canopy and protecting and restoring the region's wetlands will reduce the urban heat island effect, create and link wildlife habitats, increase carbon sequestration, improve air quality, increase natural capital, and help mitigate, adapt and build resiliency to the impacts of a changing climate.

Figure 3. – Tree canopy & Woodland Cover:



It is the policy of Council to:

3.2.19 Collaborate with area municipalities, conservation authorities, Indigenous communities and other stakeholders to identify a regional tree canopy baseline and target(s).

3.2.20 Encourage area municipalities to:

a) establish local urban and rural tree canopy targets;

b) develop or update urban forest management plans and/or tree canopy strategies that include direction on tree protection, enhancement, stewardship, outreach and monitoring;

c) ensure that tree preservation and/or planting is considered in area municipal tree by-laws and development review and approval processes;

d) include adequate soil volumes as a consideration in their official plans, secondary plans and/or applicable by-laws to support new tree growth in new developments; and

e) consider trees and wooded areas in municipal asset management planning.

3.2.21 Collaborate with area municipalities, conservation authorities, Indigenous communities and other stakeholders in the protection and restoration of the region's wetlands, in accordance with Policies 7.4.27 to 7.4.29 and Section 7.7.

3.2.22 Collaborate with area municipalities, conservation authorities, Indigenous communities and other stakeholders to increase regional tree canopy cover, while having consideration for traditional ecological knowledge, through measures such as:

a) tree planting programs on public and private lands;

b) exploring the feasibility of a regional tree canopy restoration strategy;

c) land stewardship and restoration programs (e.g. land conservancies/trusts); and

d) the use of drought-tolerant native tree species in new tree planting initiatives, including on Regional and area municipal road allowances to create windbreaks, and reduce dust and snow accumulation on roads.

Native plant and tree species that occur naturally help boost resiliency by stabilizing soil, filtering water, purifying the air and providing natural habitats, food and shelter for wildlife. Using native species can have significant benefits to climate mitigation.

Refer to the latest list of native species identified in the Grow Me Instead (Southern Ontario) guide, prepared by the Ontario Invasive Plant Council.

Urban Agriculture

It is the policy of Council to:

3.2.23 Support urban agricultural uses and practices that are appropriate and compatible with adjacent land uses.

3.2.24 Encourage consideration of access to local food, urban agriculture, community gardens and rooftop gardens.

3.2.25 Encourage area municipalities to allow urban agricultural practices on private property, where appropriate.

3.2.26 Collaborate with stakeholders to implement initiatives supporting the development of a strong regional food system.

3.3 Complete Communities

The Region is committed to maintaining vibrant neighbourhoods and building complete communities that are walkable, well-connected, age-friendly and have a mix of housing options that foster community safety and well-being, where individuals and families can feel safe, have a sense of belonging, and where their needs are met, as described in the Community Safety and Well-being Plan (CSWB).

Complete communities are built with the needs of residents in mind, including transit supportive high-quality public spaces that provide a sense of place, climate resiliency and an integrated and easily accessible transportation and open space network for residents of all ages and abilities. Such communities should allow residents to conveniently access most of the necessities for daily living, including a range of housing options, employment opportunities, transportation options, shopping, recreational facilities and health care services.

Objectives:

i. **Promote healthy, sustainable, complete communities for the enjoyment of present and future residents.**

ii. **Promote high-quality urban design and pedestrian-friendly communities that are safe, comfortable and conducive to active transportation, so that residents have a range of transportation options to meet their daily needs.**

iii. **Support the preservation of heritage and character within the region's historic downtowns, streetscapes and neighbourhoods.**

iv. **Respond to the needs of an aging population by providing opportunities for residents of all ages and abilities to actively age in place, by co-locating community services and by encouraging amenities within residential areas that are accessible by many modes of transportation.**

v. **Include age-friendly design considerations, including universally accessible design elements in the preparation of plans and policies, and in the design and construction of buildings and communities to enhance safety, mobility and independence of seniors.**

vi. **Promote the conservation, protection and enhancement of Durham's built and cultural heritage resources and landscapes, including Indigenous cultural heritage.**

vii. **Promote a balanced approach to intensification in downtowns where appropriate, while preserving built and cultural heritage value.**

viii. Support the adaptive reuse of cultural heritage sites and properties.

ix. Recognize the connection to land and the built environment through Indigenous cultures and traditions, including acknowledging the effects of colonization, by giving time, opportunity and patience to understand the cultural viewpoints and how they may differ.

Policies:

It is the policy of Council to:

3.3.1 Support the development of healthy, sustainable and complete communities that incorporate:

a) a mix of housing options, including affordable and market-based housing options, in accordance with Section 3.1;

b) employment opportunities in accordance with Policy 2.1.13;

c) community hubs that cluster together community uses, services, facilities, and shopping, in accordance with Policies 3.3.26 to 3.3.28;

d) active transportation and the use of multi-modal transportation options;

e) institutional facilities and amenities, including educational facilities, places of worship, health care facilities and long-term care homes;

f) safe, publicly accessible recreation areas, parks, open spaces, trails and other recreation facilities;

g) age-friendly and universally accessible spaces for residents of all ages and abilities through universal accessibility design principles, in accordance with Policies 3.3.14 to 3.3.16;

h) healthy, local and affordable food options, including urban agriculture;

i) enhanced and protected natural environment;

j) vibrant places and spaces, including a public realm characterized by compact built form; and

k) climate resilient development, with an emphasis on the reduction of GHG emissions, in accordance with Sections 3.2 and 4.1.

3.3.2 Require area municipal official plans and new secondary plans to plan for:

a) a range and mix of housing options by type, size and affordability;

b) community hubs within a reasonable walking distance, in accordance with Policies 3.3.26 to 3.3.28;

c) live-work opportunities provided through a combination of flexible zoning standards, including permissions for mixed uses;

d) high-quality urban design and public realm that incorporates universal accessibility design, in accordance with Policies 3.3.3 and 3.3.14;

e) energy efficiency, including alternate and renewable energy models in new developments, in accordance with Section 4.3;

f) an integrated and easily accessible open space network that includes active recreational facilities, urban squares, green spaces, parks and informal gathering spaces generally within 500 metres of all residents;

g) inclusivity and diversity of cultures, religions, abilities and beliefs in the planning, design, creation and retrofitting of complete communities;

h) climate resilient development that reduces the urban heat island effect, including considerations for:

i) low carbon, net-zero and/or net-zero ready building design;

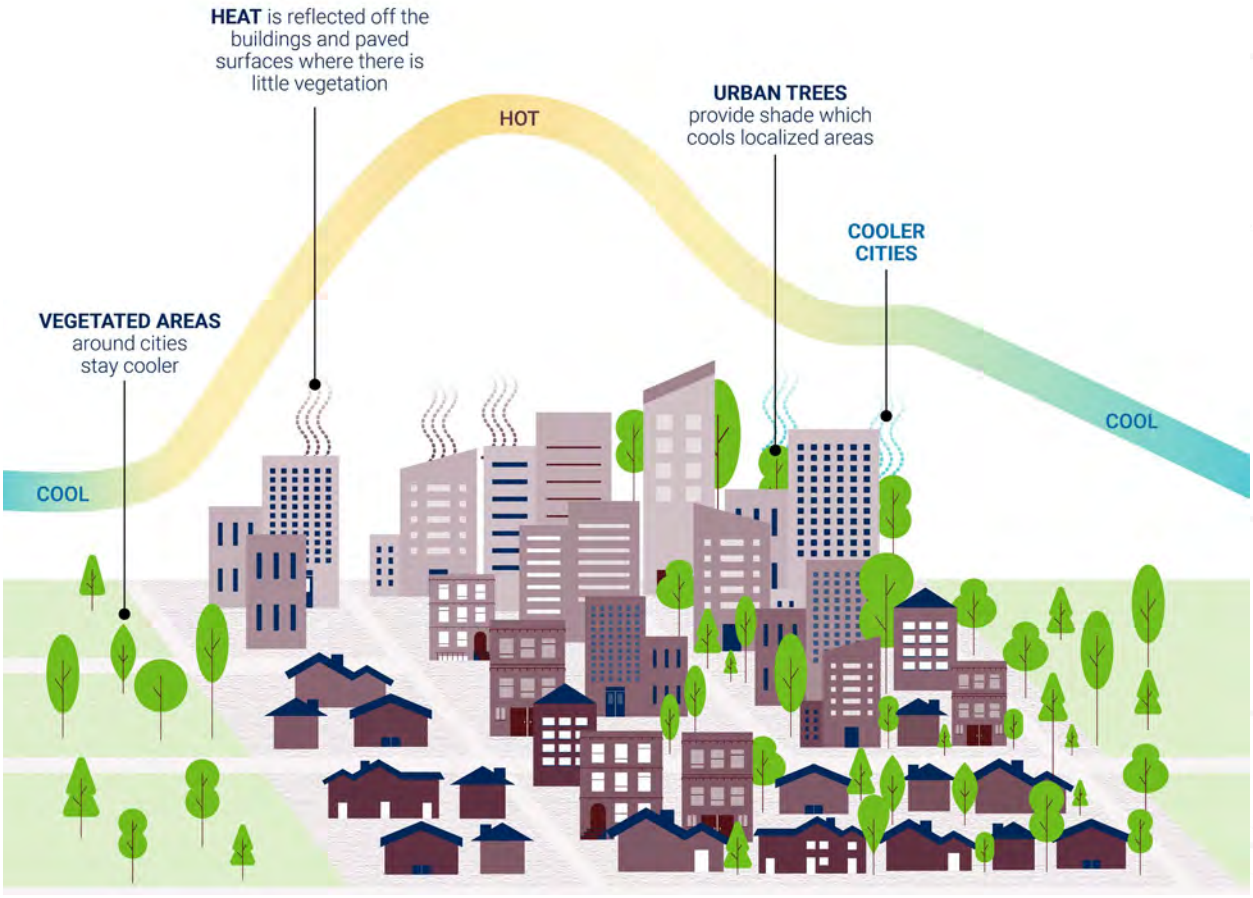
ii) solar, green and cool roofs;

iii) increasing the tree canopy;

iv) low impact development measures, including green infrastructure; and

v) other measures, in accordance with Policies 3.2.9 and 3.2.10.

Figure 4. – Urban Heat Island Effect:



Built Environment

The built environment includes the buildings we live in, the roads and transportation systems we use, the parks we play in and the layout of our communities. The built environment encompasses the public realm and shared spaces that support the character of our communities.

A well-designed public realm is built for all ages and abilities, and addresses the needs of all residents.

It is the policy of Council to:

3.3.3 Promote a high-quality public realm with regard for quality urban design, architectural and landscape treatment through the development review process with consideration for:

a) preserving and complementing the built and natural heritage and character of existing areas, fostering each community's unique attributes, and enhancing visual amenities in the urban environment;

b) opportunities for placemaking and public gathering;

c) integrating landscaping, beautification and streetscape design measures including green infrastructure and low impact development techniques;

d) compatibility and integration with surrounding land uses and built form;

e) pedestrian, transit supportive, and transit-oriented development pattern that supports active transportation;

f) age-friendly planning and accessibility for residents of all ages and abilities through universal accessibility design principles, strategic placement and orientation of buildings, including street front facing buildings and entrances, in accordance with Policies 3.3.14 to 3.3.16;

g) streetscape design that addresses the unique needs of all road users;

h) pedestrian scale, safety, comfort and connectivity, including pedestrian-oriented destinations;

i) centrally located and accessible public spaces, parks, recreational structures and public buildings;

j) cultural heritage resources in building orientation and site design;

k) energy efficient building design, in accordance with Section 4.3;

l) sustainable urban design that incorporates green infrastructure and low impact development, in accordance with Section 4.1;

m) light and noise trespass and pollution, in accordance with Policy 3.3.10 and 3.3.11;

n) the application of crime prevention through environmental design techniques;

o) identifying, protecting and developing gateways as attractive points of entry to the region;

p) ensuring that the public realm within Protected Major Transit Station Areas, is walkable, attractive and accessible incorporating enhanced public elements such as transit plazas and public squares, to create welcoming focal points within the region;

q) improving the public realm and pedestrian experience of Regional Roads, where appropriate; and

r) encouraging the province to incorporate landscape elements including native trees to improve the visual experience along provincial freeways and highways.

3.3.4 Require area municipal official plans and secondary plans to include:

a) policies that ensure high quality and sustainable urban design;

b) sufficient, publicly accessible greenspace and parks in Urban Areas, where feasible and appropriate;

c) provisions for a vibrant and attractive public realm incorporating art, culture and heritage, and contributing to a sense of place and identity. This may include engaging with Indigenous communities and incorporating Indigenous art and history, where appropriate;

d) parking management policies and standards in accordance with Policy 8.3.4, including:

i) minimum and maximum parking requirements that reflect the walking distance to transit and complementary uses;

ii) shared parking requirements, where possible, reflecting variances in parking demand between complementary uses on a time-of-day, weekday/weekend and monthly basis;

iii) on-street parking requirements;

iv) building designs that orient main pedestrian entrances to face the public street, provide a pedestrian-friendly urban form and discourage the placement of surface parking spaces between the main building entrance and the adjacent major street, where appropriate;

v) discouraging surface parking while designing surface parking lots to enable further development; and

vi) preferential locations for carpooling and car-sharing spaces and bicycle storage requirements;

e) street designs that:

i) provide connections with adjacent neighbourhoods;

ii) provide a connected grid pattern of streets with safe and convenient travel options;

iii) extend sight lines and view corridors;

iv) divide larger sites into smaller development blocks, where appropriate;

v) provide access and addresses for new development;

vi) balances the needs and priorities of the various users and uses within the right-of-way;

vii) allow visibility, access and prominence of unique natural and human-made features; and

viii) provide uninterrupted access for emergency vehicles.

3.3.5 Encourage area municipalities to establish measures to control the impacts of outdoor lighting and noise trespass on neighbouring properties.

3.3.6 Require a noise study completed by an acoustical engineer where noise sensitive land uses are proposed in the vicinity of uses that create noise, or where uses that create noise are proposed near existing noise sensitive land uses, as specified in Table 1.

3.3.7 Require a vibration study where a noise sensitive land use is proposed within 75 metres of a railway corridor, as specified in Table 1.

3.3.8 Allow area municipalities to designate Class 4 Areas on a case-by-case basis through a development application upon the review and approval by the area municipality in consultation with the Region, as per the Environmental Noise Guideline. A peer review may be required at the sole cost of the applicant.

The Ontario Ministry of the Environment and Climate Change classifies acoustical environments into four categories, or classes, in its Environmental Noise Guideline, to ensure that the potential negative impacts of noise are prevented. Class 1 and Class 2 generally refer to the urban area, while Class 3 pertains to the rural area.

The Guidelines also allow municipalities to designate Class 4 Areas, which are unique situations where development of new sensitive land uses are envisioned in proximity to existing, lawfully established stationary noise sources. The Class 4 designation provides for higher daytime and nighttime sound levels than would otherwise be permitted in Urban Areas.

It is the policy of Council to:

3.3.9 Encourage green infrastructure and passive noise attenuation measures in place of acoustical fencing, where feasible and appropriate.

3.3.10 Support measures for light attenuation by:

a) encouraging area municipalities to enact by-laws establishing environmental, aesthetic, urban design and related controls on signs and outdoor lighting, in accordance with Policy 3.3.3; and

b) promoting the use of full cut off light fixtures as part of new development.

3.3.11 Support measures for noise attenuation by:

a) requiring the attenuation of excessive noise levels through design solutions when considering noise receptors through development applications, as specified in Table 1; and

b) having consideration for noise, vibration and possible hazards associated with nearby railways, airports, freeways and industries, and considering comments from appropriate authorities therein, in the approval of developments in proximity to such facilities.

3.3.12 Encourage the use of light pollution abatement measures to avoid and reduce light trespass, glare, over-lighting and uplighting to conserve energy, improve pedestrian and road safety, contribute to an aesthetically pleasing night-time environment, and protect the night sky for its scientific and natural interest and educational value.

3.3.13 Direct outdoor lighting away from key natural heritage and/or key hydrologic features and their associated vegetation protection zones, and other environmentally sensitive areas, including the Rouge National Urban Park.

Age-Friendly Planning

Durham Region has committed to an age-friendly vision through its Age Friendly Durham Strategy and Action Plan, as well as its Community Safety and Well-Being Plan, which are intended to ensure all members of the community feel included, respected and enjoy a high quality of life, regardless of age or ability.

It is the policy of Council to:

3.3.14 Encourage the use of universal accessibility design in the built environment that is flexible to various needs and abilities to create a safe, barrier-free and inclusive environment that:

a) enhances the mobility and independence of all residents, including vulnerable populations such as seniors and people with disabilities; and

b) is flexible and adaptable to support different levels of need.

3.3.15 Encourage area municipalities to support independent, active and healthy aging of all residents within their communities by implementing the Age-Friendly Durham Strategy and Action Plan and the Durham Community Safety and Well-Being Plan through their official plans. This includes integrating:

a) a full range of housing options near community hubs that support the clustering of community facilities, programs, services, community facilities, retail and commercial uses and green spaces, in accordance with Policies 3.3.26 to 3.3.28; and

b) universal accessibility design guidelines as part of the review and approval of development applications.

3.3.16 Collaborate with area municipalities and stakeholders to:

a) identify and assess areas with a predominance of seniors, correct gaps in the built environment that hamper accessibility and mobility of vulnerable populations, and create opportunities to better support residents of all ages;

b) integrate a complete communities approach in the design of new and existing communities to ensure the safety of all residents, including diverse populations and vulnerable groups including children, seniors and people with disabilities as specified in the Age-Friendly Durham Strategy; and

c) consider the feasibility of developing age-friendly design guidelines.



Community Health & Services

The availability of community services, including cultural, health, community and education facilities are key to a thriving and diverse Region.

It is the policy of Council to:

3.3.17 Support a wide range of cultural assets, facilities, services and workforces in Urban Areas and if appropriate in scale, in Hamlets.

3.3.18 Encourage municipally-owned and operated day care and recreation facilities in Urban Areas, and if appropriate in scale, in Hamlets.

3.3.19 Support cultural facilities for such purposes as education, the arts, heritage and religion in Urban Areas, while recognizing the diversity of Durham's population, including Indigenous communities, and providing services accordingly.

3.3.20 Locate community, cultural and health facilities in areas that are visible and accessible to residents of all ages and abilities, preferably near existing and future transit routes. Community, cultural and health facilities that are deemed to be sensitive land uses shall only be permitted to locate in the Employment Areas designation, in accordance with Policies 5.5.26 and 5.5.27.

3.3.21 Promote the establishment of new or expanded health care facilities across the region to meet the needs of existing and future residents, including a new regional hospital located at Highway 407 and Highway 412 in the Town of Whitby.

3.3.22 Promote cultural facilities and services, and encourage the establishment of a regional arts centre within Durham with the cooperation of the respective area municipalities and the appropriate agencies.

3.3.23 Encourage municipal facilities, such as municipal works depots, police stations and fire halls, in Urban Areas.

3.3.24 Permit municipal facilities, in accordance with Policy 3.3.23, to locate outside of Urban Areas in any designation, as an exception, provided:

a) they are compatible with and have minimal impacts on their surroundings;

b) they are directed to lower priority agricultural lands unless there are no reasonable alternative locations which avoid Prime Agricultural Areas;

c) they are located adjacent to an arterial road;

d) they do not disrupt the agricultural community and impacts on the surrounding agricultural operations and lands are mitigated to the extent feasible;

e) they are located in accordance with the provincial Minimum Distance Separation formulae; and

f) there is a demonstrated need to serve the local community, or, in the case of a regional facility, that services the broader area.

3.3.25 Permit municipal facilities, in accordance with Policy 3.3.23, to located only in the following areas of the Oak Ridges Moraine and Greenbelt:

a) within the Countryside or Settlement Areas of the Oak Ridges Moraine, subject to fulfilling the specific requirements of the Oak Ridges Moraine Conservation Plan; and

b) outside of Prime Agricultural Areas within the Greenbelt, subject to fulfilling the specific requirements of the Greenbelt Plan.

Community Hubs

Community hubs refer to central locations where residents may access a range of services in one place. Community hubs can include social, health, retail, cultural, educational, recreational, and other services and resources that support the daily needs of the community's residents.

It is the policy of Council to:

3.3.26 Support the development of complete communities by promoting community hubs that are broadly accessible to residents of all ages and abilities to co-locate into new cultural, health and community facilities and public service facilities.

3.3.27 Encourage the renovation and adaptation of existing community facilities and spaces, provide for co-location opportunities and support the establishment of new community hubs within Strategic Growth Areas, other Nodes and Corridors, Hamlets and other locations as appropriate.

3.3.28 Encourage the establishment and development of community hubs in transit-supportive locations where existing cultural and community services and facilities exist, with preference given to locating within Strategic Growth Areas.

Cemeteries

It is the policy of Council to:

3.3.29 Promote the efficient use of cemetery lands which may include columbaria, mausolea or interment burial areas through the review of applications for new cemeteries or expansions to existing cemeteries and encourage approaches that support site stewardship.

3.3.30 Encourage the establishment of new cemeteries within the Urban Area Boundary, Rural Settlements and Major Open Space Areas.

3.3.31 Consider new cemeteries subject to the following criteria:

a) for Prime Agricultural Areas, there are no reasonable alternative locations which avoid Prime Agricultural Areas and the cemetery is located on lower priority lands;

b) there are no adverse impacts on the natural environment, hydrological features and surrounding land uses;

c) impacts from the cemetery on surrounding agricultural operations and lands are mitigated to the extent feasible;

d) if locating adjacent to an operating landfill, the cemetery is sited in accordance with the Land Use Compatibility Guidelines, and any other guidelines and/or requirements issued by the province;

e) the cemetery is no larger than 40 hectares within the Prime Agricultural Area; and

f) within the Greenbelt Plan Area, cemeteries are not permitted within the Prime Agricultural Areas.

Built & Cultural Heritage

The Region prioritizes the recognition, conservation, and enhancement of cultural heritage in the region, including resources and landscapes, such as downtowns, historical areas, scenic lookout areas, archaeological sites or natural elements that are valued together for their interrelationship, meaning or association with the community.

It is the policy of Council to:

3.3.32 Recognize downtowns and historical areas as key inter- and intra-regional destinations based on their historic and traditional function as centres for culture and commerce, their built form and their cultural and social importance.

3.3.33 Strengthen, restore and enhance the local, historical and cultural heritage, character and role of Durham's downtowns and historical areas as walkable centres of tourism, recreation, housing, employment, main street shopping and social gathering to foster cultural capital and a creative economy.

3.3.34 Encourage the conservation and enhancement of the distinct character and unique local, historical and/or cultural heritage of Durham's downtowns, especially during redevelopment or intensification of surrounding areas by considering:

a) scale and massing of new buildings to complement the existing built form within the downtown;

b) protecting important built elements and other heritage features, including facades and other built form, as part of development and redevelopment;

c) a transition that supports a visual connection between historic neighbourhoods and new development;

d) conserving cultural heritage of existing buildings and structures; and

e) preserving and enhancing the urban tree canopy in downtowns.

3.3.35 Encourage economic development and tourism and support historic shopping functions by promoting downtowns as key areas for locating local businesses, including restaurants, cafes and other attractions that are well served by transit and accessible through a variety of transportation modes.

3.3.36 Consider the following where downtowns coincide with a Strategic Growth Area or Local Centre:

a) balancing intensification and redevelopment with sensitivity to local heritage, built form and character;

b) providing healthy, accessible and complete communities that reduce vehicular dependence and support a mix of land uses, active transportation, transit routes and community services and facilities that serve the needs of residents of all ages and abilities, in accordance with Policy 3.3.1;

c) providing a range of appropriate housing options, including compact, higher density housing types, affordable housing and special needs housing that have regard for historical neighbourhoods within the downtown;

d) incorporating sustainability and climate resilient development that achieves the Region's climate resiliency and sustainability objectives, in accordance Section 3.2, while maintaining the local heritage; and

e) implementing mobility choices that facilitate active transportation and cycling that contribute to main street shopping and the overall economic development of the downtown.

3.3.37 Promote downtowns as focal points of culture, art, entertainment and assembly through the provision of public squares, cultural facilities, parks and other community services.

3.3.38 Promote a high-quality public realm, in accordance with Policy 3.3.3.

3.3.39 Require area municipal official plans to support downtowns with policies that:

a) strengthen the intended role and character of the downtown;

b) enhance and conserve historic and cultural resources and functions;

c) provide for appropriate development that addresses the built, natural and cultural heritage of the downtown within which it is situated;

d) guide development, redevelopment and intensification while protecting and preserving built heritage resources, and cultural heritage landscapes;

e) support the restoration and where appropriate, the adaptive reuse of built heritage resources;

f) provide an appropriate interface or transition between new developments and protected heritage properties or heritage conservation districts;

g) provide for development that is compatible with existing communities; and

h) identify the core values and function of the downtown(s).

3.3.40 Promote built and cultural heritage awareness throughout the region and support area municipal efforts to establish heritage conservation districts and areas.

3.3.41 Encourage area municipalities to:

a) adopt policies to protect and enhance cultural heritage resources in their official plans, including the use of heritage impact assessments where development is proposed adjacent to properties designated under the Ontario Heritage Act, heritage conservation districts and provincial heritage properties;

b) utilize the Ontario Heritage Act to conserve, protect and enhance the built and cultural heritage resources of the municipality;

c) establish and maintain Municipal Heritage Committees to consult on matters relating to built and cultural heritage resources and landscapes during the planning process and the designation of heritage conservation districts and properties as provided for in the Ontario Heritage Act;

d) update municipal heritage registers on a regular basis;

e) create urban design standards in historic districts and areas to reflect the history, character and streetscape; and

f) create and retain a list of cultural heritage landscape features and include official plan policies to protect and enhance these features throughout the region.

3.3.42 Engage with Indigenous communities, along with area municipalities, and consider their interests when identifying, protecting and managing cultural heritage and archaeological resources.

3.3.43 Encourage built and cultural resource conservation through adaptive reuse. Where original uses cannot be maintained, promote opportunities for adaptive reuse of heritage structures and sites, including the recycling of building materials, wherever feasible.

3.3.44 Evaluate and conserve, where possible, cultural heritage resources in all capital works projects.

3.3.45 Support the development of scenic lookouts or staging areas outside the Urban Area in appropriate areas to promote the preservation and utilization of the region's cultural heritage landscapes.

3.3.46 Encourage area municipalities to conserve and protect significant natural and cultural heritage landscapes through the development process, including the Lake Ontario waterfront, the Lake Ontario Waterfront Trail, Lake Scugog, Lake Simcoe and the Rouge National Urban Park views and vistas.

3.3.47 Require areas identified as having archaeological potential by the Region or the area municipality to be studied to their fullest extent prior to development of a property. The proponent shall provide the municipality, the Region and the First Nations or Metis identified as having cultural and/or local heritage within the area with a copy of the provincial assessment letter confirming the reports have been filed with the provincial Register prior to any grading or development occurring on a site.

3.3.48 Ensure that, where it is determined that the archaeological resources must be preserved in situ, the area be excluded from development and require the area municipality to consider regulatory tools to protect the resources such as zoning, heritage easements, and/or designations.

3.3.49 Require that, where human burial sites or remains are exposed during any land disturbance activity, all work must cease immediately, and the site be secured. The appropriate authorities must be notified, including the First Nations or Metis identified as having cultural and/or local heritage within the area, and the provisions of all applicable federal and provincial statues and requirements, along with any other relevant protocols, must be followed.

3.3.50 Ensure that, where archaeological resources are found to be of Indigenous affiliation, the proponent and/or their archaeological consultant are required to:

a) where the finding takes place through a Stage 2 archaeological assessment, provide a copy of the findings and receive a response from the Indigenous community identified as having cultural and/or local heritage within the area prior to development proceeding the subsequent stage of archaeological assessment; and

b) during the Stage 3 archaeological assessment, engage and receive a response from the relevant Indigenous community identified as having cultural and/or local heritage within the area in the formulation of mitigation strategies.

3.3.51 Ensure that, where the preservation of a site containing archeological resources of Indigenous, First Nation or Metis origin is not possible, the proponent and/or their archaeological consultant, the Region and area municipality shall engage immediately, prior to any fieldwork taking place, with the appropriate Indigenous, First Nations or Metis affiliation to identify interpretive and commemorative opportunities to ensure the long-term protection of any archeological resources.

3.3.52 Encourage area municipalities to prepare archaeological management plans and cultural plans, where appropriate.





Chapter 4

Supportive Infrastructure & Services

Chapter 4. Supportive Infrastructure & Services

The planning, financing and provision of adequate infrastructure and services are key responsibilities of the Region. Regional infrastructure and services include regional roads, transit, water distribution and treatment, sewage collection and treatment, waste collection and diversion, social services, including housing services, public health, and paramedicine.

The province established population and employment forecasts for the Region, and the Region integrates the planning and growth management of its network of infrastructure and provision of services to accommodate existing and future population and employment growth in Durham's communities.

Ensuring supportive municipal infrastructure and services are in place – or will be in place for future needs – and maintained on a regular basis to be financially viable over its life cycle, is essential for a growing, prosperous and economically competitive region.

Goals:

I. **Provide the necessary Regional municipal infrastructure and services to meet current and projected needs for orderly growth in the region in an environmentally and financially sustainable manner.**

II. **Enable the efficient delivery, location and effective use of energy and utilities.**

III. **Maintain the long-term financial sustainability of the Region by managing its financial resources in a fiscally responsible and prudent manner.**

4.1 Municipal Servicing

The following supportive infrastructure policies are intended to ensure that appropriate services, including water and sewage services and other services, both public and private, are planned and available to support the growth, health and sustainability of Settlement Areas.

By integrating green infrastructure and climate mitigation at the start of the design process, the community's underlying infrastructure can play a major role in supporting the Region's commitment to reducing GHG emissions and demonstrating leadership in climate action.

Objectives:

i. **Ensure adequate municipal water supply and sanitary sewage services are provided to support planned levels of intensification and development within Urban Areas as appropriate, with an emphasis on Strategic Growth Areas.**

ii. **Encourage the highest standards of sustainable design and construction to improve the environmental performance of new and existing development and infrastructure that adapts to and mitigates the impacts of a changing climate.**

iii. **Ensure the delivery of clean drinking water and provision of safe, sustainable water and sewage services over the long-term.**

iv. **Promote the safe, sustainable and efficient management of stormwater.**

Policies:

Regional Infrastructure & Services

It is the policy of Council to:

4.1.1 Plan for new or expanded infrastructure to occur in an integrated manner, including evaluations of long-range scenario-based land use planning, environmental planning and financial planning.

4.1.2 Prioritize the provision of municipal water and sewage services within Urban Areas to development and redevelopment applications which produce an intensive and compact form of development to optimize the use of the services. This includes prioritizing the provision of municipal services and infrastructure to Strategic Growth Areas.

4.1.3 Prioritize infrastructure and services in marginalized communities identified as Durham's Priority Neighbourhoods, where possible, with an emphasis on minimizing the impacts of a changing climate by prioritizing low impact development, resilient design and green infrastructure.

4.1.4 Require that the location, design and construction of Regional infrastructure and services be determined and provided in a cost-efficient and environmentally-sustainable manner, based on capitalizing on the existing infrastructure, considering opportunities for adaptive reuse, and minimizing adverse impacts on the natural environment.

4.1.5 Promote the co-location of linear infrastructure, where appropriate.

4.1.6 Ensure that, within the Greenbelt Plan Area, the location and construction of infrastructure and expansions, extensions, operations and maintenance of infrastructure adhere to the policies of the Greenbelt Plan.

4.1.7 Assess infrastructure risks and vulnerabilities, including those caused by the impacts of a changing climate and natural hazards, and identify actions and investments to address these challenges, which could be identified as part of municipal asset management planning in accordance with Section 4.4.

4.1.8 The Region shall not be compelled to supply water or sewage to a development, property or building where sufficient capacity does not exist. Connections will only be provided when it is determined the water and/or sewage system has sufficient capacity to accommodate planned growth.

Transportation and Transit

The Region has jurisdiction over a network of Regional roads, forming a key component of the arterial road network as designated on Map 3b. The Regional road network includes existing roads and supporting infrastructure that the Region maintains and expands, extends and rehabilitates over time. The Regional road network includes a growing network for active transportation, and supports transit and goods movement.

Durham Region Transit (DRT) is a Regional service and forms an integral component of the long-term transit priority network as designated on Map 3a. Infrastructure for DRT includes not only the buses themselves but also the bus stops and bays, dedicated transit lanes, stations and terminals, and maintenance facilities.

It is the policy of Council to:

4.1.9 Update a service strategy for DRT every five years to guide medium-term transit planning in response to a growing population and job market, student travel and addressing the needs for all ages and abilities in supporting multi-modal travel.

4.1.10 Prepare an implementation plan for all components of the transportation system, which shall be reviewed annually as part of the capital budget and forecast, to define priorities and assess financial implications.

Stormwater Management

Along regional roads, the Region provides and maintains ditches, catch basins, maintenance holes, culverts and underground stormwater pipes and employs stormwater quality and quantity controls to reduce stormwater impacts on the water resources system. The Region also reviews new development proposals to ensure that stormwater flows do not affect the capacity of the regional stormwater system.

It is the policy of Council to:

4.1.11 Ensure that, for lands located on the Oak Ridges Moraine and the lands within the Lake Simcoe watershed and/or the Protected Countryside of the Greenbelt Plan, regional stormwater infrastructure meets the requirements of the Oak Ridges Moraine Conservation Plan, Lake Simcoe Protection Plan and the Greenbelt Plan respectively.

4.1.12 Encourage area municipalities to include in their official plans, requirements, where appropriate, for comprehensive stormwater management and erosion and sedimentation control plans that are prepared in the context of subwatershed plans, or other similar plans and that stormwater management facilities be implemented as part of the pre-servicing of development proposals.

4.1.13 Work with area municipalities, conservation authorities and other agencies to ensure stormwater management plans encourage implementation of a hierarchy of source, lot-level, conveyance and end of pipe controls, to address the impacts of a changing climate and impacts from natural hazards, including through improved stormwater management design and the use of innovative technologies and best practices.

4.1.14 Encourage area municipalities to include policies within their official plans to implement source control programs that reduce stormwater runoff volume and pollutant loadings within designated Urban Areas in the Lake Simcoe watershed, in accordance with the Lake Simcoe Protection Plan.

Green Infrastructure

It is the policy of Council to:

4.1.15 Consider the impacts of a changing climate in the location, design and construction of Regional infrastructure and services, and promote green infrastructure within these projects.

4.1.16 Identify green infrastructure projects in regional asset management planning.

4.1.17 Promote the development and redevelopment of lands, and upgrades and retrofits of existing infrastructure and buildings that incorporate:

a) green infrastructure to minimize the impacts of stormwater runoff, including low impact development, based on the existing water budget for the development application;

b) energy efficient building and site design, including low carbon, net-zero and net-zero ready homes and buildings in accordance with Policy 3.2.10; and

c) water conservation.

4.1.18 Encourage stormwater management planning, practices and retrofits including low impact development measures in the design and construction of development to reduce flood risk and strain on stormwater infrastructure, such as:

a) green roofs that reduce the urban heat island effect and enhance urban ecology;

b) permeable pavement and permeable surfaces such as soft landscaping;

c) rainwater harvesting to promote water reuse;

d) infiltration facilities and vegetated swales that incorporate native or non-invasive species;

e) bioretention; and

f) natural landscapes to minimize water use and consumption.

4.1.19 Encourage area municipal official plans to incorporate green infrastructure policies, such as stormwater management practices and low impact development where feasible, to reduce flood risk, mitigate impacts of the urban heat island effect, and reduce GHG emissions.

Water & Sewage

Regional water and sewage infrastructure including water supply plants, water pollution control plants and sewage lagoons are indicated on Map 1.

It is the policy of Council to:

4.1.20 Support the development of Urban Areas in accordance with the policies in Section 5.1, based on the principles of sequential development, progressive extension, improvement, rehabilitation and economical utilization of the regional water supply and sanitary sewage systems and minimization of financial impacts on the Region in accordance with Section 4.4.

4.1.21 Ensure sufficient municipal water and sanitary sewage facilities are provided to Urban Areas, within the financial capability of the Region, in accordance with Section 4.4, to accommodate forecasted growth and to achieve the goals of this Plan.

4.1.22 Permit municipal water wells, water storage facilities, water supply and water pollution control plants and water and sewage pumping stations in any designation in this Plan.

4.1.23 Consider the location of designated vulnerable areas, such as wellhead protection areas, intake protection zones, significant groundwater recharge areas and/or areas of high aquifer vulnerability, in the siting of new municipal and other wells.

4.1.24 Minimize the impact of municipal services on the environment by:

a) requiring potential polluting industries to pre-treat sewage to reduce impacts on sanitary sewage facilities or, as the case may be, prohibiting connections to Regional services for industries in locations which could potentially discharge sanitary sewage into fragile environments;

b) encouraging industries that consume large quantities of water to recycle water to reduce consumption of the Region's water resources;

c) encouraging industries that require water and sanitary sewage facilities, in excess of domestic needs, to locate their plants in areas where adequate water and sewage services are available; and

d) encouraging the conservation of water.

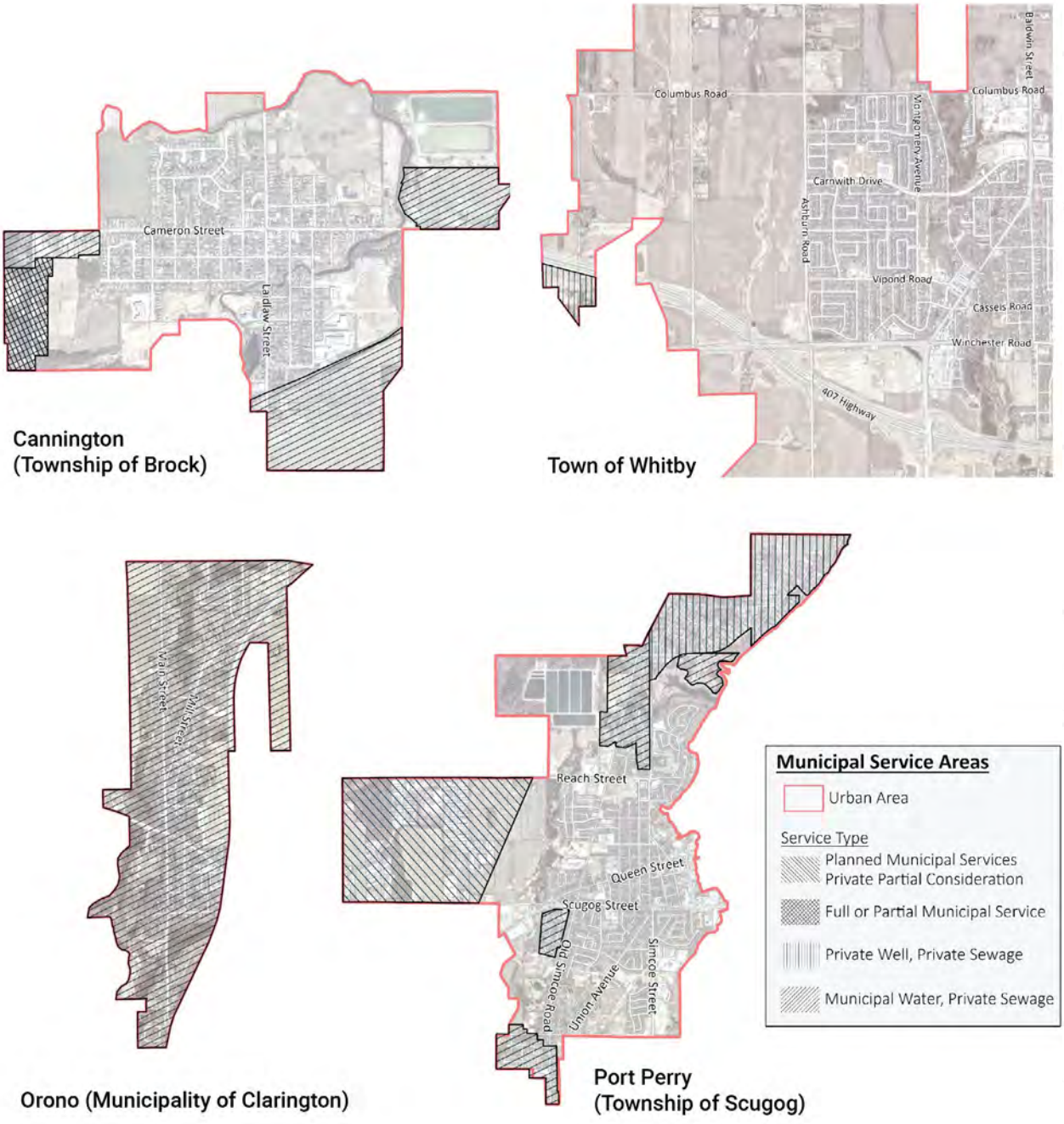
4.1.25 Undertake the necessary engineering studies and assessments, including regional water and sanitary sewage master plans in accordance with this section, to support the achievement of the overall population and employment forecasts, intensification target and other density targets contained in this Plan. Growth within the Beaverton, Sunderland, Cannington, Uxbridge, Port Perry and Orono Urban Areas may be constrained by existing municipal servicing capacity. This policy shall not be construed to require the Region to provide municipal water and/or sewage facilities in contravention of this section.

4.1.26 Recognize there are locations within the Urban Area in which the provision of municipal water and/or sewage services is not technically or financially feasible, or may be in process but not yet completed, including but not limited to the areas identified on Figure 5. In such circumstances, development on the basis of individual on-site sewage services and individual on-site water services or partial municipal services may be considered, subject to the following:

a) prior to any development on partial or full private services, the feasibility of providing full municipal services must first be assessed, including consideration of any additional capacity resulting from municipal water supply or municipal sanitary sewage plant expansions, and/or other servicing alternatives, such as communal systems; and

b) any development on the basis of partial municipal services or full private services shall be in accordance with the relevant provisions of Policies 6.5.6 to 6.5.15, and subject to a regional agreement that the development will be connected by the landowner as soon as Regional services are available.

Figure 5. – Areas developable on private and/or partial municipal services:



It is the policy of Council to:

4.1.27 Allow lands subject to Policy 9.2.12 located within the Uxbridge Urban Area to be considered for development without the need for a comprehensive review of this Plan, and shall:

a) have priority over expansions to the Uxbridge Urban Area; and

b) be allocated any additional servicing capacity, in accordance with the relevant policies of the area municipal official plan.

Aligning Growth & Infrastructure Planning

It is the policy of Council to:

4.1.28 Ensure that long-term Regional infrastructure planning is coordinated and integrated with long-term population and employment growth, in accordance with Section 1.1.

4.1.29 Phase the delivery of Regional infrastructure in a manner that supports the achievement of the growth forecasts outlined in Policy 1.1.7 while maintaining the financial sustainability of the Region.

4.1.30 Support coordination between regional and area municipal infrastructure master planning exercises and official plan updates.

4.1.31 Prepare and update, in consultation with area municipalities, a servicing master plan for water supply and sanitary sewage facilities, at least every 5 years, to establish servicing requirements for Urban Areas. This servicing plan shall address the following:

a) the required long-term improvements, expansions and additions to water supply and sanitary sewage systems to meet the population forecasts and related employment forecasts for a minimum of 25 years, including intensification in accordance with Policy 1.1.7 and Figure 9;

b) the immediate requirements for the provision of services to Strategic Growth Areas and Employment Areas, in accordance with Policies 2.1.8 and 2.1.9;

c) identify opportunities where infrastructure may be underutilized and growth should be prioritized;

d) the estimated expenditures necessary for the provision of the required works;

e) provision for monitoring and adjusting to timing of infrastructure delivery in the Capital Budget in order to align with actual growth;

f) the staging of construction and financing of the required works, having regard for Policy 4.4.4; and

g) the coordination of regional services with area municipal services, school boards, conservation authorities, energy utilities and other agencies to ensure infrastructure and operational efficiencies.

4.1.32 Adopt and update a Transportation Master Plan every 5 to 10 years, in consultation with area municipalities, Metrolinx and the Ministry of Transportation, to establish the transportation infrastructure, policies and programs necessary to support and implement the policies of this Plan.

4.1.33 Prioritize works that implement development which will not place a financial burden on the Region in the consideration of the expansion of capital works within designated Urban Areas.

4.1.34 Not support the provision of any Regional infrastructure and services to a development application that would cause significant or undue financial, environmental or other hardship for the Region.

4.1.35 Authorize, after due consideration, the oversizing of any site, intake, outfall and trunk components of any regional water supply system and sanitary sewage system to permit servicing capacity beyond the population and employment forecasts in this Plan.

4.1.36 Agree to draft approval of a plan of subdivision in Urban Areas in circumstances where full municipal services are not immediately available, provided that the draft approval does not over-commit servicing capacity identified through a servicing master plan or an approved Environmental Assessment, the lands are appropriately designated for development, and other Regional conditions have been satisfied.

4.1.37 Allocate servicing capacity for development addressed in Policy 4.1.36, in consultation with the area municipality, at the time a development agreement is executed with the Region and the appropriate financial securities are in place.

4.1.38 Investigate the provision of municipal services to Orono and alternative means of providing additional servicing capacity for the Urban Areas located in the Townships of Brock, Scugog and Uxbridge, for the purpose of servicing the existing areas developed on private or partial water and/or sewage services and in order to support long-term development of the Urban Areas to accommodate the population and employment forecasts included in Policy 1.1.7.

4.1.39 Investigate the long-term servicing of Urban Areas identified in Policy 4.1.38. Further expansions to these Urban Areas shall only be considered if there is a long-term plan in place to provide full municipal services and in accordance with applicable provincial plans.

Private Systems

It is the policy of Council to:

4.1.40 Permit limited infilling or minor expansion to existing development in Urban Areas to proceed on private drilled wells and/or private sewage disposal systems, in accordance with the provisions of this Plan and notwithstanding the policies in Section 5.1, prior to the availability of municipal services, provided that:

a) a satisfactory agreement has been entered into with the Region, including the requirement for future connection to the regional water supply and sanitary sewer system at the landowner's expense;

b) the proposed use does not require excessive use of water and appropriate provisions have been included in the zoning by-law to that effect;

c) the proposed use complies with the standards of the Region and the Ministry of the Environment, Conservation and Parks;

d) consideration is given to designing the development in such a way as to allow for further subdivision of the land upon provision of full regional services; and

e) for development on partial water and/or sewage services, the development is within the reserve sewage and water treatment system capacity.

4.1.41 Support the development of Rural Settlements on individual on-site private services.

4.1.42 Refuse new private sewage disposal systems within 100 metres of the Lake Simcoe Shoreline, other lakes or any permanent streams within the Lake Simcoe watershed, in accordance with and notwithstanding any exceptions to the Lake Simcoe Protection Plan.

4.1.43 Work with area municipalities to assess the long-term impacts of individual on-site sewage services and individual on-site water services on the environmental health and the desired character of Rural Settlement Areas and the feasibility of other forms of servicing.

Extensions & Connections

It is the policy of Council to:

4.1.44 Extend municipal water systems and/or sanitary sewage facilities to the areas described in Policy 5.1.16, notwithstanding any other provisions in this Plan to the contrary, provided that such areas are contiguous to areas designated as areas on full municipal services. In addition, the provisions of Policies 4.1.36 and 4.1.37 shall apply to these areas.

4.1.45 Refuse extensions to or expansions of existing services to Urban Areas that do not currently have Great Lake or Lake Simcoe based water and sewage services, unless such servicing is required to address failed individual on-site water or sewage services or to ensure the protection of public health where it has been determined by the Region's Medical Officer of Health that there is a public health concern associated with existing services within the Urban Area, in accordance with the Lake Simcoe Protection Plan.

4.1.46 Restrict the capacity of the services provided in the circumstances identified in Policy 4.1.45 to capacity required to service the affected existing Urban Area, plus the capacity for potential development within the existing approved Urban Area Boundary.

4.1.47 Extend, after due consideration and notwithstanding Policy 4.1.41, full or partial municipal services to Rural Settlements or consider the limited use of new regionally-owned and operated water and/or sewage facilities in Rural Settlements, without amendment to this Plan, in circumstances where it is deemed necessary to address a serious health or environmental concern identified by the Region's Medical Officer of Health or other designated authority, subject to the principles of Policies 6.5.12 and 6.5.15.

4.1.48 Permit a municipal water and/or sanitary sewer connection outside the Urban Area Boundary, notwithstanding any other policy of this Plan to the contrary, to the following:

a) a legally existing use;

b) a vacant lot of record that meets the requirements of applicable law for a building permit;

c) within the Greenbelt Plan Area, a vacant lot of record that meets the requirements of applicable law for a building permit for a single dwelling only; or

d) where lot creation is permitted by this Plan, subject to conforming to the applicable regional lot sizing policies related to private services.

4.1.49 Ensure that, for a property to be considered under Policy 4.1.48, it shall directly abut a municipal watermain or sanitary sewer service within a public right-of-way or easement, and the connection shall be technically feasible, to the satisfaction of the Region.

4.2 Waste Management

The Region operates four waste management facilities and is responsible for the collection of source separated organics, leaf and yard waste, and residential garbage from Region households. Blue Box recyclables are subject to extended producer responsibility regulations by the province and will transition to full producer responsibility.



The Durham York Energy Centre (DYEC) in Clarington is the primary long-term disposal option for waste. The DYEC processes household waste remaining after organics diversion, recycling and reuse programs.

Figure 6. – The 5Rs – Rethink, Reduce, Reuse, Recycle & Recover:

Objectives:

i. **Ensure that integrated, innovative and sustainable approaches to waste management implement the principles of conservation and diversion, reduction, reuse and recycling of waste.**

ii. **Support a circular economy by managing waste as a resource.**

iii. **Promote improved excess soil management for Regional projects in coordination with the area municipalities, conservation authorities and province.**

Policies:

It is the policy of Council to:

4.2.1 Complete and implement a Long-Term Waste Management Plan, in consultation with area municipalities and other stakeholders that will implement Regional waste management initiatives.

4.2.2 Ensure sufficient waste management infrastructure within Urban Areas, in accordance with Section 4.4, to accommodate forecasted growth and to achieve the goals of this Plan, subject to the financial capability of the Region.

4.2.3 Pursue new opportunities for energy from waste and organics management.

4.2.4 Encourage consistent delivery of waste management and diversion services across the region for all housing types.

4.2.5 Encourage the conservation and adaptive reuse of buildings, as well as the reuse and recycling of construction materials.

4.2.6 Encourage area municipalities to direct waste disposal sites to appropriate locations that avoid:

a) Natural Core Areas, Natural Linkage Areas, areas of high aquifer vulnerability, key natural heritage features, key hydrologic features and related minimum vegetation protection zones, in accordance with the Oak Ridges Moraine Conservation Plan;

b) key natural heritage features, key hydrologic features and associated vegetation protection zones, in accordance with the Greenbelt Plan; and

c) wellhead protection areas, in accordance with Section 7.5.

4.2.7 Minimize the potential adverse impacts of new and expanding waste disposal sites by ensuring they are buffered and/or separated from sensitive land uses and the location and design of such sites is in accordance with area municipal, regional, provincial and federal legislation and standards.

4.2.8 Consider the following when reviewing proposals for the establishment of new, expansions or increases in capacity of existing waste disposal sites that are subject to a provincial Environmental Assessment:

a) the principle of reduction, reuse and recycling of waste and alternative solutions for waste disposal;

b) recovery of energy;

c) the impact of the proposal on the health of surrounding residents, the transportation system and existing and future surrounding land uses;

d) dust, noise, odour and leachate impacts;

e) the impact of the proposal on the natural environment, including water quality and quantity; and

f) financial implications to the Region.



4.2.9 Select and retain a qualified consultant or consultants to conduct a peer review of any reports submitted in accordance with Policy 4.2.8. The proponent shall bear any costs associated with a peer review.

4.2.10 Support provincial initiatives to identify active and former domestic and industrial landfill sites and waste disposal sites, to determine the health risks associated with such sites and to establish decommissioning programs.

4.2.11 Encourage area municipalities to identify all active and former domestic and industrial landfill sites within area municipal official plans for information purposes only and establish appropriate policies dealing with lands in the vicinity, taking into consideration the decommissioning considerations and designations in this Plan.

Landfill Site refers to a waste disposal site where waste is permanently deposited on/in land or on land covered by water, under controlled conditions, and includes compaction of waste into a cell and covering of the waste at regular intervals.[1] For the purpose of this Plan, waste includes ashes, garbage, refuse, domestic waste, industrial waste or municipal refuse and such other wastes as designated under the Environmental Protection Act.

Excess Soil Management

Excess Soil refers to soil, or soil mixed with rock, that has been excavated as part of a development or infrastructure project and removed from the area.

It is the policy of Council to:

4.2.12 Employ best management practices for excess soil resulting from regional operations, where feasible.

4.2.13 Collaborate with area municipalities to ensure that excess soil reuse strategies are developed as part of planning for growth and development.

4.2.14 Encourage area municipalities to include official plan policies that adopt best management practices for excess soil generated and fill received during development and site alteration, including infrastructure development, to ensure:

a) excess soil is reused on-site or locally, to the maximum extent possible;

[1] Ontario Regulation 347 General Waste Management under the Environmental Protection Act.

b) development proponents are responsible for ensuring excess soil removed from a project site reaches appropriate receiving sites;

c) excess soil reuse planning is undertaken concurrently with development planning and design, where feasible;

d) site grading and drainage pattern changes are minimized to the greatest extent possible;

e) outside of the Oak Ridges Moraine Plan Area, appropriate sites for excess soil storage and processing are permitted close to areas where potential development is concentrated, near areas of potential soil reuse and preferably along higher order roads;

f) fill quality received and fill placement at a site must be compatible with adjacent land uses and will not cause an adverse effect to the current or proposed use of the property, the natural environment or cultural heritage resources; and

g) education and outreach related to excess soil management to be undertaken by the proponent.

4.2.15 Encourage area municipalities to regulate excess soil through their fill and site alteration by-laws both on and off the Oak Ridges Moraine to mitigate negative impacts to human health and the environment, in accordance with provincial legislation and guidance.

4.2.16 Collaborate with area municipalities, the development industry, conservation authorities and Indigenous communities in the development of locational criteria for excess soil management sites.

4.3 Utilities & Energy

In addition to the Region's provision of infrastructure and services, there is a range of agencies and service providers that have a direct interest or involvement in long-term growth planning in the region, such as utility providers.

Implementation of energy conservation and efficiency measures and the establishment of renewable, district and alternative energy systems across the region will help our communities mitigate, adapt and build resilience to the impacts of a changing climate.

Objectives:

i. Ensure adequate regional municipal services and utilities to meet the existing and future needs of orderly growth in the region in an environmentally and financially sound and efficient manner.

ii. **Promote energy conservation, efficiency measures and renewable and alternative energy systems to reduce GHG and adapt and build resiliency to the impacts of a changing climate.**

Policies:

Utilities

Utilities include such facilities as electricity generation facilities and transmission and distribution systems, district energy facilities, and pipelines for oil and gas.

It is the policy of Council to:

4.3.1 Liaise with other utility service providers to ensure that utilities are provided in an efficient and timely manner, coincident with development. Development proposals within proximity to utilities shall be reviewed in accordance with Policy 5.5.31. Utility service providers are encouraged to proactively study the capacity and condition of their infrastructure and undertake necessary steps to ensure sufficient capacity is available to support the growth forecasts contained in this Plan.

4.3.2 Utility infrastructure that meets the definition of Major Facilities may occur in any designation subject to the policies of this Plan.

4.3.3 Encourage proponents to minimize negative impacts and constraints on the natural, built and cultural environments in the consideration of the location, design and construction of utilities.

4.3.4 Encourage proponents to give primary consideration to existing utility corridors in locating and designing new utilities, where feasible.

4.3.5 Permit secondary uses, such as active and passive recreation, agriculture, including urban agriculture, community gardens, other utilities, and uses such as parking lots and outdoor storage that are accessory to adjacent land uses, on hydro corridor lands, where compatible with surrounding land uses and in consultation with the area municipality. However, the primary function of a hydro corridor is for electricity generation facilities, transmission and distribution systems, and therefore secondary uses require approval from Hydro One Networks Inc.

4.3.6 Encourage various agencies, boards and commissions that issue licenses and/or have jurisdiction over utilities to consult with the Region during their licensing processes.

4.3.7 Investigate district energy opportunities in conjunction with Ontario Power Generation, other energy utilities and the respective area municipalities.

Telecommunications Infrastructure

It is the policy of Council to:

4.3.8 Encourage development be designed to provide, where feasible, for the implementation of leading-edge communication technologies, including but not limited to broadband fibre optics.

4.3.9 Support the implementation of a Dig Once approach to allow and/or require the inclusion of conduit appropriately sized to accommodate broadband fibre optic infrastructure, and/or other similar communication infrastructure, during road construction, reconstruction and other major development activities.

4.3.10 Encourage the co-location of new telecommunication/communication equipment on shared towers and structures wherever possible, including regional and area municipal facilities where feasible.

Energy Facilities

It is the policy of Council to:

4.3.11 Promote the importance of the supply of electricity generation facilities and transmission and distribution systems, district energy, alternative and renewable energy facilities, such as commercial wind turbines, in order to facilitate the efficient and reliable provision of electric power to meet current and projected needs.

4.3.12 Encourage the development of district energy facilities that leverage regional infrastructure to support low carbon energy to new or existing Community Areas.

4.3.13 Encourage area municipalities to consider the inclusion of policies in their respective official plans to ensure that energy facilities, including renewable energy facilities, are located appropriately.

4.3.14 Encourage Ontario Power Generation or other electricity providers/ suppliers to consult with the Region on the location of any new electricity generation facilities and transmission and distribution systems, and throughout any required environmental assessment processes.

Energy Conservation & Efficiency

It is the policy of Council to:

4.3.15 Promote efficient land use and the development of complete communities that facilitate and encourage sustainable transportation, energy efficient design, district energy and renewable and alternative energy generation options.

4.3.16 Collaborate with area municipalities, local utilities and other stakeholders to advance energy conservation, demand management and local generation across the region.

4.3.17 Encourage the development of community energy plans as part of the secondary planning process to assist in achieving reduced energy demand, support active transportation and transit and utilize renewable and alternative energy system options.

4.3.18 Encourage and support energy conservation and energy efficiency measures to achieve the Region's net-zero objectives, including:

a) deep building retrofits, in both municipal and private developments, that reduce energy consumption and GHG emissions, in accordance with Section 3.2;

b) local green development practices and related initiatives, consistent with Policy 3.2.14, including programs and incentives;

c) green infrastructure, in accordance with Sections 3.2 and 4.1; and

d) renewable natural gas production through Regional infrastructure.

4.3.19 Permit alternative energy systems and renewable energy systems throughout the region, in accordance with provincial and federal requirements, with consideration for the protection of Prime Agricultural Areas and the regional natural heritage system, proximity to existing sensitive land uses, noise and odour and existing infrastructure.

4.3.20 Prohibit large-scale, commercial renewable energy facilities, notwithstanding Policy 4.3.19, within Prime Agricultural Areas, key natural heritage features and natural hazard lands.

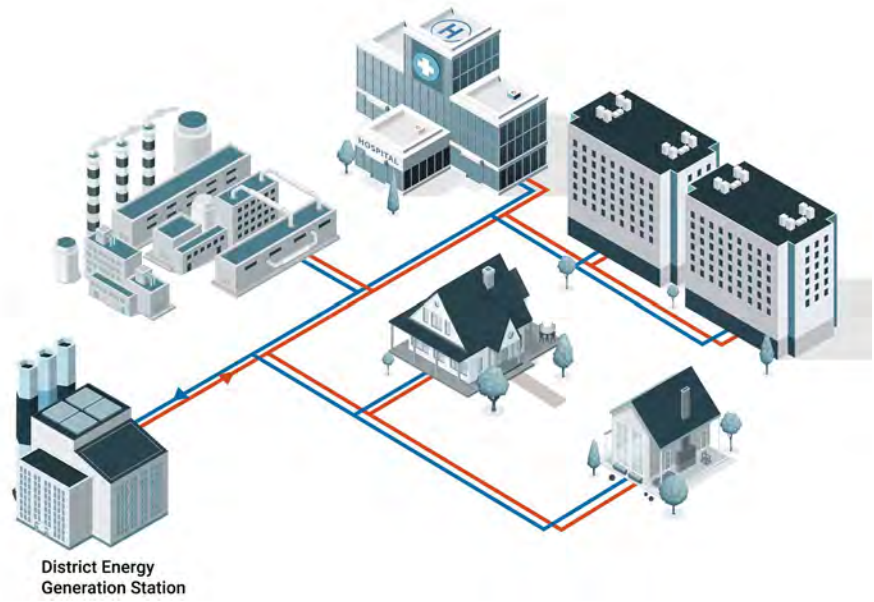
4.3.21 Require area municipal official plans and zoning by-laws to regulate the design and scale of renewable energy systems, with consideration for land use compatibility including impacts to the natural environment.

4.3.22 Support innovative ways to develop renewable and alternative energy projects through mechanisms such as public-private partnerships or demonstration and pilot projects.

4.3.23 Encourage the province to upgrade existing infrastructure to support renewable and alternative energy projects.

4.3.24 Encourage new development and municipally-owned facilities to connect to existing and planned district energy networks, whenever feasible.

Figure 7. – District Energy:



It is the policy of Council to:

4.3.25 Permit district energy generation and on-site alternative energy systems and require that area municipalities promote and facilitate such systems through their official plans and zoning by-laws.

4.3.26 Identify locations with potential for district energy generation, in consultation with the area municipalities and identify next steps for implementation in collaboration with stakeholders.

4.4 Financial Management

Growth forecasts within this Plan are used as the basis to develop a framework for growth-related capital infrastructure and services investment.

Consistent with the principle that "growth pays for growth", the Region will maintain its long-term financial sustainability by supplying new and expanded infrastructure and services to service development in a fiscally responsible and prudent manner.

Objectives:

i. Continue to ensure development bears the full cost of its share of municipal growth-related expenditures.

ii. Ensure strategic decisions regarding improvements to services and infrastructure include an evaluation of risk, and that strategies be employed to mitigate risk as part of the decision-making process.

iii. Ensure the Region's annual business planning, budget and long-term financial planning process include financial, risk and/or budgetary impacts of projects or undertakings, such as infrastructure capital and ongoing operating servicing and maintenance costs.

Policies:

It is the policy of Council to:

4.4.1 Ensure that Regional costs attributable to development are recovered, to the extent possible, through development charge levies and/or any other method or source of financing as appropriate, including but not limited to, property tax financing, senior government funding and/or debt financing, in accordance with the Development Charges Act, the Municipal Act and/or any other applicable statutes.

4.4.2 Investigate options and opportunities to optimize cost effectiveness of servicing, coordination, prioritization, phasing and construction of infrastructure and that approaches to minimize risk of providing unnecessary excess capacity, underutilized and/or stranded assets be minimized.

4.4.3 Consider the following in the review of major development applications, when determining financial impact on the Region:

a) impact on servicing needs and infrastructure requirements;

b) estimated short and long-term operating, maintenance and infrastructure capital costs;

c) the ability of development charge levies to finance the required regional services and infrastructure;

d) the effect of the proposal on the Regional general tax levy and/or user rates and revenues;

e) the potential revenue-generating ability of the proposal;

f) asset management considerations, including full life cycle costs, service levels and risk; and

g) any other financial considerations that Council may deem necessary.

4.4.4 Undertake, at the discretion of the Region, a Fiscal Impact Study and/or financing plan to address significant development proposals of a size and scale that may impact the feasibility, viability, timing or phasing of providing regional services. Such a Study shall address the following:

a) development and analysis of servicing options (i.e. scenario analysis);

b) the estimated full life cycle costs of the servicing and infrastructure investments options/scenarios;

c) the financial implications to the Region of servicing and infrastructure investments;

d) the availability of potential sources of financing;

e) the Region's capability to finance the required regional services and infrastructure investments, including any potential debt obligations and commitments if applicable, over the full life cycle; and

f) review the progress of development annually or as appropriate, to evaluate changing circumstances, determine any short and long-term financial impacts on the Region and undertake any necessary actions.





Chapter 5

Vibrant Urban System

Chapter 5. Vibrant Urban System

Durham's Urban Areas are where most residents and businesses will reside and where the majority of future growth is directed.

Durham's Urban Areas are diverse and will continue to grow and change. The five southern municipalities of Pickering, Ajax, Whitby, Oshawa and Clarington will continue to develop, intensify, will be supported by improved transit and transportation connections to the rest of the Greater Golden Horseshoe and will continue to evolve as complete communities.

Moving north, the Region will continue to be characterized by a distinctly rural environment, with active farms, resource-based activities, and natural areas dominating the landscape. The Urban Areas of Beaverton, Cannington, Sunderland, Uxbridge, Port Perry and Orono will continue to be distinct, with a character and built form and range of activities that are reflective of their roots as historic places, with active downtowns serving the rural setting.

The pace of growth across the region will vary. The policies in this Chapter guide growth while respecting local context. Sustainable growth, through continued urbanization that prioritizes placemaking, promotes the efficient use of public transit and optimizes strategic municipal infrastructure and servicing investments are essential considerations in developing complete communities.

Goals:

I. **Establish a vibrant Urban System that supports the development of compact, efficient and complete communities characterized by a mix of uses, a full range of housing options, transit and active transportation linkages and pedestrian-oriented built form that is accessible to all abilities and ages.**

II. **Balance employment and population growth by planning for an adequate supply of serviced Employment Areas.**

III. **Support emerging employment sectors and trends in how and where people choose to work.**

IV. **Encourage intensification of employment generating uses in all designations of the Urban System.**

V. **Value the diversity of areas and places that comprise the Urban System by protecting, enhancing, and integrating natural and cultural heritage resources, encouraging distinctive placemaking through architecture and high-quality urban design, supporting historic downtowns, and recognizing the distinct character of Urban Areas in Durham's northern municipalities.**

VI. **Advance the development of Strategic Growth Areas as focal points for activity, intensification, economic investment, jobs, culture and entertainment, by promoting placemaking, people-oriented urban built form and transit-oriented development.**

VII. **Promote intensification and development that optimizes infrastructure, public service facilities and supports the achievement of transit supportive densities.**

VIII. **Implement practices that support sustainability, climate change mitigation and adaptation, while protecting and enhancing the components of the Greenlands System.**

5.1 General Urban System Policies

Durham's Urban Areas will continue to evolve and intensify as the Region plans for an overall 2051 forecast of 1.3 million people and 460,000 jobs. Urban Areas will be characterized by walkable communities and more compact built form and a greater mix of uses will open opportunities for residents to work and access services, amenities and recreational opportunities, close to where people live.

Providing multi-modal transportation options will improve access to jobs, services and amenities. Providing strategic investment in municipal infrastructure and services to support and enable growth is essential to developing complete communities.

Objectives:

i. **Plan for growth to create efficient, compact and complete communities within Urban Areas.**

ii. **Ensure strategic locations within the Urban System are planned, developed and serviced as transit-oriented communities.**

Policies:

It is the policy of Council to:

5.1.1 Establish an Urban Area Boundary and designate land use components within the Urban System on Map 1 and in accordance with Policy 12.1.3.

5.1.2 Recognize that a hierarchy of Urban Areas will continue to exist in Durham Region consisting of:

a) the Urban Areas along the Lake Ontario shoreline within the municipalities of Pickering, Ajax, Whitby, Oshawa and Clarington; and

b) the smaller Urban Areas within the Greenbelt Plan Area, including Beaverton, Cannington, Sunderland, Uxbridge, Port Perry and Orono, surrounded by a primarily rural landscape.

5.1.3 Prohibit the establishment of new Settlement Areas within the Greenbelt Plan Area.

5.1.4 Recognize that the Minister Municipal Affairs and Housing, at their sole discretion may enact Minister's Zoning Orders that would allocate additional population and employment to Durham and its area municipalities, and/or expand the Urban Area Boundary.

Growth Management

It is the policy of Council to:

5.1.5 Plan, notwithstanding Policy 5.1.4, for population and employment growth based on the growth forecasts, including area municipal allocations contained in Policy 1.1.7.

5.1.6 Plan for a minimum of 50% of all new residential units across the region to be provided through intensification on an annual basis within the delineated built-up area. The boundaries of the delineated built-up area are shown on Map 1.

5.1.7 Plan for intensification based on the forecasts and area municipal intensification targets contained in Figure 9.

5.1.8 Strive to ensure development within Urban Areas makes efficient use of land, and supports the efficient use of existing and planned infrastructure, including transit, municipal water and sewage services, and public service facilities, by prioritizing and promoting intensification, redevelopment and growth within:

a) Strategic Growth Areas, including:

i) Urban Growth Centres;

ii) Regional Centres;

iii) Protected Major Transit Station Areas;

iv) Rapid Transit Corridors;

b) other nodes and corridors, including:

i) Rural Regional Centres;

ii) Regional Corridors;

iii) Local Centres;

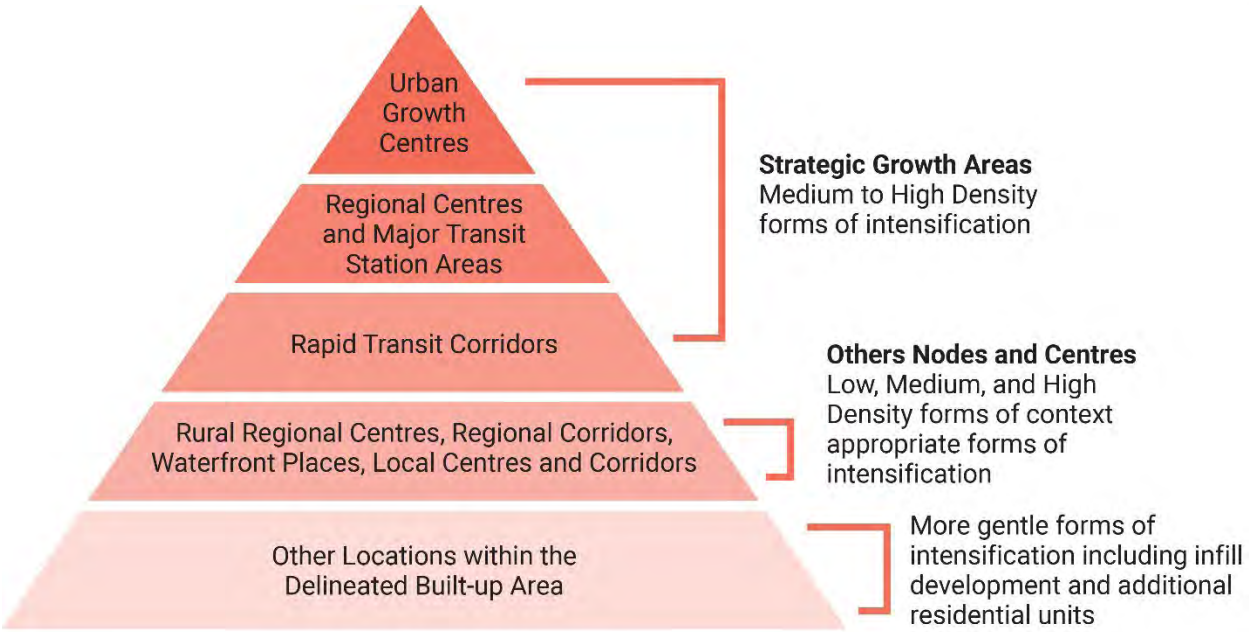
iv) Local Corridors;

c) other areas that can support intensification within delineated built-up areas; and

d) the redevelopment of brownfield sites and greyfield sites.

5.1.9 Require area municipal official plans to implement the growth management targets, designations and policies for lands within the Urban System in accordance with this Plan.

Figure 8. – Growth & intensification framework:



Intensification within the Delineated Built-up Area

It is the policy of Council to:

5.1.10 Identify the delineated built-up area on Map 1.

5.1.11 Achieve, on an annual basis, a minimum of 50% of all new residential units across the Region as intensification and be constructed within the delineated built-up area.

5.1.12 Prioritize intensification within the delineated built-up area in accordance with the hierarchy of places, as outlined in Policy 5.1.8.

5.1.13 Encourage intensification throughout the broader Community Areas designation, including through the provision of additional residential units and other forms of gentle intensification.

Figure 9. – Intensification targets table:

Municipality	Total Housing Unit Growth	Units allocated to intensification	% of Municipal total	% of Regional Intensification total
Ajax	32,140	27,690	86%	25%
Brock	2,930	570	20%	1%
Clarington	44,200	17,460	40%	15%
Oshawa	46,340	22,940	50%	20%
Pickering	55,150	21,790	40%	19%
Scugog	2,890	1,530	53%	1%
Uxbridge	2,900	1,440	50%	1%
Whitby	39,260	19,440	50%	17%
Durham	225,810	112,860	50%	100%

It is the policy of Council to:

5.1.14 Require area municipal official plans to provide intensification strategies in consultation with the Region, that would include the following:

a) implementation of intensification targets, in accordance with Figure 9;

b) encouraging additional residential units and other forms of gentle intensification;

c) achieving the planned function and minimum density targets for Strategic Growth Areas and other nodes and corridors designated in this Plan;

d) identifying other areas appropriate for intensification and determining the appropriate scale of development and transition to surrounding areas;

e) addressing the availability of existing and/or planned transit services, municipal water and sanitary sewage capacity, public service facilities, and other community services and amenities to support intensification;

f) updating area municipal official plans, secondary plans, and zoning by-laws that support the achievement of minimum density targets; and

g) notwithstanding the intensification policies herein, new or intensified development is not directed to Floodplain Special Policy Areas, and shall be subject to the applicable provisions of the area municipal official plan.

Floodplain Special Policy Area refers to an area within the community that has historically existed within the floodplain, and where site-specific policies, approved by the province, are intended to provide for the continued viability of existing uses (which are generally on a small scale) and address the significant social and economic hardships to the community that would result from the strict adherence to provincial policies concerning development. The criteria and procedures for approval are established by the province. A floodplain special policy area is not intended to allow for new or intensified development and site alteration if a community has feasible opportunities for development outside the floodplain.

Development within Urban Areas

It is the policy of Council to:

5.1.15 Support the planning and development of Urban Areas as complete communities with consideration for long-term sustainability and adaptability. Development within Urban Areas will be supported on the basis of the following principles:

a) the achievement of compact, urban and pedestrian-oriented built form, which promotes efficient use of infrastructure, active transportation and the achievement of transit supportive density;

b) logical and sequential development patterns, with new development generally taking place adjacent to existing developed areas. The development of larger sites shall occur through detailed planning processes, in accordance with Policies 5.4.9 to 5.4.16;

c) a mix and diversity of uses and amenities offering convenient access to local amenities, community hubs, parks, trails, open spaces and other recreational facilities, services, shopping, job opportunities and public service facilities;

d) built form that considers social equity, human health and improves overall quality of life by developing high-quality urban environments that are accessible to people of all ages, abilities and incomes, in accordance with Section 3.3;

e) commercial uses are provided in appropriate locations, with larger concentrations directed to Strategic Growth Areas as deemed appropriate in area municipal official plans, as well as Rural Regional Centres, Regional Corridors, and Local Centres and Corridors;

f) existing underutilized shopping centres and plazas are encouraged to redevelop at higher densities with a mix of uses including residential uses, incorporating transit supportive and pedestrian-oriented built form, particularly within Strategic Growth Areas;

g) providing and enhancing convenient access to multi-modal transportation options, with priority given to active transportation options and transit connectivity, in accordance with Section 8.2;

h) the integration, protection and enhancement of the Greenlands System, including appropriate minimum setbacks and buffers between development and environmental features and other sensitive and vulnerable areas, in accordance with Sections 7.1, 7.4 and 7.5;

i) with consideration of sustainability and the effects of development on the environment in accordance with Section 3.2;

j) locating outside of and away from hazardous lands, in accordance with Section 7.6;

k) the achievement of land use compatibility considerations by avoiding, or where avoidance is not possible, minimizing and mitigating any adverse effects between sensitive land uses and major facilities, Employment Area uses and other uses that may emit odour, dust, vibration, noise and/or other contaminates or emissions, in accordance with Policies 5.5.22 to 5.5.36;

l) the conservation of cultural heritage resources in accordance with Section 3.3 and consideration of the impacts of development on the integrity of historic downtowns and/or historical areas in accordance with Policies 3.3.32 to 3.3.39; and

m) appropriate stormwater management techniques and low impact development measures, as implemented by area municipalities.

5.1.16 Encourage an orderly withdrawal of agricultural related land uses where urban development is designated in areas presently characterized by agricultural activities. Municipalities may consider placing such areas in an Agricultural Zone or under a Holding Symbol in the respective zoning by-laws.

5.1.17 Recognize that area municipalities may designate, notwithstanding any other provision of this Plan, special purpose commercial areas and include specific provisions in their municipal official plans and zoning by-laws to distinguish the function of these areas.

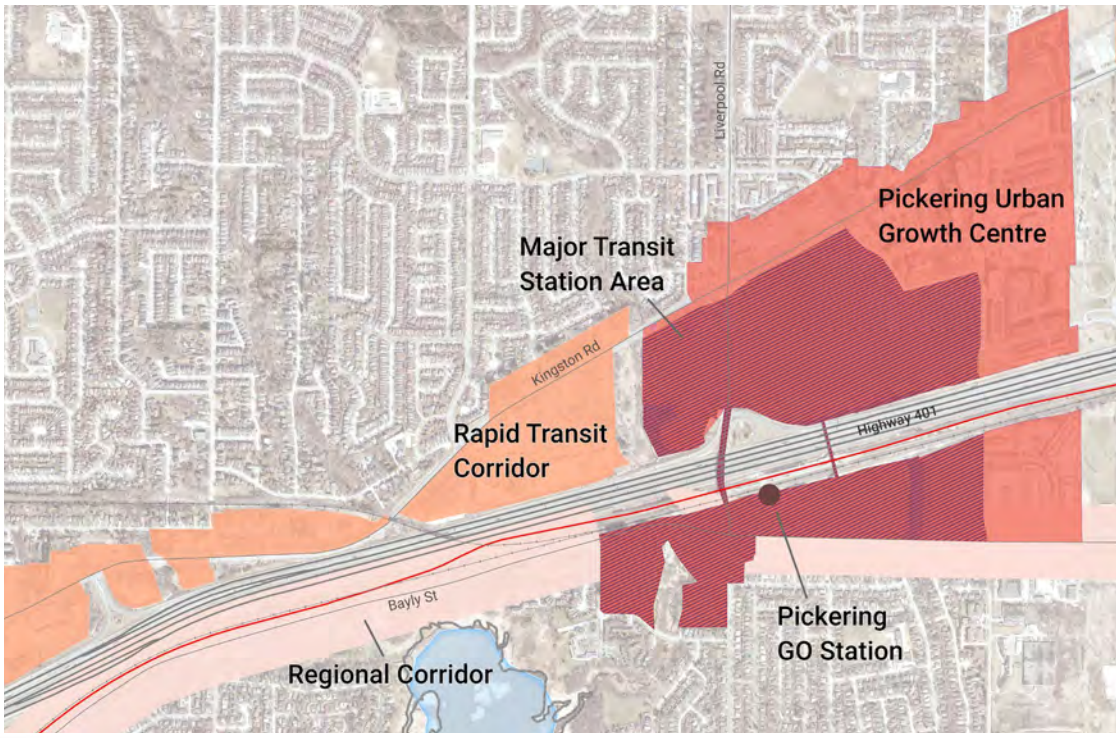
5.2 Strategic Growth Areas

This Plan promotes an "intensification first" approach to development, infrastructure investment, and region-building by placing an emphasis on optimizing the use of existing land and optimizing infrastructure capacity and investment.

Strategic Growth Areas represent optimal locations for prioritizing intensification and higher density mixed-use development. Strategic Growth Areas are planned as focal points for more intensive forms of development and as locations to achieve transit supportive densities within the Region's Urban System. The designation of certain nodes and corridors as Strategic Growth Areas signifies the intention for these places to develop as mixed-use, compact and dense urban and amenity-rich environments.

Strategic Growth Areas in Durham include Urban Growth Centres, Regional Centres, Protected Major Transit Station Areas and Rapid Transit Corridors. The success of Strategic Growth Areas will depend on proactive planning and investment to provide adequate municipal services and transit services to support development within these areas.

Figure 10. – Example of a Strategic Growth Area (Pickering):



Objectives:

i. **Support the achievement of complete communities by prioritizing development and intensification within Strategic Growth Areas and by balancing residential and non-residential growth so Durham's residents can live, work, shop and access services within their community.**

ii. **Support higher-density forms of development and redevelopment within Strategic Growth Areas.**

iii. **Support the development and long-term transition of Strategic Growth Areas as walkable, transit and pedestrian-oriented communities where active forms of mobility are viable and attractive features in a connected Urban System.**

iv. **Support the evolution of Urban Growth Centres and Regional Centres as more intensive, mixed-use and complete communities that act as focal points for residential intensification, and continue to strengthen as destinations offering commercial, cultural, entrainment, recreational and government functions for the broader surrounding community.**

v. **Ensure that developments within Protected Major Transit Station Areas strengthen their role as focal points for high-density, mixed-use destinations characterized by a walkable, transit-oriented, pedestrian friendly public realm, with strong and active transportation connections within convenient walking distance of existing and planned rapid transit stations.**

vi. **Support innovation and entrepreneurship within Protected Major Transit Station Areas.**

vii. **Plan for Rapid Transit Corridors located along Rapid Transit Spines, which are key connections to other Strategic Growth Areas within the region, where development is provided at transit supportive densities and new built form is provided based on transit-oriented development design principles.**

Policies:

It is the policy of Council to:

5.2.1 Designate Urban Growth Centres, Regional Centres, Protected Major Transit Station Areas and Rapid Transit Corridors as Strategic Growth Areas on Map 1.

5.2.2 Direct intensification and higher density, compact forms of residential, commercial and employment generating uses such as office and major office, major institutional uses and mixed-use development to Strategic Growth Areas.

5.2.3 Plan for the achievement of the following long-term transit supportive density targets within Strategic Growth Areas. The targets apply to the entirety of the area within the boundary delineation and when measuring are not netted of undevelopable features and are not applied on the basis of individual parcels:

Figure 11. – Strategic Growth Area targets table:

Strategic Growth Area	Minimum Transit Supportive Density Target (people and jobs per gross hectare)
Urban Growth Centres	200
Regional Centres (located along the Rapid Transit Corridor)	150
Regional Centres (located off of the Rapid Transit Corridor)	100-150
Protected Major Transit Station Areas	150*
Rapid Transit Corridor	150

Note:

*Notwithstanding the above, the Oshawa GO/VIA Protected Major Transit Station Area will be planned to achieve a minimum density target of 25 people and jobs per gross hectare.

It is the policy of Council to:

5.2.4 Apply the higher density target where the boundaries of Strategic Growth Areas, specifically an Urban Growth Centre, Regional Centre, Protected Major Transit Station Area or Rapid Transit Corridor, coincide or overlap with each other or with another designation.

5.2.5 Allow Strategic Growth Areas to achieve their planned potential by protecting these areas from uses and activities that should be accommodated in other designations, including low-density residential uses, automobile-oriented uses and low-density employment uses, such as warehousing, self-storage, car washes, gas stations and similar single storey buildings. Existing uses may continue but are encouraged to intensify consistent with the policies of this Plan.

5.2.6 Require area municipalities to plan for Strategic Growth Areas by updating official plans, secondary plans and zoning by-laws to:

a) delineate the boundaries of Strategic Growth Areas;

b) set out appropriate:

i) land use designations;

ii) minimum residential and employment density targets in accordance with Figure 11; and

iii) built form standards, including minimum and maximum building heights;

c) include transition policies to guide appropriate building heights, siting, land use compatibility, and scale of new development in relation to surrounding neighbourhoods and areas;

d) plan for appropriate public service facilities, parks and recreational space, and other supporting social and cultural amenities within and surrounding Strategic Growth Areas;

e) include urban design policies, guidelines or approaches to promote placemaking, active transportation, pedestrian and transit-oriented land uses and built form; and

f) consider a full range of implementation strategies to advance development within Strategic Growth Areas that include as-of-right zoning, streamlining development approvals, introducing community planning permit systems in accordance with Policy 11.3.2, or other approaches as applicable.

5.2.7 Not support reducing densities on sites in a Strategic Growth Area that have been designated or approved for medium or high-density development.

5.2.8 Plan for development within Strategic Growth Areas that:

a) incorporates transit-oriented development design principles, in accordance with Policy 8.1.3, and including:

i) enhancing mobility to and from transit services through an urban grid system of streets and walkways, and providing for active transportation connections within Strategic Growth Areas and adjacent neighbourhoods;

ii) orienting development and entrances towards streets and towards transit station and stop locations;

iii) incorporating design elements that contribute to complete, active and pedestrian-oriented streets and public places as part of a high-quality public realm through measures such as sidewalks, street furniture, patios, seating areas, street trees, landscaping, wayfinding and gateway features;

iv) providing active uses and entrances at grade, and integrating open space, parks and plazas along with public art and community spaces, and other considerations, in accordance with Section 3.3;

v) providing a mix of uses including residential uses, retail and commercial uses, compatible employment generating uses such as office and major office, educational and other institutional uses, public service facilities and entertainment and cultural facilities;

vi) providing compact built form with densities ranging from medium to high-density, with the highest densities located closest to transit station locations while providing appropriate transition to adjacent neighbourhoods;

vii) facilitating the integration of transit stations within the community by optimizing street crossings to stations, reducing walking distances and, providing sheltered connections where appropriate;

b) provides a range of housing options, including additional residential units and affordable housing, in accordance with Section 3.1;

c) contributes to, and does not detract from, the long-term transit supportive density targets, in accordance with Policy 5.2.3;

d) adheres to development limitations and setbacks to natural features and areas and other vulnerable areas as described in Chapter 7;

e) contributes to, recognizes, and conserves cultural heritage resources, in accordance with Section 3.3. For greater certainty, the inclusion of lands within a Strategic Growth Area boundary does not prevent area municipal official plans and/or zoning by-laws from identifying and designating properties and areas to be protected for heritage conservation purposes. Where cultural heritage resources are to be protected over the long-term, sensitive repurposing, limited intensification and infill, which do not negatively impact heritage value, is encouraged; and

f) addresses local road and private access spacing and access permissions to Regional arterial roads within Strategic Growth Areas on a case-by-case basis to the satisfaction of the Region. Joint access is encouraged using cross-access easements between properties to reduce the overall number of access points along arterial roads.

5.2.9 Require, in consultation with area municipal staff and infrastructure and service providers, the phasing and staging of development including the principles of Policies 5.4.9 to 5.4.16.

Refinements to Strategic Growth Area Boundaries

It is the policy of Council to:

5.2.10 Permit minor refinements to any Strategic Growth Area designated on Map 1 without the need for amendment to this Plan. A minor refinement is limited to a boundary adjustment as a result of a recent Environmental Impact Study or similar evaluation which delineates the boundaries and associated setback of environmental features and/or an adjustment to flood plain limits where the boundary of a Strategic Growth Area follows existing features, flood plain and/or Conservation Authority Regulation limits. A minor adjustment could also include the addition of an adjacent property deemed suitable for inclusion in the Strategic Growth Area boundary.

5.2.11 Require an amendment to this Plan for any major refinements to the boundary of a Strategic Growth Area. Major refinements include the addition or reduction of a significant amount of land or an addition of land that would have the effect of extending the boundary of a Strategic Growth Area beyond locations where the boundary currently coincides with a road, rail line, Urban Area Boundary, waterbody, or any other fixed and clearly defined demarcation.

5.2.11.1 Notwithstanding Policies 5.2.10 and 5.2.11, the further refinement of the boundaries of Strategic Growth Areas shall only be undertaken in accordance with provincial plans and policy.

Urban Growth Centres & Regional Centres

Durham's Urban Growth Centres and Regional Centres come in different shapes and sizes, each having a unique history and context. Some Centres currently function as predominantly auto-oriented shopping destinations containing retail and commercial plazas, while others have historic roots as traditional downtowns characterized by mixed uses, main shopping streets, a grid pattern of local roads, a mix of low and mid-rise buildings and surrounded by lower-density neighbourhoods. In all cases, Urban Growth Centres and Regional Centres will continue to evolve as complete, walkable, mixed-use and compact urban communities appropriate to their role and context.

There are two Urban Growth Centres located within Durham Region – one in the City of Pickering and one in the City of Oshawa. As principal destinations and opportunities for intensification and mixed-use development, Urban Growth Centres are the highest order centre where opportunities for urbanization, mixed-use development and iconic placemaking will continue to strengthen. Urban Growth Centres will grow as focal points for region-wide public services, major office, commercial, recreation, entertainment and high-density residential uses.

There are a total of eleven Regional Centres designated in southern Durham, which are smaller than Urban Growth Centres in terms of their regional function but are significant destinations, offering a range of opportunities for urban and mixed-use redevelopment, while serving as focal points for both regional and local services. Five Regional Centres are located along Rapid Transit Spines, where rapid transit is planned over the long term. Currently, Bus Rapid Transit is being implemented along Highway 2 from the Pickering/Toronto border to Simcoe Street in Oshawa.

It is the policy of Council to:

5.2.12 Plan and develop Urban Growth Centres as the highest order centre within the Urban System and the main concentrations of urban activities. Urban Growth Centres shall be planned as:

a) areas of significant population and employment growth and as Regional focal points for institutional, region-wide public service facilities, office and major office, commercial (which may include major retail), recreational, cultural, entertainment, high-density mixed-use and residential development, and serving as major employment centres supporting higher order transit services;

b) a built form mix of high-rise and mid-rise development with appropriate transitions in building height, density and massing to surrounding areas; and

c) a mix of uses and public spaces that contribute to complete and vibrant communities.

5.2.13 Plan and develop Regional Centres as the main concentrations of urban activities, but generally at a smaller scale than Urban Growth Centres. Regional Centres are intended to be hubs for culture, services, shopping, and key to the identity of their broader surrounding communities, and shall be planned:

a) for a full and integrated array of institutional, commercial (which may include major retail), public service facilities, higher density mixed-use and residential development, recreational, cultural, entertainment, office and major office uses; and

b) for a built form mix of contextually appropriate high-rise and mid-rise development, providing an appropriate transition in building height, density and massing to surrounding areas, and with a mix of uses and public spaces that provide for complete and vibrant communities, as determined by area municipalities.

5.2.14 Require area municipal official plans to include detailed policies for Urban Growth Centres and Regional Centres, including:

a) identification of a target population-to-jobs ratio;

b) policies that support the creation of focal points for culture, art, entertainment, and public assembly and gathering through the provision of publicly accessible squares, parks, cultural facilities and public service facilities; and

c) policies that support community hubs, government offices, post-secondary education facilities and health care facilities, in accordance with Policy 2.1.3 and Section 3.3.



Protected Major Transit Station Areas

There are eight Protected Major Transit Station Areas located within southern Durham along the Lakeshore East GO Train line. Four Protected Major Transit Station Areas surround existing stations in Pickering, Ajax, Whitby and Oshawa, and four new stations are being planned along the GO East Extension, two of which are in the City of Oshawa (Thornton's Corners and Central Oshawa) and two of which are in the Municipality of Clarington (Courtice and Bowmanville).

It is the policy of Council to:

5.2.15 Designate by amendment to this Plan additional Protected Major Transit Station Areas in consultation with the area municipalities and Metrolinx, coincident with planning for existing and future rapid transit facilities or stations.

5.2.16 Plan Protected Major Transit Station Areas as communities centered around higher order transit services. Permitted uses include medium and high density residential, mixed-use development, compatible employment generating uses including but not limited to office and major office, cultural and entertainment uses, commercial and retail uses, institutional and educational uses including post-secondary facilities, recreational and community amenities such as parks, urban squares, and trail systems.

5.2.17 Prohibit the following uses within Protected Major Transit Station Areas:

a) automobile-oriented uses such as drive-through establishments, gasoline stations, service stations and car washes;

b) land-extensive uses such as automobile dealerships with outdoor vehicle storage and display areas, warehouses and storage facilities, including self-storage facilities; and

c) any land use that would adversely affect the achievement of the minimum density target.

5.2.18 Not permit sensitive land uses, notwithstanding any other policies of this Plan to the contrary, at the following locations:

a) on the lands located within the existing Oshawa GO/VIA Protected Major Transit Station Area in the City of Oshawa, due to surrounding industrial uses, railway and highway infrastructure; and

b) on the lands located within the Courtice Protected Major Transit Station Area, east of Courtice Road and south of Baseline Road in the Municipality of Clarington, due to proximity to the Darlington Nuclear Generating Station.

5.2.19 Require development within Protected Major Transit Station Areas to offer convenient, direct and sheltered pedestrian access from high-density development sites to neighbouring Commuter Stations wherever possible, recognizing matters of accessibility for pedestrians, cyclists and persons of varying abilities, as well as connections to a variety of transportation modes.

5.2.20 Recognize that the province has authorized the use of inclusionary zoning within Protected Major Transit Station Areas, to require the provision of affordable housing units within new developments.

5.2.21 Encourage area municipalities to consider the application of inclusionary zoning in their respective Protected Major Transit Station Areas through housing assessment reports, secondary planning or equivalent processes, and subsequent zoning by-law amendments.

5.2.22 Require, where development is proposed above a rail corridor, all appropriate technical studies be undertaken to the satisfaction of the applicable railway authority, to ensure the following:

a) existing and future capacity and safety of train operations in the rail corridor will not be compromised;

b) flexibility for future expansion to rail operations and modifications and improvements to the track and signal system will not be reduced; and

c) all environmental, safety and mitigation concerns associated with such development, including noise, vibration, air quality, parking, snow and ice accumulation, servicing, pedestrian access and vehicle access, and the capacity of the transportation system serving such development have been satisfactorily addressed to the satisfaction of the rail authority, the Region and the applicable area municipality.

5.2.23 Require area municipal official plans to include detailed policies, for each Protected Major Transit Station Area, which will:

a) delineate Protected Major Transit Station Area boundaries coincident with the boundaries identified on Map 1 and provide detailed land use designations within the boundary;

b) establish minimum density, population, employment and housing targets to demonstrate achievement of the overall target of at least 150 people and jobs per gross hectare;

c) establish a minimum job target for Protected Major Transit Station Areas;

d) enable alternative development standards to support transit-oriented development, including but not limited to parking requirements which support the use of transit;

e) support the creation of focal points by concentrating the highest densities near Transit Stations;

f) include policies or approaches to ensure that the heights and densities of buildings are appropriately scaled to ensure compatibility with neighbouring lower density residential areas and appropriate transition is provided to adjacent Employment Areas, where applicable;

g) include policies to ensure that required transportation, servicing and other infrastructure is in place prior to, or coincident with new development;

h) support the efficient use of land, including requirements for structured parking, shared parking and/or reduced parking as part of new development;

i) include plans to accommodate multi-modal access to Protected Major Transit Station Areas by accounting for the retention or replacement of existing station access infrastructure (pedestrian, bus, cycle, pick-up and drop-off, and vehicle parking) and give priority to local and inter-regional transit, active transportation and passenger pick-up and drop off. Include plans for the protection for future facility expansion when new development on existing GO Station land is proposed;

j) incorporate urban design and sustainability guidelines to guide the desired density, built form, building placement, access requirements and approaches for a pedestrian-oriented public realm, that:

    i) provide appropriate transitions in building heights to surrounding areas and public spaces;

    ii) direct that all development will be designed to be pedestrian-oriented and accessible to all ages and abilities;

iii) require buildings to frame streets, with frequent pedestrian entrances;

iv) where feasible restrict vehicular access to private property from adjacent local roadways;

v) support the use of rear lanes to serve development loading, servicing and vehicular parking access requirements rather than strictly along local public streets, where appropriate;

vi) minimize the visual impact vehicular parking on streets, parks, open spaces, pedestrian walkways and other land uses. With the exception of bus parking, surface parking will be minimized;

vii) incorporate the use of urban design elements to assist with orientation, including wayfinding and the use of gateways and entrance features;

viii) require that connections to the transit stations include pedestrian weather protection and station wayfinding;

k) include policies that encourage placemaking through policy approaches that:

i) ensure a well-defined public realm that provides active gathering spaces, pedestrian destinations and connections;

ii) support the establishment of integrated trails, parks and open space systems for various levels of use year-round;

iii) provide active streetscapes with sidewalks or multi-use paths on both sides of all roads, and related pedestrian amenities;

iv) encourage streets and boulevards to be designed to allow for patios, sitting areas, while ensuring adequate space for pedestrians and streetscape plantings for shade and beautification;

v) encourage sustainable technologies, permeable pavers, low impact development techniques, and designs which support the use of renewable energy and/or district energy systems in the design of new development, the public realm and streetscapes;

l) include sustainable transportation policies that:

i) ensure road designs prioritize transit use, pedestrian travel, and cycling while accommodating automobile travel;

ii) support active transportation through safe, well-designed and direct connections between and amongst component uses and transit stations;

iii) Include adequate and secure long-term and short-term bicycle parking and end-of-trip facilities;

iv) Include below grade pedestrian connections, including knockout panels where deemed appropriate, to facilitate a continuous pedestrian network between development sites; and

m) require, where development is proposed adjacent or in the vicinity of MTO permit control areas, a transportation impact study be undertaken to determine the impacts of proposed development and intensification on highway interchange nodes within the Ministry's permit control area.

5.2.23.1 Notwithstanding Policies 5.2.15 to 5.2.23, the existing Oshawa GO/VIA station is to be planned for Employment Area permitted uses only with a minimum density target of 25 people and jobs per hectare.

Rapid Transit Corridors

Rapid Transit Corridors are the highest order Regional Corridors. They are located along portions of Highway 2 and Simcoe Street where those roads are designated as Rapid Transit Spines, in accordance with Policy 8.1.2. On Highway 2, bus rapid transit is currently being implemented and light rail transit may be planned over the long-term. Rapid transit is also being planned on Simcoe Street.

Rapid Transit Corridors are intended to provide essential connections to other Strategic Growth Areas in the region and have been assigned a transit supportive density to support the implementation of planned higher order transit service.

It is the policy of Council to:

5.2.24 Support the planning and development of Rapid Transit Corridors based on a built form that is compact, pedestrian-friendly, and implements transit-oriented development design principles. Rapid Transit Corridors are intended to provide for a full range and mix of uses including commercial, retail, institutional, residential, personal services, offices and other uses while implementing the built form principles contained in Policies 5.2.8 and 8.1.3.

5.2.25 Designate Employment Areas within Rapid Transit Corridors on Map 1 and require that they be protected for employment uses and not be used for residential uses or other sensitive land uses that would be contrary to Section 5.5. Higher density employment uses, including but not limited to office and research and development facilities, with enhanced architectural standards, landscaping design and sign controls, are encouraged.

5.2.26 Require area municipal official plans to include detailed policies for Rapid Transit Corridors that:

a) delineate Rapid Transit Corridor boundaries in accordance with boundaries identified on Map 1 and provide detailed land use designations within the boundary;

b) permit a full range and mix of uses including residential, commercial, compatible employment uses such as offices, and other uses, in a higher density, compact and pedestrian-oriented built form;

c) notwithstanding b) above, where lands within the Rapid Transit Corridor are designated as Employment Areas on Map 1, area municipal official plans shall identify the appropriate employment uses which achieve the objective of Policy 5.2.25;

d) include policies to ensure that required transportation, servicing and other infrastructure is in place prior to, or coincident with new development;

e) support the preparation of segment-specific policies through corridor studies, master plans, secondary planning, or other similar comprehensive assessments of corridor segments, as determined by area municipal official plans; and

f) incorporate policies that ensure block plans are submitted as part of development applications to guide development where considerations of the context of a broader area along the corridor is necessary.

5.3 Other Nodes & Corridors

Outside of Strategic Growth Areas described in Section 5.2, there are other nodes and corridors where higher density forms of development are encouraged, subject to local context. These nodes and corridors include:

- Rural Regional Centres: in Uxbridge, Port Perry, Beaverton, Cannington and Sunderland Urban Areas.

- Regional Corridors: form key connections between Strategic Growth Areas, other nodes and corridors, and certain Employment Areas, acting as the arteries of the Urban System. Regional Corridors support the movement of people and goods by encouraging development and intensification that is characterized by compact built form at a transit supportive density.
- Waterfront Places: there are five Waterfront Places located in Durham Region, planned to act as focal points along the Lake Ontario waterfront. Waterfront Places are intended to develop as vibrant and active "people places" that offer ease of access and sustainable use of natural and Lake Ontario waterfront-based amenities, while respecting the unique characteristics of the surrounding local context.
- Local Centres: vary in size and planned function. Certain Local Centres may function at the neighbourhood scale and be oriented to serve the day-to-day needs of nearby residents, while other Local Centres may be planned similar to, but generally at a smaller scale, as a Regional Centre and be intended to act as a node for compact mixed-use urban development that provides shopping, services and other amenities to a broader area.
- Local Corridors: are intended to have a similar function, but may occur at a smaller scale than Regional Corridors, while providing for transit supportive density and connections between Strategic Growth Areas, Waterfront Places and/or Local Centres, where appropriate.

Objectives:

i. Encourage the designation of nodes and corridors in area municipal official plans.

ii. Support Rural Regional Centres as business, economic, administrative, cultural and tourist centres for the broader community in the Townships of Uxbridge, Scugog and Brock.

iii. Promote and plan for the achievement of transit supportive densities along Regional Corridors.

iv. Support the evolution of Waterfront Places into mixed-use destinations along the Lake Ontario waterfront, while balancing urban development and intensification, where appropriate, with the protection of environmental features and areas of the Greenlands System.

v. Support Local Centres and Local Corridors as focal points for development and urban activity for their surrounding communities, at a scope and scale that is complementary to the planned function of Strategic Growth Areas and Regional Corridors.

Policies:

Rural Regional Centres

It is the policy of Council to:

5.3.1 Designate Rural Regional Centres on Map 1.

5.3.2 Support the planning and development of Rural Regional Centres as focal points for urban activities and centralized hubs for commercial uses such as retail shopping and service uses, public service facilities and the establishment of community hubs, office uses, and residential and mixed-use development, within their respective Townships.

5.3.3 Require area municipalities, in consultation with the Region, to include policies for Rural Regional Centres in their respective official plans which:

a) include a minimum density target for each Rural Regional Centre appropriate to the local context and future growth potential;

b) delineate the boundaries of Rural Regional Centres;

c) enable balanced population and employment growth, through measures which may include developing a long-term job to population ratio for each Rural Regional Centre;

d) include an appropriate mix of uses including commercial, retail, residential, office, institutional, entertainment, public service facilities and other community and recreational uses such as parks, museums and places of worship; and

e) include appropriate development and built form policies to guide context appropriate forms of development and intensification, which may include building heights, setbacks, building orientation or other measures that support compact and pedestrian-oriented design, both along and surrounding main street locations, while protecting cultural heritage resources and heritage character including facades and streetscape features, and providing appropriate transitions and connections to surrounding neighbourhoods.

5.3.4 Allow refinements or adjustments to the boundaries of Rural Regional Centres without amendment to this Plan.

Regional Corridors

It is the policy of Council to:

5.3.5 Identify Regional Corridors as an overlay on Map 1.

5.3.6 Recognize Regional Corridors generally as appropriate locations for higher density, mixed-use development.

5.3.7 Encourage built form along Regional Corridors to be multi-storey, compact, pedestrian-friendly and transit supportive, and apply the relevant transit-oriented development design principles, in accordance with Policy 8.1.4.

5.3.8 Permit uses within Regional Corridors in accordance with the underlying Community Areas or Employment Areas designation of this Plan. For greater certainty, the identification of lands as a Regional Corridor overlay does not permit residential or other sensitive land uses contrary to Section 5.5 where the underlying designation is Employment Areas. Regional Corridors with an underlying Employment Areas designation are considered appropriate locations for higher density employment generating uses.

5.3.9 Recognize that portions of Regional Corridors may be constrained by existing development and may not be appropriate for redevelopment within the timeframe of this Plan.

5.3.10 Encourage area municipalities to establish transit supportive density targets along Regional Corridors and where appropriate designate key development areas that represent prime opportunities for development, redevelopment and intensification.

Waterfront Places

Waterfront Places include lands surrounding Frenchman's Bay, the Whitby Harbour, the Oshawa Harbour, Port Darlington and the Port of Newcastle.

It is the policy of Council to:

5.3.11 Designate Waterfront Places on Map 1.

5.3.12 Ensure that Waterfront Places prioritize public access to waterfront-based amenities, including the water, parks and waterfront trails.

5.3.13 Support the planning and development of Waterfront Places as locations for context-appropriate forms of intensification which may support higher densities and which may include a mix of residential and commercial uses, marinas, recreational uses, tourist establishments and destinations, cultural and public service facilities.

Local Centres & Corridors

It is the policy of Council to:

5.3.14 Encourage area municipalities to designate Local Centres and Local Corridors, situated within the Community Areas designation within their respective official plans.

5.3.15 Promote Local Centres as locations for higher density residential uses, concentrations of commercial and retail uses, and public service uses and other community-based uses and amenities, at scale suitable to their surrounding communities.

5.3.16 Encourage Local Centres and Corridors to be planned and developed at an appropriate transit supportive density.

5.3.17 Support uses within Local Corridors in accordance with the underlying Community Areas or Employment Areas designation of this Plan. For greater certainty, the designation of lands as a Local Corridor does not permit residential or sensitive land uses contrary to Section 5.5 where the underlying designation is Employment Areas.

5.4 Community Areas

Community Areas are intended to offer a complete living environment for Durham's residents. They are comprised of housing, commercial uses such as retail shopping and personal service uses, offices, institutional uses, community uses, and public service facilities such as schools, libraries and hospitals, as well as an array of cultural and recreational uses.

Objective:

i. **Ensure Community Areas develop as complete communities, providing a range of housing, transportation and lifestyle choices, and creating opportunities for residents to live, shop, work and access services and amenities within their community.**

Policies:

It is the policy of Council to:

5.4.1 Designate Community Areas on Map 1.

5.4.2 Plan Community Areas for a variety of housing types, sizes and tenures within connected neighbourhoods that include population-serving uses such as commercial, retail (including major retail), personal service uses, home businesses, recreational uses, public service facilities, institutional uses and office uses, provided such uses are appropriately located and compatible with their surroundings.

5.4.3 Permit major retail uses in Community Areas, subject to the inclusion of appropriate provisions and designations in the respective area municipal official plan.

5.4.4 Recognize existing Employment Area uses, provided such uses are not obnoxious in nature, appropriate provisions are included in area municipal official plans to provide for an appropriate transition and the requirements of Policies 5.5.22 to 5.5.36 have been addressed.

Designated Greenfield Areas

It is the policy of Council to:

5.4.5 Identify and plan for designated greenfield areas which includes lands within Community Areas, certain Strategic Growth Areas and other nodes and corridors that are outside of the delineated built-up area on Map 1.

5.4.5.1 Development within the designated greenfield area shall be planned to achieve a minimum density target of not less than 53 people and jobs per hectare.

5.4.6 Support the implementation of complete communities by encouraging the achievement of more compact and higher density forms of development beyond the minimum designated greenfield areas density target prescribed under the Growth Plan.

5.4.7 Measure designated greenfield area densities following a methodology that excludes the following features:

a) natural heritage features and areas, natural heritage systems, floodplains and active erosion zones, provided development is prohibited in these areas;

b) rights-of-way for:

i) electricity transmission systems;

ii) energy transmission pipelines;

iii) freeways (400 series highways), as defined by and mapped as part of the Ontario Road Network;

iv) railways;

c) Employment Areas; and

d) cemeteries.

5.4.8 Require large-scale development in designated greenfield areas to be informed by a subwatershed plan or equivalent prior to draft approval of any proposed plans of subdivision or condominium.

Development, Secondary Plans & Phasing

It is the policy of Council to:

5.4.9 Require development within Community Areas on lands that are greater than approximately 20 hectares to proceed through secondary planning exercises that include the following elements:

a) a mix of diverse and compatible land uses and a full range of housing options, including additional residential units and affordable housing, to support complete communities, vibrant neighbourhoods, active transportation and transit use;

b) the implementation of the applicable watershed plan policies, in accordance with Section 7.3. For areas where a watershed plan has not been developed, Policy 7.3.2 shall apply;

c) the implementation of appropriate stormwater management techniques to ensure that the risks of downstream flooding are addressed;

d) the principles of sequential, orderly and phased development;

e) the availability, feasibility and timing of providing full municipal water supply and sanitary sewerage services, in accordance with Section 4.1;

f) an assessment of how development will affect the natural, built and cultural environments, including:

i) where new growth is adjacent to existing Rural Settlements, how new development is planned in a manner that is sensitive to the character of existing Rural Settlements;

ii) where there are existing Major Open Space designations or components of the regional natural heritage system in the secondary plan area, they shall be subject to an environmental study to determine the extent of lands that may be considered for development, and subject to an appropriate designation in an area municipal official plan;

g) transportation needs for all modes, including increased opportunities for active transportation and public transit use;

h) the growth management objectives, policies and targets of this Plan, including any area specific density targets;

i) an assessment of the area municipal services and facilities required to support the development of the area, including whether they are within the financial capability of the area municipality over the full life cycle;

j) an assessment of the potential for land use conflicts between existing agricultural uses and new Urban System uses, and the potential means to alleviate such conflicts;

k) an assessment of key natural heritage features and/or key hydrologic features within the secondary plan area, as well as connections between and among key natural heritage features and/or key hydrologic features, and the water resource system to inform appropriate development within that area;

l) land use compatibility, including the requirements of Policies 5.5.22 to 5.5.36; and

m) additional requirements apply to lands within the 2051 Urban Expansion Areas, as outlined in Section 5.7.

5.4.10 Encourage the planning of large areas in a holistic manner through a single secondary plan or through the coordination and consolidation of adjacent secondary plan areas.

5.4.11 Discourage fragmentation of land through severance in future growth areas prior to the completion of secondary plans.

5.4.12 Require, where appropriate the coordination of development applications through measures such as Master Development Agreements or other similar approaches, to ensure an orderly, coordinated and phased approach to the provision of transportation, servicing and other infrastructure are provided prior to or coincident with development.

5.4.13 Require, where deemed appropriate by the Region and area municipalities, cost-sharing agreements, front-ending agreements or other measures as appropriate to ensure the timely delivery of infrastructure and the equitable distribution of development and infrastructure costs.

5.4.14 Monitor the progress of development within secondary plan areas to inform decisions on future servicing of adjacent secondary plan areas.

5.4.15 Require any review and updates to an existing approved secondary plan to consider and implement to the extent possible the policies and intensification and density targets of this Plan.

5.4.16 Implement detailed phasing policies through future infrastructure master plans which optimize investment, taking into consideration the policies of this Plan, and set out implementation strategies to deliver the necessary infrastructure and public service facilities provided by the Region.

5.5 Employment Areas, Land Use Compatibility & Major Facilities

Employment Areas are typically situated along or near major transportation corridors with separation and buffering from adjacent Community Areas. This provides for attractive and suitable locations for uses such as manufacturing, warehousing, storage, assembly and processing. Industrial forms of development are directed to locate within designated Employment Areas.

Employment Areas will play a vital role in accommodating future job growth in Durham.

Objectives:

i. Ensure an adequate supply of vacant serviced land, offering a variety of parcel sizes and locations, within designated Employment Areas.

ii. Promote the maximization of employment potential, including the achievement of higher employment densities and intensification of underutilized sites within designated Employment Areas.

iii. Ensure the long-term stability of Employment Areas through protection from encroachment by sensitive or incompatible land uses.

Policies:

It is the policy of Council to:

5.5.1 Designate Employment Areas on Map 1.

5.5.2 Plan Employment Areas as locations for primary employment generating uses such as manufacturing, assembly, processing, generation, freight and transportation, warehousing, storage, major facilities and similar uses that require access to highway, rail, shipping facilities and/or separation from sensitive land uses. Hotels, subject to land use compatibility, service industries, and limited supportive uses including associated retail and ancillary facilities may also be permitted.

5.5.3 Protect and preserve designated Employment Areas located adjacent to or near the strategic goods movement network, including major highway interchanges, for manufacturing, warehousing, logistics and associated uses and ancillary facilities. Limited service industries and limited supportive uses, including associated retail and ancillary facilities may be permitted in these locations.

5.5.4 Recognize Employment Areas as preferred locations for knowledge-based industries including research and development facilities and offices.

5.5.5 Encourage the achievement of more compact and higher density forms of employment development while recognizing that the total Employment Area land supply has been established on the basis of achieving a long-term, overall region-wide density target within Employment Areas of 28 jobs per gross hectare. Area municipalities are encouraged to determine appropriate density targets for Employment Areas within their respective area municipal official plans reflective of local context and conditions.

5.5.6 Encourage increased employment densities including through the intensification and redevelopment of existing developed Employment Area sites with specific emphasis on high exposure locations that also offer convenient access to transit and transportation options.

5.5.7 Monitor the supply and servicing status of designated Employment Areas on a regular basis, in accordance with Policy 2.1.8. The Region may undertake studies, strategies and infrastructure projects to advance the provision of municipal water and sewage services to Employment Areas to ensure a sufficient supply of vacant and serviced employment land of varying parcel sizes and locations is maintained and available for development.

5.5.8 Encourage higher density employment generating uses, such as office buildings and other prestige employment uses, to locate in high exposure locations that also offer convenient access to transit and transportation options.

5.5.9 Encourage major office uses within Employment Areas where they cannot be accommodated within Strategic Growth Areas. Support major office as part of integrated campus development where manufacturing, warehousing and/or research and development uses are provided.

5.5.10 Prohibit uses declared to be obnoxious under the provisions of any applicable statutes, regulations or guidelines from locating within Employment Areas.

5.5.11 Only consider of the conversion of lands within Employment Areas designated on Map 1 to non-employment uses through a municipal comprehensive review.

5.5.12 Not permit major retail uses in Employment Areas, except where currently designated as a permitted use in an area municipal official plan as of June 3, 2009.

5.5.13 Require the development of major retail uses or major office uses to avoid, or where avoidance is not possible, minimize and mitigate adverse impacts on employment area uses.

5.5.14 Encourage the province of Ontario to provide policy guidance, contribute to infrastructure and support the long-term viability of Provincially Significant Employment Zones.

5.5.15 Designate Rural Employment Areas on Map 1. Development within Rural Employment Areas shall be in accordance with Policies 6.5.20 to 6.5.22.

5.5.16 Require development taking place within Employment Areas to address the policies of this Plan and the following:

a) incorporate compact and urban forms of employment development where possible;

b) locate buildings in a manner that would enable future additions and the further intensification of employment sites over the long-term;

c) minimizing surface parking and other impervious surfaces where feasible;

d) incorporate attractive and high-quality architecture, urban design and landscaping standards, particularly in high exposure locations;

e) protect the long-term stability of Employment Areas by limiting non-employment uses and instituting land use compatibility measures. The use of landscaping and natural buffers between Employment Area uses and adjacent uses is encouraged;

f) apply the principles of sequential development and phasing where appropriate through secondary planning or equivalent, in accordance with Policies 5.4.9 to 5.4.16;

g) maximizing opportunities for walkability and the use of active transportation modes; and

h) incorporate measures to encourage green and sustainable building practices including energy efficient building techniques including energy efficient building techniques, low impact development, renewable energy, and bird-friendly design, in accordance with Policies 3.2.9 to 3.2.11.

5.5.17 Require, in addition to Policy 5.5.16, the development of Employment Area lands within the 2051 Settlement Area Boundary Expansion Area shown on Map 1 to occur in accordance with the relevant policies of Section 5.7.

5.5.18 Require area municipalities to implement the Employment Area policies of this Plan through their official plans, including density targets, phasing of larger employment parcels and areas, urban design guidelines, landscaping requirements and protection from non-employment uses.

Employment Supportive & Accessory Uses

It is the policy of Council to:

5.5.19 Permit uses that are integrated with and accessory to Employment Area uses, including but not limited to showrooms and retail sales associated with manufacturing, warehousing uses and other similar uses, subject to inclusion of appropriate provisions in the area municipal official plan and/or zoning by-law. Accessory uses shall not exceed 10% of the gross floor area of the primary employment use, to a maximum of 2,000 square metres.

5.5.20 Permit, on a limited basis, employment supportive uses that complement and serve the overall function of the Employment Area including but not limited to restaurants, personal service and retail uses. Such uses shall be limited in size and scale in area municipal official plans and zoning by-laws to ensure as an aggregate they only form a minor component of the overall Employment Area (e.g. 10% of the gross floor area), with individual uses not exceeding 500 square metres. Nothing in this policy shall prevent area municipal official plans from further limiting the size of employment supportive uses or limiting such uses to appropriate locations within the broader Employment Area.

5.5.21 Permit, notwithstanding Policy 5.5.20, employment supportive uses that complement and serve the overall function of the Employment Area up to a maximum of 2,000 square metres by amendment to an area municipal plan and zoning by-law, subject to the following conditions being met:

a) the aggregate of employment supportive uses only forms a minor component of the overall Employment Area (e.g. 10% of the gross floor area);

b) the use primarily serves and supports employment uses within the broader Employment Area;

c) the use will not have an adverse effect on the stability of the broader Employment Area;

d) the use does not introduce land use compatibility issues and meets the requirements of Policies 5.5.22 to 5.5.32; and

e) the use has been appropriately located within the Employment Area. Appropriate locations are those located outside of core Employment Areas characterized by manufacturing, logistics, warehousing, processing uses and other similar uses, and may include major intersections or along collector and arterial roads, along Regional Corridors, entrances/gateways and transition areas between Employment Areas and non-employment designations.

Land Use Compatibility & Sensitive Land Uses within Employment Areas

It is the policy of Council to:

5.5.22 Ensure land use compatibility between Employment Areas and major facilities, and non-employment uses and sensitive land uses.

5.5.23 Protect Employment Areas from encroachment by non-employment uses and sensitive land uses.

5.5.24 Direct major facilities and other uses that generate emissions such as odour, dust, vibration and/or noise to locations that are well removed and buffered from sensitive receptors such as residential areas and other sensitive land uses.

5.5.25 Direct area municipalities to consider appropriate land use permissions and policies in their respective official plans to provide for transition and an appropriate interface between Employment Areas and the other designations of this Plan.

5.5.26 Prohibit residential uses, long-term care and retirement homes, elementary and secondary schools from locating within Employment Areas. This policy does not limit or prevent area municipal official plans and zoning by-laws from prohibiting additional sensitive land uses from locating within Employment Areas, as deemed appropriate for the local context.

5.5.27 Encourage all other sensitive land uses to locate outside of Employment Areas. A sensitive land use, other than those described in Policy 5.5.26, may be permitted within an Employment Area by an amendment to an area municipal official plan or zoning by-law, where it has been demonstrated that land use compatibility can be achieved and any detrimental impact to the broader area and nearby employment uses and/or major facilities will be avoided, or where avoidance is not possible, minimized and mitigated. Area municipalities, when applying this policy, are encouraged to:

a) limit sensitive land uses to locations at the edge of the broader Employment Area;

b) not permit sensitive land uses within Provincially Significant Employment Zones or other areas considered interior to the broader Employment Area;

c) limit sensitive land uses in Employment Areas that are within proximity to Nuclear Generating Stations and Airports, in accordance with Policies 5.5.33 to 5.5.35; and

d) limit the size and scale of sensitive land uses.

5.5.28 Require supporting studies that evaluate all provincial guidelines and standards, as described in Table 1, as part of a complete application where there is the potential for land use compatibility issues. This includes applications which would:

a) introduce a sensitive land use within proximity to Employment Areas and/or major facilities; or

b) introduce new or expanded employment uses and/or major facilities within proximity to existing sensitive land uses and/or lands designated for such purposes.

Major Facilities

It is the policy of Council to:

5.5.29 Identify certain major facilities on Map 1 which are generally large, land intensive operations of a regional scale. This includes the Pickering and Darlington Nuclear Generating Stations, the Durham York Energy Centre and future Anaerobic Digestion Facility, the regionally-owned Water Pollution Control Plants and Sewage Lagoons, the Oshawa Executive Airport, the federal lands reserved for a potential future airport in Pickering, pipeline and hydro corridors, and rail lines. Other major facilities are located throughout the regional structure, although not specifically identified on Map 1.

5.5.30 Encourage the protection of the lands in proximity of current and/or future planned major facilities by ensuring the compatibility of adjacent land uses, including the requirements of Policies 5.5.32 to 5.5.36. Should such lands no longer be required for major facilities, additional uses may be permitted as a result of a planning study that considers the site context and condition, surrounding area, and land use compatibility.

5.5.31 Adhere to minimum separation distances and setbacks associated with oil and gas pipelines, rail corridors, and hydro corridors. Fulfill this obligation by requiring regional and area municipal development review processes to include the circulation of applications to the owners of such infrastructure in a manner that meets or exceeds the requirements of provincial regulations.

5.5.32 Encourage the development of Employment Areas adjacent to major facilities for uses and industries that benefit and create synergies.

5.5.33 Implement the obligations of a nuclear host community by appropriately limiting sensitive land uses within proximity to nuclear facilities and by engaging with the provincial and federal regulating bodies in the planning and regulatory process for any new or expanding nuclear generating facilities, fuel storage sites, the decommission of existing facilities and sites, or any other related or similar activities.

In 2021 Council approved **Empowering the Community: Durham's Nuclear Sector Strategy 2022-2032**. This is an inter-departmental plan that aims to:

- grow the understanding of the nuclear sector among Regional Council, staff, and the community;
- build prosperity by maximizing the benefits of being a nuclear host community and Canada's premier centre of the nuclear industry and innovation;
- protect and sustain the community by addressing the impacts and opportunities of being a nuclear host community; and
- lead and develop partnerships within the nuclear sector to build leadership capacity and influence decision-making.

It is the policy of Council to:

5.5.34 Work with area municipalities to protect the Automatic Action Zones, as defined in the Provincial Nuclear Response Plans for the Darlington and Pickering Nuclear Generating stations, from encroachment by sensitive land uses to the greatest extent possible, as follows:

a) the Automatic Action Zone for Darlington Nuclear Generation Station includes all lands that are between Courtice Road and Martin Road, from the Lake Ontario shoreline to Darlington Baseline Road. New sensitive land uses are not permitted, unless already designated as a permitted use by the Clarington Official Plan as approved by the Region on June 19, 2017;

b) the Automatic Action Zone for the Pickering Nuclear Generation Station includes lands between Whites Road and Duffins Creek, from the Lake Ontario shoreline to Highway 401. This includes extensive existing residential areas. New development which proposes a sensitive land use within this area are required to minimize and mitigate potential adverse impacts; and

c) any development proposal for a sensitive land use within an Automatic Action Zone, where permitted, shall be supported by a study which considers all regional and provincial planning requirements, land use compatibility, including any applicable guidelines and emergency planning measures.

Automatic Action Zones are pre-designated areas that are identified in the Pickering and Darlington Provincial Nuclear Emergency Response Plans. Further details can be found in those documents.

Figure 12. – Automatic Action Zones for the Pickering & Darlington Nuclear Generation Stations:



Pickering Sector	Automatic Action Zone* – Sector Boundary
P1	Highway 401; Liverpool Road; Lake Ontario; Whites Road/RR38
P2	Highway 401; Duffin's Creek; Lake Ontario; Liverpool Road
P23	Lake Ontario

*Automatic Action Zone (AAC) = 0–3 kilometres from the Nuclear Generating Station (NGS)



Darlington Sector	Automatic Action Zone* – Sector Boundary
D1	Baseline Road; Bowmanville Ave; Lake Ontario; Courtice Road
D14	Lake Ontario

*Automatic Action Zone (AAC) = 0–3 kilometres from the Nuclear Generating Station (NGS)

It is the policy of Council to:

5.5.35 Work with the Cities of Oshawa and Pickering to protect the Oshawa Executive Airport and the potential for a future airport on the federal lands in Pickering as shown on Map 1 from incompatible uses by:

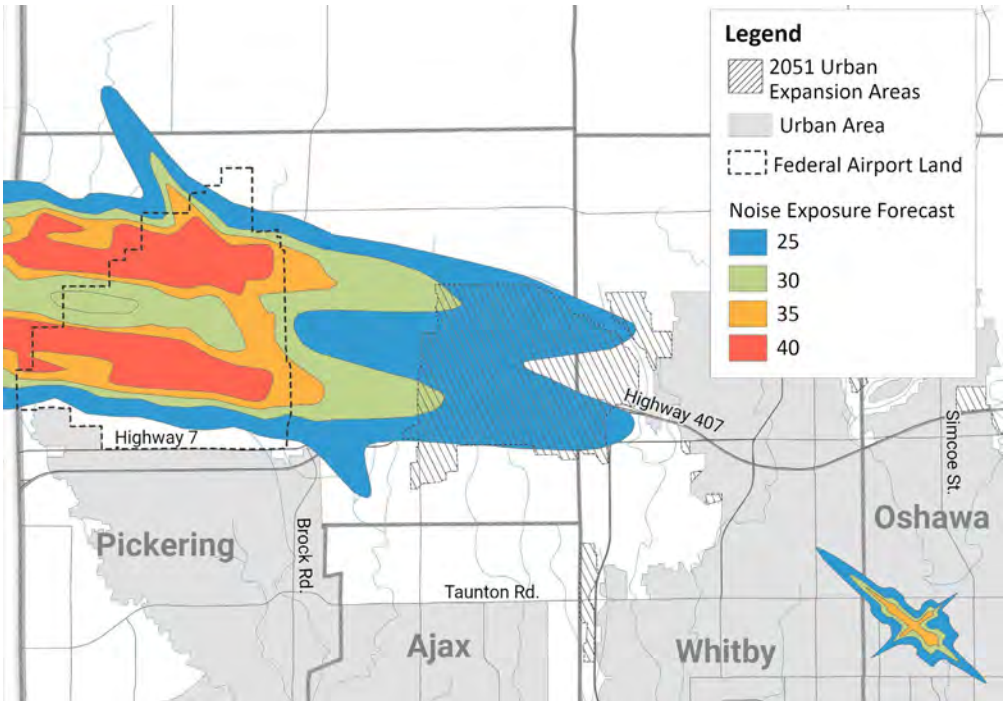
a) prohibiting residential and sensitive land uses on lands that are within or above the 30 Noise Exposure Forecast/Noise Exposure Projection Contours as shown in Figure 13;

b) only allowing the redevelopment of existing residential uses and other sensitive land uses within or above the 30 Noise Exposure Forecast/Noise Exposure Projection Contour as shown in Figure 13 if it has been determined there will be no negative impact on the long-term function of the affected airport;

c) discouraging any land use which may cause a potential aviation safety hazard; and

d) recognizing that Federal Airport Site Orders and Federal Airport Zoning Regulations restrict building heights in proximity to existing and future airports and that existing provincial Minister's Zoning Orders restrict any development in proximity to the potential future airport in Pickering. Development within these regulated areas are required to demonstrate compliance with any applicable federal and provincial regulations and may be dependent on the future actions identified in Policy 5.5.36.

Figure 13. – Map of the 30 Noise Exposure Forecast/Noise Exposure Projection Contour:



It is the policy of Council to:

5.5.36 Request the federal and provincial governments to undertake updates to the regulations and documents that apply to the federal lands in Pickering to reflect the current land area and planned runway configurations for the potential future airport, as follows:

a) completing the proposed updates to the Pickering Airport Site Order and Pickering Airport Zoning Regulations to reflect the revised/ reduced federal lands in Pickering and provide detailed mapping related to any applicable building height restrictions;

b) undertaking updated Noise Contour Mapping to reflect the revised/reduced federal lands in Pickering and updated potential airport configuration and flight paths;

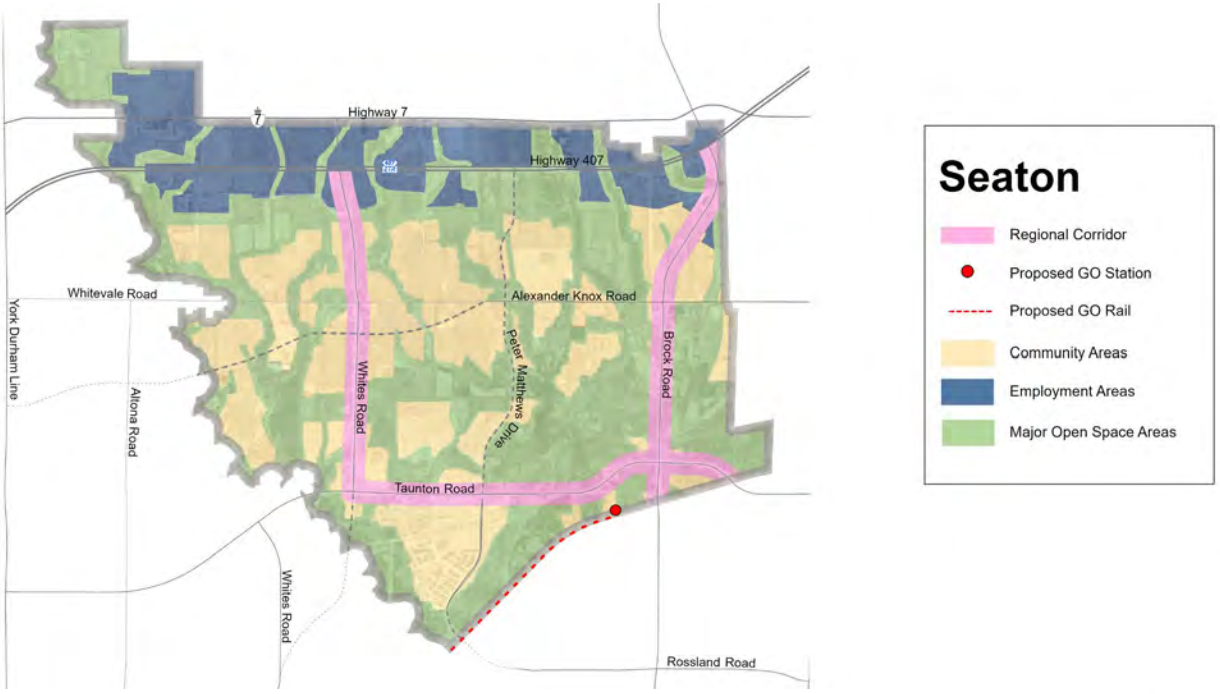
c) based on the results of a) and b), undertaking updates to the existing Minister's Zoning Orders to reflect the revised/reduced federal lands in Pickering and updated Noise Contour Mapping; and

d) in consultation with the Region of Durham, City of Pickering, Indigenous communities and other affected stakeholders, undertake the preparation of an airport master plan.

5.6 Seaton Community

Lands located to the east of the West Duffins Creek that are within the Urban Area Boundary and north of the Canadian Pacific Rail line comprise the Seaton community, which are planned to develop as an urban community surrounded by a protected natural heritage system. The Policies in this section apply to the Seaton Urban Area.

Figure 14. – Map of Seaton (Pickering):



Objective:

i. **Support and enable development within Seaton in accordance with the vision of the former Central Pickering Development Plan as a sustainable urban community.**

Policies:

It is the policy of Council to:

5.6.1 Recognize that the lands within the Seaton Urban Area are to be developed in accordance with the City of Pickering Official Plan and associated neighbourhood plans.

5.6.2 Identify the limits of the Seaton Community on Map 1.

5.6.3 Plan and implement servicing and infrastructure arrangements for the Seaton Urban Area based on a population of 61,000 people and 30,500 jobs, and with the potential for up to 70,000 residents and 35,000 through intensification over the long-term.

5.7 2051 Urban Expansion Areas & Future Expansions

Settlement Area Boundary Expansions represent increases to the amount of land within the Urban System for the purposes of facilitating new development.

Lands within the 2051 Urban Expansion Area were added to the Urban Boundary through latest Regional municipal comprehensive review in 2023 and are subject to a specific set of policies to guide their further detailed planning and implementation at the area municipal level.

Objectives:

i. **Ensure the land need and the most appropriate locations for potential Settlement Area Boundary Expansion.**

ii. **Ensure that future decisions on land use, densities, development standards, impacts, infrastructure, servicing and financing requirements are informed through comprehensive study, consultation and evaluation.**

Policies:

It is the policy of Council to:

5.7.1 Identify on Map 1 lands within the 2051 Urban Expansion Areas.

5.7.2 Require area municipalities to update their official plans to designate land for development up to the time frame of this Plan, including Settlement Area Boundary Expansions to the extent of the Region's Urban Area Boundary as shown on Map 1, provided that the amendment:

a) is only undertaken as part of a comprehensive review of the area municipal official plan to implement this Plan;

b) is supported by an analysis which addresses how the growth management objectives, population and employment forecasts, housing unit allocation, policies and targets of this Plan are being achieved;

c) includes a phasing strategy for greenfield areas and intensification areas and Regional phasing approaches in accordance with any regional water and sanitary sewage master plans;

d) takes into consideration the implementation of a watershed plan. The area municipality shall consult with the Region and appropriate conservation authority to determine if any updates are required to an existing watershed plan;

e) ensures where possible, that expansions to area municipal Urban Area Boundaries are contiguous to existing Urban Areas and do not extend beyond the Urban Area Boundary included on Map 1 to this Plan; and

f) takes into consideration the extent of existing Major Open Space designation and Natural Heritage System, in accordance with Section 7.1, to determine the extent of lands that may be considered for development and be designated accordingly.

5.7.3 Require and support detailed planning by the area municipalities for lands within the 2051 Urban Expansion Areas, primarily through the preparation of secondary plans that meets and goes beyond the requirements of Policies 5.4.9 to 5.4.16, and includes the following:

a) confirmation of the availability of existing or planned infrastructure and public service facilities, as informed by a regional water supply and sanitary sewage master plan and transportation master plan, or equivalent;

b) preparation of a Fiscal Impact Study and other servicing plans and background studies that demonstrate how orderly and sequential development will be implemented, and how the provision of Regional infrastructure and municipal services will be financially viable over their full life cycle and within the financial capacity of the Region and the area municipality;

c) preparation of a master environmental servicing plan which demonstrates the planned development and proposed servicing extensions will avoid, or where avoidance is not possible, minimize and mitigate any potential impacts on watershed conditions and the water resource system, including water quality and quantity, erosion and water balance;

d) preparation of a subwatershed plan or equivalent;

e) preparation of a stormwater master plan or equivalent;

f) studies which identify how the natural heritage system and water resource system, including key hydrologic areas, will be protected, restored and enhanced in an urban context, and how enhanced natural heritage systems and natural coverage targets identified in this Plan or the applicable watershed plan(s) will be implemented;

g) preparation of an agricultural impact assessment to assess the ability of development to avoid and/or minimize impacts on the agri-food network and surrounding agricultural areas. For further clarity, existing agricultural uses and livestock facilities within and adjacent to the 2051 Urban Expansion Areas shall be protected, and urban development shall be limited until such time that agricultural impacts can be managed and compliance with provincial Minimum Distance Separation formulae can be demonstrated;

h) delineation of appropriate boundaries, implementation of appropriate transit supportive density targets, and preparation of detailed land use policies for conceptually designated Regional Centres and Regional Corridors;

i) delineation of appropriate boundaries for regional Major Open Space Areas;

j) designation of Local Centres and Local Corridors as locations for higher density mixed-use hubs for residential, commercial and retail activity, employment generating uses and public service facilities for the broader area;

k) implementation of community energy plans, including renewable and alternative energy systems and considerations for how new communities may achieve net-zero and/or net-zero ready energy performance; and

l) be supported by a climate change mitigation and adaptation plan which considers, among other matters, climate change vulnerability.

5.7.4 Permit, notwithstanding Policy 5.7.3, the planning and development of lands within the 2051 Urban Expansion Areas located wholly within the Greenbelt Plan Boundary to proceed in the absence of a secondary plan, provided the relevant provisions of Policy 5.7.3 have been met

5.7.5 Limit residential development to a maximum of 50% (5 hectares) of land identified within the Port Perry 2051 Urban Expansion Area.

5.7.6 Ensure that the 2051 Urban Expansion Areas shown on Map 1 do not create new natural hazards or aggravate existing natural hazards through any new development within the Urban Expansion Areas.

5.7.7 Apply the following additional requirements as part of a secondary plan process and subwatershed study for lands located within the Pickering, Whitby, Oshawa and Clarington 2051 Urban Expansion Areas:

a) the preparation of a hydrologic and hydraulic assessment;

b) delineate and assess natural hazards to determine how they will be mitigated (i.e. the risk of flooding and erosion will not increase) which could include the application of regional flood control and/or downstream infrastructure improvements;

c) identify how the Natural Heritage System and Water Resource System will be protected, enhanced, and restored;

d) identify how water quality and quantity will be protected, including demonstrating how stormwater quality and quantity, and extended detention/erosion control measures will be achieved; and

e) determine how flood mitigation solutions, where required, will be funded, including identification of the responsible parties for providing the funding, completion of associated cost sharing agreements, and timing for implementation. This includes the cost of any necessary studies, engineering design, and actual construction and maintenance of flood mitigation works.

5.7.8 Apply, in addition to Policy 5.7.7, the following additional requirements as part of a secondary plan process and subwatershed study for lands located within the Pickering 2051 Urban Expansion Area:

a) prior to the approval of a secondary plan, ensure that all other applicable policies of the Carruthers Creek Watershed Plan have been addressed, including those directed to area municipalities related to existing and future natural hazards/downstream water flows; and

b) assess the impacts of existing Minister's Zoning Orders and Airport Site Order and Zoning Regulations which currently restricts the development of these lands as a result of the potential for a future airport to the west. Development shall not proceed until such time it has been demonstrated that the relevant requirements, including those related to noise and building height restrictions have been met. Satisfying the requirements of this policy may be dependent on future actions first being undertaken by provincial and federal levels of government, as described in Policy 5.5.36.

5.7.9 Require the actions described in Policies 5.7.7 and 5.7.8 a) for lands within the Pickering 2051 Urban Expansion Area to include consultation between the City of Pickering, Town of Ajax, Toronto and Region Conservation Authority, Indigenous communities and Region of Durham.

5.7.10 Only support further Settlement Area Boundary Expansions beyond those shown on Map 1 through a municipal comprehensive review.

5.7.11 Consider, at the time of a municipal comprehensive review, the following as part of any proposed Settlement Area Boundary Expansion:

a) that the required studies and considerations detailed in A Place to Grow: Growth Plan for the Greater Golden Horseshoe, and any other applicable provincial policy including the Provincial Policy Statement, the Greenbelt Plan, the Oak Ridges Moraine Conservation Plan, Lake Simcoe Protection Plan, and any applicable Source Protection Plan(s), have been satisfied;

b) it has been demonstrated, through a land need assessment or similar comprehensive analysis, that there is not sufficient existing Urban Area land to accommodate growth, and there is a need for the Urban Area Boundary expansion;

c) existing and/or planned infrastructure are feasible and the financial capacity of the Region to provide any additional regional services that may be required has been confirmed;

d) the logical, contiguous and orderly expansion to existing Urban Areas;

e) the policies and requirements of applicable Watershed Plans;

f) within any wellhead protection area – Quantity 1/Quantity 2, the requirements of Policy 7.5.42 are satisfied; and

g) any other matters deemed necessary by Council at the time of a municipal comprehensive review.





Chapter 6

Thriving Rural System

Chapter 6. Thriving Rural System

The Rural System comprises the majority of the region's land base and is home to approximately 8% of Durham's population (54,000 residents). With over 12,000 hectares of Durham in production, agriculture is one of the largest primary goods producing sectors within the region.

The land use designations that make up the Rural System are:

- Prime Agricultural Areas;
- Rural Settlements;
- Regional Nodes; and
- Aggregate Resource Extraction Areas.

Durham's Rural System is located outside of settlement areas. While agriculture is the dominant land use, the Rural System also houses a small rural population, aggregate extraction, cemeteries, large and small businesses, recreational uses and a robust system of major open space and natural heritage areas.

The Region's thriving Rural System is supported through collaboration with a range of stakeholders, including Durham's area municipalities, the Ontario Ministry of Agriculture, Food and Rural Affairs, the Ontario Ministry of North Development, Mines, Natural Resources and Forestry, the agricultural community, the public and other key stakeholders, who together support and implement various policy directions tailored to the Durham context.

Goals:

I. **Support a vibrant rural and productive agricultural economy.**

II. **Support a thriving Rural System that supports rural businesses including agriculture, aggregate extraction and tourism.**

III. **Support the health and vitality of existing Rural Settlements which serve the needs of rural residents and area businesses.**

IV. **Support a sustainable, diversified, and productive Agricultural System.**

V. **Champion the wise-use and management of resources.**

VI. Encourage land stewardship to enhance natural heritage, protect drinking water and support climate resiliency.

6.1 Agricultural System

The Agricultural System is intended to protect farmland in the region and provide support for the viability of the agri-food industry. The system consists of Prime Agricultural Areas, Major Open Space areas and the agri-food network.

The agri-food network is a component of the Agricultural System that complements and supports the agricultural land base. The agri-food network includes the infrastructure, services and other agri-food assets that are needed to sustain and enhance agriculture and the prosperity and viability of the broader agri-food sector.

Objective:

i. Establish a continuous Agricultural System through a protected and productive land base across the region.

Policies:

It is the policy of Council to:

6.1.1 Support the agricultural industry by implementing Regional agri-food strategies and action plans, as well as other approaches to sustain and enhance the viability of the Agricultural System.

6.1.2 Promote the protection of agricultural resources, to minimize land use conflicts, to provide opportunities to support local food, and to maintain and improve the agri-food network.

6.1.3 Promote the protection of the agri-food network by discouraging further fragmentation and loss of the agricultural land base caused by lot creation.

6.1.4 Support a healthy and productive agricultural industry as an important element to the Region's heritage, identity and its economic base.

6.2 Prime Agricultural Areas

Agriculture and the agri-food industry in Durham are a vital and productive economic engine and one of the largest primary goods manufacturing sectors in the region. Prime Agricultural Areas are a finite, non-renewable resource that form the foundation for agricultural production and the agri-food industry.

Prime Agricultural Areas are lands where current agricultural operations and future potential operations are located. These lands are classified based on the Canada Land Inventory Classes 1 to 3 lands as well as agricultural areas with organic soils. They also include areas of lesser agricultural significance and additional areas where there is a local concentration of farms which exhibit characteristics of ongoing agriculture.

Objectives:

i. **Support agriculture as the predominant land use within the Prime Agricultural Areas designation and enhance the long-term viability and productivity of agriculture for future generations.**

ii. **Ensure communities are more resilient to the impacts of a changing climate by protecting agricultural lands.**

Policies:

It is the policy of Council to:

6.2.1 Designate Prime Agricultural Areas outside of the Oak Ridges Moraine on Map 1. Oak Ridges Moraine Prime Agricultural Areas are designated on Map 2b.

6.2.2 Support the protection of Prime Agricultural Areas by preventing further fragmentation and loss of the agricultural land base caused by lot creation and the redesignation of Prime Agricultural Areas.

6.2.3 Encourage the use of an Agricultural System approach to maintain and enhance the geographic continuity of the agricultural land base and the functional and economic connections to the agri-food network.

6.2.4 Avoid adverse impacts on the Agricultural System where non-agricultural land uses may encroach into Prime Agricultural Areas. If avoidance is not possible, such adverse impacts are required to be minimized or mitigated, based on provincial guidance. The mitigation measures should be incorporated into the area being developed.

6.2.5 Ensure that new land uses and lot creation in Prime Agricultural Areas, as permitted by the policies of this Plan, and new or expanding livestock facilities comply with the Provincial Minimum Distance Separation formulae, as amended by the province from time to time.

6.2.6 Protect Prime Agricultural Areas for long-term use for agriculture, as a significant element of the Region's economy and a secure source of food.

6.2.7 Promote all types, sizes and intensities of agricultural uses and normal farm practices in accordance with provincial standards.

6.2.8 Discourage the establishment of new non-agricultural uses in Prime Agricultural Areas. Non-agricultural uses may only be permitted in Prime Agricultural Areas, after the completion of an agricultural impact assessment, for:

a) infrastructure, the extraction of minerals, petroleum resources or mineral aggregate resources; or

b) limited non-residential uses, provided that all of the following are demonstrated:

i) the proposed use complies with the Minimum Distance Separation formulae;

ii) there is an identified need for additional land to accommodate the proposed use;

iii) alternative locations have been evaluated, and there are no reasonable alternative locations which avoid Prime Agricultural Areas;

iv) alternative locations have been evaluated, and there are no reasonable alternative locations in Prime Agricultural Areas with lower priority agricultural lands; and

c) notwithstanding Policy 6.2.8 b), within the Greenbelt Plan Area, uses are limited to those permitted by the applicable provincial plans.



6.3 Agriculture-related & On-farm Diversified Uses

Agriculture-related uses are farm-related commercial and industrial uses that add to the vitality and economic viability of Prime Agricultural Areas. Agriculture-related uses are directly related to and service farm operations in the area as a primary activity.

On-farm diversified uses are intended to enable farm operators to diversify and supplement their farm income, as well as to accommodate value-added and agri-tourism uses in Prime Agricultural Areas. Examples could include retail uses, value added processes, small scale micro-breweries or home occupations. Agri-tourism uses could include those farm-related tourism uses, including limited accommodation such as a bed and breakfast, that promote the enjoyment, education or activities related to the farm operation.

Agriculture-related and on-farm diversified uses within the Rural System help farm operators supplement on-farm income while balancing the need to preserve the agricultural land base.

Objectives:

i. **Promote opportunities to support a thriving agricultural industry and a diversified rural economy.**

ii. **Promote a full range of agriculture-related uses and on-farm diversified uses.**

Policies:

It is the policy of Council to:

6.3.1 Allow a range of proposed agriculture-related and on-farm diversified uses based on the criteria outlined in the Provincial Guidelines on Permitted Uses in Ontario's Prime Agricultural Areas.

6.3.2 Promote the protection of normal farm practices from proposed agriculture-related uses and on-farm diversified uses by requiring these uses to be compatible with and not hinder surrounding agricultural operations.

6.3.3 Encourage area municipalities to include the necessary measures in their respective official plans and zoning by-laws to support the establishment of agriculture-related uses and on-farm diversified uses.

6.3.4 Require any proposed agriculture-related use in a Prime Agricultural Area and Major Open Space Area to meet all of the following criteria:

a) be a farm-related commercial or a farm-related industrial use;

b) be compatible with, and must not hinder, surrounding agricultural operations which must be able to pursue their agricultural practices without impairment or inconvenience;

c) be appropriate to available rural service levels;

d) be directly related to farms in the area, primarily providing products or services that are associated with, required by or that enhance agricultural operations in the area;

e) support agriculture;

f) provide direct products and/or services to farm operations as a primary activity; and

g) benefit from being in close proximity to farm operations.

6.3.5 Require any proposed on-farm diversified use in a Prime Agricultural Area and Major Open Space Area to meet all of the following criteria:

a) located on a farm;

b) secondary to the principal agricultural use of the property;

c) limited in area, where the standard for an acceptable area occupied by a proposed on-farm diversified use is up to 2% of a farm parcel to a maximum of one hectare; and

d) compatible with, and must not hinder, surrounding agricultural operations.

6.4 Rural Lot Creation & Severances

Rural lot creation is a complex matter that requires a balance between the economic needs of the agricultural community and the preservation of viable agricultural land to ensure the viability of the Rural System, it is necessary to strike a balance between the needs of today's rural business and property owners, with the long-term goals for the land base.

Objectives:

i. Implement a policy framework that discourages the fragmentation of the agricultural land base.

ii. Promote the consolidation of agricultural parcels of land to support the creation of economically viability tracts of land that support agriculture in the region.

Policies:

It is the policy of Council to:

6.4.1 Allow the establishment of second dwellings to accommodate persons employed full-time on the farm, where the size and nature of the operation warrants additional employment.

6.4.2 Encourage area municipalities to adopt best practices from the Guidelines on Permitted Uses in Ontario's Prime Agricultural Areas regarding dwellings that accommodate persons employed full-time on the farm in their official plans and/or zoning by-laws. Refuse applications to sever such a dwelling, regardless of the date they were established.

6.4.3 Not allow for severances for agriculture-related and on-farm diversified uses.

6.4.4 Not support the creation of parcels of land for agricultural uses less than 40 hectares.

6.4.5 Encourage the consolidation of farms, wherever possible. Severance of a habitable farm dwelling rendered surplus as a result of consolidation of abutting farms may be granted, provided that:

a) the farms are merged into a single parcel;

b) the dwelling is not needed for a farm employee;

c) the dwelling was in existence in accordance with the date set out in the applicable provincial plan;

d) the retained farm parcel is zoned to prohibit any further severances and the establishment of any residential dwelling;

e) where a farm operation owns two or more abutting farm parcels, they are merged as a condition of approval;

f) the maximum size of the surplus dwelling lot shall be the size required for private servicing, minimizing to the extent possible, the lot area taken out of agricultural production; and

g) no further severances from the retained farm parcel shall be granted.

6.4.6 Require that, notwithstanding Policy 6.4.5, a severance of a farm dwelling rendered surplus as a result of a farmer acquiring a non-abutting farm may be granted, provided that:

a) the dwelling is not needed for a farm employee;

b) the farm parcel to be acquired is of a size which is viable for farming operations;

c) the dwelling was in existence in accordance with the date set out in the applicable provincial plan;

d) the farm parcel to be acquired is zoned to prohibit any further severances and the establishment of any residential dwelling;

e) the applicant is a bona-fide farmer, meaning the applicant is actively engaged in farming and derives income from farming; the farming income must be obtained from activities which are considered agricultural uses. Growing food for your family, or as a hobby, does not qualify as farming;

f) farm consolidation shall be a condition of approval;

g) the surplus dwelling was not originally constructed as an accessory farm dwelling;

h) the maximum size of the surplus dwelling lot shall be the size required for private servicing, minimizing to the extent possible, the lot area taken out of agricultural production;

i) the shape and dimensions of the surplus farm dwelling lot shall:

i) not impede agricultural operations on the retained land;

ii) generally not exceed a certain depth, i.e. 122 metres (400 feet); and

j) discourage further severances from the acquired farm parcel.

6.4.7 Support only one severance for each lot, subject to all other applicable requirements and policies. All consents granted on or after the approval of the first Durham Regional Official Plan (1978) should be included in the calculation of the cumulative total.

6.4.8 Not support severances for farm retirement or intra-family purposes.

6.4.9 Allow consents that do not result in the creation of a new lot, in the following cases:

a) the minor adjustment of lot lines for purposes such as easements;

b) rights-of-way;

c) correction to titles;

d) building or servicing encroachments on abutting lots; and

e) conveyances between existing lots of record.

6.5 Rural Settlements

Rural Settlements consist of existing Hamlets, Country Residential Subdivisions, Shoreline Residential Areas, Residential Clusters and Rural Employment Areas. Rural Settlements are the focus of modest growth within rural areas and support the viability of these areas. The vitality and regeneration of Rural Settlements is critical to the long-term economic prosperity of Durham's communities.

Objectives:

i. Support the rural character and cultural heritage of existing Rural Settlements while permitting limited growth through infilling.

ii. Promote the vitality and regeneration of Rural Settlements, considering rural characteristics, the scale of development and the provision of appropriate service levels.

iii. Ensure that development in Rural Settlements shall occur with careful consideration to the natural, built and cultural environments.

iv. **Promote existing Rural Settlements and support their function of providing for the limited residential, social and commercial needs for the surrounding area as part of a thriving Rural System.**

v. **Ensure growth and development within the Rural System is focused on Rural Settlements while protecting the viability of the rural area.**

vi. **Support healthy, integrated and viable rural areas by accommodating an appropriate range and mix of housing in Rural Settlements.**

Policies:

It is the policy of Council to:

6.5.1 Require that individual on-site sewage and water services can be used only where municipal sewage and water services or communal sewage and water services are not available, planned or feasible, and provided that site conditions are suitable for the long-term provision of such services with no negative impacts.

6.5.2 Protect and designate established Rural Settlements as designated on Map 1, subject to applicable Provincial plans.

6.5.3 Maintain the rural character of Rural Settlements.

6.5.4 Require development within Rural Settlements be limited to infilling and minor rounding out of existing development, subject to the ability to service the use(s) by individual private on-site water and wastewater systems where groundwater quality and quantity permits, and in compliance with the standards of the Region of Durham Drilled Wells and Lot Sizing Policies and the Ministry of the Environment, Conservation and Parks.

6.5.5 Minor rounding out to the boundary of a Rural Settlement Area will not be permitted in the Greenbelt Plan Area.

Hamlets

It is the policy of Council to:

6.5.6 Designate existing hamlets on Map 1 of this Plan.

6.5.7 Encourage hamlets to be the focus of modest growth and development in the Rural System.

6.5.8 Encourage a variety of cultural and economic opportunities within hamlets to serve the needs of rural residents and area businesses.

6.5.9 Require growth in Hamlets be limited to minor infilling subject to the ability to service the growth with individual on-site water and individual on-site sewage services.

6.5.10 Encourage development within hamlets to be compatible with surrounding uses and the rural landscape consisting of a mix of housing types appropriate for existing service levels, employment uses and commercial uses that meet the needs of the residents of the hamlets and the surrounding rural area.

6.5.11 Encourage that any new lots to be developed within hamlets do not extend or promote strip development.

6.5.12 Require that, when municipal water service is proposed to be extended to a Rural Settlement to address the failure of an individual on-site water service, one or more studies as described in Policy 6.5.13 shall be undertaken by the appropriate area municipality in consultation with the Region in order to identify any adverse impact on public health and safety, including implications for further development of individual on-site wastewater services.

6.5.13 Require the details of the permitted land uses within the hamlet in area municipal official plans. Consideration should be based on the following:

a) an assessment of the impact of future development on existing groundwater and surface water drainage, quality and quantity, and the impact on existing sources of drinking water, including municipal, communal and private wells;

b) an assessment of the long-term suitability of the soil conditions for the effective operation of private sewage disposal systems;

c) an environmental inventory and assessment of the impact of new growth on the natural, built and cultural environments;

d) an assessment of the impact on adjacent agricultural operations and identification of directions for minor rounding out which will minimize and/or mitigate potential conflicts between Hamlet and agricultural uses;

e) the ability to develop the Hamlet in depth rather than strips;

f) where municipal water or sewage facilities currently service the Hamlet, an assessment of the ability for development to improve the efficiencies of the system; and

g) utilizing a grid system of roads.

6.5.14 Require that development within a hamlet proceed by plan of subdivision, except for limited infilling as described in Policy 6.5.13. In addition to the requirements of the Planning Act, an application for approval of a draft plan of subdivision within a hamlet shall be accompanied by:

a) a recent hydrogeological report, based on test wells on the subject site, addressing existing conditions and the potential impact of the proposed subdivision on the available water supply in terms of quantity, quality and sustainable yield for both the proposed and existing wells. The report shall also assess the potential impact of proposed private sewage disposal systems on the groundwater supply in terms of bacterial and chemical parameters, as determined by the Region and the Ministry of the Environment, Conservation and Parks;

b) a lot servicing plan, indicating the proposed location of all structures, drilled wells and the subsurface sewage disposal system envelopes, including a 100% replacement area for each inground conventional Class 4 sewage disposal system;

c) in the case of hamlets that are serviced by municipal water supply, a report demonstrating to the satisfaction of the Region, that development on partial municipal services is feasible and sustainable;

d) a report of the results of a soil sampling program that adequately represents the geology of the subdivision; and

e) an existing and final grading plan, indicating elevations and lot drainage patterns.

6.5.15 Require that the provision of new and/or expanded municipal water and/or sewage services in a hamlet, in accordance with Policies 6.5.12 and 4.1.47, be subject to the following:

a) the availability of municipal water and/or sewerage facilities;

b) the feasibility of providing such municipal water and/or sewerage facilities;

c) the financial policies contained in Section 4.4 and a financial contribution from the residents of the hamlet, as Regional Council may deem appropriate.

d) in those cases where new areas for growth on vacant land in a hamlet have been identified in a) above, proponents shall be required to enter into necessary servicing agreements with the Region and bear their respective shares of the cost of the municipal water and/or sewerage facilities;

e) the prohibition of extensions to municipal water and/or sewerage facilities outside the hamlet boundary, as defined in the area municipal official plan;

f) an engineering report confirming that the municipal system servicing the hamlet has sufficient capacity to service any existing or proposed development, including provision for a reserve capacity, as determined by the Region, to maintain long-term security of the water supply;

g) an engineering report, demonstrating to the satisfaction of the Ministry of the Environment, Conservation and Parks and the Region that soil and groundwater conditions will enable the effective operation of private sewage disposal systems without any adverse effects on the soil and groundwater conditions of surrounding lands and the water quality of adjacent permanent and/or intermittent streams. In addition, such a report shall justify the lot sizes proposed and the phasing of new development; and

h) a monitoring program, as defined by the Region, is in place to determine the cumulative effect of the various stages of development on adjacent wells, the capacity of the municipal water supply system and the soil and groundwater conditions.

Residential Clusters

It is the policy of Council to:

6.5.16 Maintain the distinct clusters of non-farm residential development that exist in the Rural and Greenlands Systems that have been identified for development in area municipal official plans and/or zoning by-laws.

Shoreline Residential Areas

It is the policy of Council to:

6.5.17 Designate existing Shoreline Residential Areas on Map 1.

6.5.18 Prohibit the establishment of new Shoreline Residential Areas.

6.5.19 Require that development in Shoreline Residential Areas be limited to infill development, redevelopment and resort development, provided that:

a) opportunities for public access to shorelines are provided, where feasible;

b) integration with existing or proposed parks and trails is established, and ongoing or planned stewardship and remediation efforts are not constrained;

c) the planning, design, and construction will protect hydrologic functions, minimize erosion, and avoid or mitigate sedimentation and the introduction of nutrient or other pollutants into the water body;

d) be individually serviced with a private drilled well and a private sewage disposal system which complies with the standards of the Ministry of the Environment and Climate Change and the Region;

e) be serviced by efficient and appropriately sized sewage disposal facilities in order to reduce nutrient inputs to groundwater and the lake;

f) integrate landscaping and habitat restoration into the design to enhance the ability of native plants and animals to use the shoreline as both wildlife habitat and a movement corridor; and

g) demonstrate the available capacity of the receiving water body, taking into consideration inputs from both existing and approved development. Development shall comply with any relevant watershed or subwatershed study and in the case of Lake Simcoe, any such analysis must be considered in the context of the Lake Simcoe Protection Plan.

Rural Employment Areas

It is the policy of Council to:

6.5.20 Designate existing Rural Employment Areas on Map 1.

6.5.21 Prohibit the establishment of new Rural Employment Areas.

6.5.22 Establish that, with the exception of Rural Employment Area 2 which is serviced by municipal water, development within approved Rural Employment Areas shall be serviced by individual private on-site water and wastewater systems which comply with the standards of the Region and the Ministry of the Environment, Conservation and Parks require that existing Rural Employment Areas:

a) be comprised of Employment Area uses in accordance with Policies 5.5.2 to 5.5.4;

b) not detract from the surrounding natural environment or require significant alterations of the existing topography, waterways or vegetation;

c) be of high-quality design and take advantage of exposure to major transportation corridors;

d) demonstrate that any impacts from the development or site alteration on agricultural activities will be mitigated to the extent feasible; and

e) demonstrate that the development or site alteration does not have an adverse cumulative impact on the environment, particularly the soil, surface water and groundwater resources.

Country Residential Subdivisions

It is the policy of Council to:

6.5.23 Prohibit the establishment of any new Country Residential Subdivisions. Existing Country Residential Subdivisions are shown on Map 1.

6.5.24 Development within the approved Country Residential Subdivisions shall:

a) be serviced by individual private on-site water and wastewater systems which comply with the standards of the Region and the Ministry of the Environment, Conservation and Parks, except as otherwise noted in this Plan;

b) not have an adverse cumulative impact on the environment, including but not limited to any key natural heritage and/or key hydrologic features, groundwater, wells and soil;

c) be serviced with an internal road system having a minimum of two access points without direct access to a Provincial highway or a Type 'A' arterial road;

d) development in approved Country Residential Subdivisions shall not exceed the maximum number of residential units permitted, as contained in Table 2; and

e) require that once a Country Residential Subdivision has been registered, no severance for an additional lot shall be granted.

6.6 Regional Nodes

Regional Nodes are long standing, site specific based policies that recognize unique regional scale areas within Durham's Rural System.

Objective:

i. Support existing regional scale nodes for major recreational activities, such as centres of tourist activity and specialized recreational facilities.

Policies:

It is the policy of Council to:

6.6.1 Recognize existing regional scale nodes and provide for their continued function identified as:

a) Brimacombe; and

b) Lands within the vicinity of the Canadian Tire Motorsport Park.

6.6.2 Support development of existing Regional Nodes in a manner that will:

a) attract other compatible non-residential uses; and

b) incorporate high quality designs and visual standards.

6.6.3 Encourage development of these existing Nodes that would conform with the Oak Ridges Moraine Conservation Plan and Greenbelt Plan, as applicable, with detailed provided in area municipal official plans and zoning by-laws.

6.7 Aggregate Resources

Durham contains significant aggregate resources, with most of these resources concentrated in Uxbridge, Scugog, Brock and north Clarington, coincident with the Oak Ridges Moraine. Sites where extraction occurs are licensed by the province through the Ministry of Northern Development, Mines, Natural Resources and Forestry and are subject to Regional Official Plan Amendments.

Objectives:

i. Support opportunities for the extraction of mineral aggregate resources for local, regional and provincial needs.

ii. Encourage the protection of significant environmental features and minimize financial and social impacts on residents, the area municipalities and the Region through mineral aggregate resource extraction.

iii. Support the protection of high potential aggregate resource areas from incompatible land uses.

Policies:

It is the policy of Council to:

6.7.1 Identify Aggregate Resource Areas on Map 4, for such purposes.

6.7.2 Encourage area municipalities to include in their official plans, detailed locations of all aggregate resource extraction activities within their respective municipalities on a land use map and in a schedule identifying Aggregate Resource Areas.

6.7.3 Discourage the establishment of land uses within 300 metres of high potential aggregate resource areas which could hinder existing or future aggregate extraction in such areas.

6.7.4 Ensure that the development of mineral aggregate operations and wayside pits shall, where applicable, conform with provincial plans and policies, where applicable, in addition to the policies of this Plan.

6.7.5 Encourage mineral aggregate resource conservation, including through the use of accessory aggregate recycling facilities within operations, where feasible.

The conservation of mineral aggregate resource refers to:

- the recovery and recycling of manufactured materials derived from mineral aggregates (e.g. glass, porcelain, brick, concrete, asphalt, slag, etc.), for reuse in construction, manufacturing, industrial or maintenance projects as a substitute for new mineral aggregates; and
- the wise use of mineral aggregate including utilization or extraction of on-site mineral aggregate resources prior to development occurring.

It is the policy of Council to:

6.7.6 Permit mineral aggregate operations within Aggregate Resource Extraction Areas that may include the extraction of gravel, sand, clay, earth, shale, stone, limestone, dolestone, sandstone, marble, granite, rock other than metallic ores, and other accessory uses related thereto.

6.7.7 Encourage conservation, forestation and reforestation, as well as agricultural and agricultural-related uses, in accordance with Aggregate Resource Extraction Areas.

6.7.8 Encourage the implementation of mitigation measures when considering new or expanded Aggregate Resource Extraction Areas so that impacts on the existing adjacent land uses are minimized to applicable provincial standards and guidelines.

6.7.9 Support the establishment measures such as setbacks, screening, berms, location of machinery, and hours of operation as conditions of the license or site plan under the Aggregate Resources Act.

6.7.10 Update Map 4, from time to time, to reflect updated geological information, without amendment to this Plan. Information about individual licenses can be found on the Ministry of Northern Development, Mines, Natural Resources and Forestry's Pits and Quarries Online website.

6.7.11 Support the establishment and continuation of aggregate-related industrial uses, such as asphalt plants, ready-mix concrete plants and aggregate transfer stations in Employment Areas and active licenced Aggregate Resource Extraction Areas and that these are adequately buffered to protect adjacent land uses and meet the industrial pollution control and any other applicable standards of the Region and Ministry of the Environment, Conservation and Parks.

6.7.12 Permit portable asphalt plants and portable concrete plants used by or for a public authority, for a temporary period in any designation, except for within key natural heritage or hydrologic features and residential areas, as defined in area municipal official plans, without requiring an official plan amendment or an amendment to an area municipal zoning by-law.

Portable Asphalt Plant refers to a facility:

- with equipment designed to heat and dry aggregate and to mix aggregate with bituminous asphalt to produce asphalt paving material, and includes stockpiling and storage of bulk materials used in the process; and
- which is not of permanent construction, but which is to be dismantled at the completion of the construction project.

Portable Concrete Plant refers to a building or structure:

- with equipment designed to mix cementing materials, aggregate, water and admixtures to produce concrete, and includes stockpiling and storage of bulk materials used in the process; and
- which is not a permanent construction, but which is designed to be dismantled at the completion of the construction project.

It is the policy of Council to:

6.7.13 Permit wayside pits and quarries used by or for a public authority, for a temporary period, in accordance with the Aggregate Resources Act, without requiring an official plan amendment or an amendment to an area municipal zoning by-law, except as follows:

a) an amendment to this Plan and respective zoning by-laws shall be required for wayside pits and quarries in proximity to key natural heritage or hydrologic features identified on Maps 2a, 2c and 2d; and

b) a zoning by-law amendment shall be required to permit a wayside pit and quarry in Urban Areas and Rural Settlements.

Aggregate Extraction Licence Applications

It is the policy of Council to:

6.7.14 Require that an application to amend this Plan to designate a new or expanded Aggregate Resource Extraction Area or to permit aggregate-related industrial uses be accompanied by:

a) a hydrogeological study that assesses the potential impacts on water resources where the depth of excavation is proposed to go below the water table or the application is located on or near a hydrogeologically sensitive feature, such as a Provincially significant wetland, coldwater permanent and/or intermittent stream, aquifer recharge area or located on the Oak Ridges Moraine;

b) an assessment of the following potential impacts:

i) intended activities and magnitude of the operation;

ii) operational aspects related to noise, lighting, dust and other potential nuisances;

iii) effects on key natural heritage and/or key hydrologic features in accordance with Policy 7.4.15;

iv) volume of truck traffic and haul routes;

v) changes in living environment for residents in the vicinity, taking into account the other potential impacts identified in this policy;

vi) heritage resources and visual impacts;

vii) costs to the Region or the area municipality;

viii) in Prime Agricultural Areas, an agricultural impact assessment;

c) a description of how identified impacts will be satisfactorily addressed and where applicable, what mitigation is required to meet provincial standards and guidelines;

d) site plans and reports as required by the Aggregate Resources Act and regulations and standards thereto;

e) within the Greenbelt Natural Heritage System, applications shall also be accompanied by a report, demonstrating how:

i) the connectivity between key natural heritage and/or key hydrological features will be maintained before, during and after extraction;

ii) the operator could replace any key natural heritage features and key hydrologic features that would be lost from the site with equivalent features on another part of the site or on adjacent lands;

iii) both ground and surface water features and functions will be protected or enhanced; and

iv) any key natural heritage features and key hydrologic features and their associated vegetation protection zones will be addressed in accordance with the Greenbelt Plan.

6.7.15 Ensure that within the Greenbelt Natural Heritage System:

a) no new Aggregate Resource Extraction Areas and no new wayside pits and quarries, or ancillary accessory uses thereto will be permitted within significant wetlands, habitat of endangered or threatened species, or significant woodlands, unless the woodland is occupied by young plantation or early successional habitat, as defined by the Ministry of Northern Development, Mines, Natural Resources and Forestry. In this case an application to amend this Plan to designate a new Aggregate Extraction Area, or to establish a new wayside pit or quarry, aggregate-related industrial use, or accessory uses thereto, must demonstrate that the relevant provisions of the Greenbelt Plan have been addressed, and that they will be met by the operation;

b) an application to amend this Plan to designate a new Aggregate Resource Extraction Area, or to establish a new wayside pit or quarry may only be permitted in other key natural heritage and/or key hydrologic features and any vegetation protection zone where the application demonstrates:

i) how the water resources will be protected or enhanced;

ii) that the relevant provisions of the Greenbelt Plan have been addressed, and that they will be met by the operation; and

c) applications requiring new approvals under the Aggregate Resources Act to expand existing operations may be permitted within the Greenbelt Natural Heritage System, including in key natural heritage, hydrologic features and in vegetation protection zones, provided the related decision is consistent with the Provincial Policy Statement and satisfies the rehabilitation requirements of the Greenbelt Plan.

6.7.16 Ensure that an application to amend this Plan to designate an Aggregate Resource Extraction Area or aggregate-related industrial use within the Natural Linkage Area of the Oak Ridges Moraine shall not be approved unless it is demonstrated that:

a) there will be no extraction within 1.5 metres of the water table; and

b) there will at all times be an excluded area of at least 1.25 kilometres in total width, such distance being measured either entirely within the Natural Linkage Area or including areas within the Natural Core Area that is adjacent to the excluded area, laying outside of the active or unrehabilitated portion of the site and connecting the Natural Linkage Area outside of the site in order to maintain connectivity.

Aggregate Site Rehabilitation

It is the policy of Council to:

6.7.17 Encourage the rehabilitation of all abandoned pits and quarries and the progressive rehabilitation, including simultaneous stripping, extraction and rehabilitation, of all operating pits and quarries.

6.7.18 Encourage the rehabilitation of pits and quarries in a manner that is compatible with the surrounding land uses and landscape. Final rehabilitation shall take surrounding land use, relevant provincial plans and approved land use designations into consideration.

6.7.19 Consider rehabilitation plans in conjunction with adjacent operations in an area, in order to provide for more comprehensive rehabilitation planning.

6.7.20 Encourage the rehabilitation of Aggregate Resource Extraction Areas on the Oak Ridges Moraine to provide for a regional trail and continuous forest cover where possible.

6.7.21 Ensure rehabilitation plans shall be reviewed in conjunction with an environmental impact study in accordance with Policy 7.4.15. In addition, within the Greenbelt Protected Countryside, rehabilitation shall also be subject to the relevant provisions of the Greenbelt Plan.

6.7.22 Facilitate the coordination of cross-jurisdictional matters among area municipalities, related to rehabilitation planning, such as identifying opportunities to provide linkages and corridors with natural heritage features when reviewing rehabilitation plans. Encourage progressive rehabilitation to be undertaken in a timely manner, in accordance with the approval site plan for a licence issued under the Aggregate Resources Act.

6.7.23 Encourage area municipalities and landowners to continue to pursue the rehabilitation of abandoned pits and quarries through the Management of Abandoned Aggregate Properties Program, or its successor.

6.7.24 Ensure the rehabilitation of mineral aggregate extraction sites in Prime Agricultural Areas is undertaken in accordance with applicable provincial plans and policy.



Chapter 7

Protected Greenlands System

Chapter 7. Protected Greenlands System

Over 80% of the region is located within the provincially protected Greenbelt. Important features, such as the Oak Ridges Moraine, valley systems and waterfronts will be protected, enhanced and restored for their important ecological functions, scenic features and landscape elements, their role in building climate resilience, as well as for the recreational opportunities they provide.

The policies of this Plan work with those of the province and area municipalities to prioritize the natural environment in the planning and development of the region so that long-term environmental, social, economic and public health benefits are preserved.

Goals:

I. **Identify a protected Greenlands System that conserves, protects and enhances water and land resources for present and future generations.**

II. **Protect, restore and enhance an interconnected natural heritage system and water resources system across the region.**

III. **Support the linkages between the region's waterfronts and the Oak Ridges Moraine through the connecting valley systems.**

7.1 General Greenland System Policies

The region's Greenlands System, comprised of the Major Open Space Areas, Oak Ridges Moraine Areas and Waterfront Areas, links the region's waterfronts with the Oak Ridges Moraine through the connecting valley systems.

Objectives:

i. **Ensure the maintenance of a continuous system of Major Open Space Areas that serve to define the boundaries of Urban Areas, support ecological health of the region, and protect environmental features and functions.**

ii. Promote development within communities on the Oak Ridges Moraine that balance the needs of residents with protecting and enhancing the ecological integrity of the Moraine.

iii. Ensure the protection and enhancement of waterfronts as vital components of the region's natural, built and cultural environments.

Policies:

It is the policy of Council to:

7.1.1 Designate Major Open Space Areas, Oak Ridges Moraine Areas and Waterfront Areas, shown on Map 1, as components of the region's Greenlands System. The exact boundaries of the components of the Greenlands System within the Urban Area shall be determined in accordance with Policy 12.1.3.

7.1.2 Protect the Greenlands System from intrusion by urban type land uses.

7.1.3 Require that development proposals within the Greenlands System demonstrate how the following have been addressed:

a) preservation, enhancement and restoration of biodiversity and ecological goods and services;

b) protection, enhancement and restoration of groundwater resources;

c) sequestration of carbon and minimization of impacts on air quality;

d) protection of habitats for plants, fish and wildlife;

e) implementation of flood and erosion control; and

f) protection of scenic and recreational values.

Ecological Goods and Services refers to the benefits which accrue to all living organisms resulting from the ecological functions of healthy ecosystems. Ecological goods and services include clean air, fresh water, biodiversity, nutrient cycling, water management, soil retention, genetic resources, food production, and climate regulation which contribute to meeting health, social, cultural and economic needs. The products and processes of ecological goods and services are complex and occur over long periods of time.

It is the policy of Council to:

7.1.4 Encourage the transfer of natural heritage and hydrologic feature lands to public agencies through the development approvals process.

7.1.5 Protect agricultural uses, agriculture-related uses and on-farm diversified uses as components of the Greenlands System outside of the Urban Area.

Major Open Space Areas

Major Open Space Areas are a component of the region's Greenlands System that generally follow major permanent and/or intermittent stream and valleys and contain high concentrations of key natural heritage features and key hydrologic features. Outside of the Urban Area Boundary, Major Open Space Areas can also include prime agricultural lands and rural lands.

It is the policy of Council to:

7.1.6 Ensure that the predominant use of land within Major Open Space Areas is environmental protection and conservation, while also allowing for a range of agricultural uses, agriculture-related uses, on-farm diversified uses, and recreational uses, where appropriate.

7.1.7 Discourage fragmentation and maintain the continuity of Major Open Space Areas, including ownership patterns, especially where key natural heritage features and key hydrologic features are present.

7.1.8 Ensure that uses permitted within valleylands do not alter the flood capacity of the valley, slope stability and erosion hazards, fish habitats, wildlife habitats, woodlands, or the character of the permanent and/or intermittent stream.

7.1.9 Require that development or site alteration within Major Open Space Areas and/or the Greenbelt Natural Heritage System demonstrate that:

a) there will be no negative impacts on key natural heritage features or key hydrologic features or their functions;

b) connectivity between key natural heritage features or key hydrologic features located within 240 metres of each other is maintained, or where possible, enhanced;

c) the removal of natural features not identified as key natural heritage features or key hydrologic features is avoided and such features are incorporated into the planning and design of the proposed use, wherever possible; and

d) the disturbed area of any site does not exceed 25% and the impervious surface does not exceed 10% of the total developable area, except for major recreational uses and aggregate extraction areas. With respect to golf courses, the disturbed area shall not exceed 40% of the site. The use of low impact development, such as permeable pavers and grassed swales is encouraged to achieve this requirement.

7.1.10 Consider non-agricultural uses within Major Open Space Areas, subject to the policies of this Plan, the Lake Simcoe Protection Plan and the Greenbelt Plan. Area municipalities are encouraged to distinguish between non-agricultural uses which are compatible with the character of Major Open Space Areas within their urban and rural areas.

7.1.11 Require that the development of non-agricultural uses within Major Open Space Areas shall:

a) minimize the use of prime agricultural land, including Canada Land Inventory Classes 1, 2 and 3 soils;

b) demonstrate that the use is appropriate for location in the Major Open Space Area and, apart from recreational uses, cemeteries, and mineral aggregate extraction, is small in scale and serves the resource and agricultural sectors;

c) be encouraged to locate on existing parcels of appropriate size for the proposed use;

d) incorporate appropriate separation distances from farm operations in accordance with provincial Minimum Distance Separation formulae;

e) be compatible with sensitive land uses in compliance with provincial Land Use Compatibility Guidelines, particularly issues of noise and dust must be addressed;

f) be located on an existing opened public road and shall not compromise the design and function of the road;

g) be serviced with an individual private sewage disposal system and an individual private drilled well which meet regional and provincial standards, outside of the Urban Area;

h) be planned to optimize the compatibility of the development with the natural surroundings;

i) ensure there will be no negative impact on key natural heritage features or key hydrologic features;

j) ensure at least 30% of the total developable area of the site will remain or be returned to natural self-sustaining vegetation (this requirement does not apply to new or expanding Aggregate Resource Extraction Areas);

k) ensure that connectivity along the system and between key natural heritage features or key hydrologic features located within 240 metres of each other is maintained or enhanced, or in the case of aggregate extraction, rehabilitated;

l) avoid the use of outdoor lighting that causes light trespass, glare and uplight;

m) not have an adverse effect on the ability of surrounding agricultural operations to carry on normal farm practices;

n) be subject to area municipal planning approvals; and

o) meet the requirements of the Oak Ridges Moraine Conservation Plan, Lake Simcoe Protection Plan and the Greenbelt Plan, if applicable.

Total Developable Area refers to the total area of the property less the area occupied by key natural heritage features, key hydrologic features and any related vegetation protection zones.

It is the policy of Council to:

7.1.12 Permit new and expanding major recreational uses and accessory facilities within Major Open Space Areas by amendment to this Plan, or an area municipal official plan where appropriate policies are in place, in accordance with the requirements of Policy 7.1.11 and the following:

a) a hydrogeological study addressing the protection of water resources;

b) a best management practices report that addresses design, construction and operating considerations, including traffic and a demonstration of how the application of pesticides, fertilizers and water, nutrient and biocide use will be minimized, including the establishment and monitoring of targets; and

c) that new natural self-sustaining vegetation be located in areas that maximize the ecological value of the area.

Ecological Value refers to the value of vegetation in maintaining the health of the key natural heritage feature or key hydrologic feature and the related ecological features, such as those naturally occurring land, water and biotic features that contribute to ecological integrity and ecological functions, as measured by factors such as the diversity of species, the diversity of habitats, and the suitability and amount of habitats that are available for rare, endangered and threatened species.

It is the policy of Council to:

7.1.13 Require that, outside of designated Urban Areas, clubhouses and other accessory and associated uses shall be of a scale to ensure that they remain secondary to the major recreational use. Details shall be provided in area municipal official plans and/or zoning by-laws as appropriate.

7.1.14 Encourage landscape industry uses which consist of businesses associated with horticulture to locate in Employment Areas and Rural Employment Areas.

7.1.15 Permit small-scale landscape industry uses on existing lots of record within Major Open Space Areas and within the Countryside Area, outside of Oak Ridges Moraine Prime Agricultural Area, in accordance with the requirements of Policy 7.1.11, as applicable, and provided that:

a) the use does not require large-scale buildings or structures or the large-scale modification of terrain, vegetation, or both;

b) buildings and structures will be planned, designed and constructed so as not to have an adverse effect on the rural character of the area; and

c) there are no negative impacts on the ecological integrity of the Oak Ridges Moraine or the Greenbelt Natural Heritage System.

7.1.16 Prohibit new severances for small-scale landscape industry uses within Major Open Space Areas.

7.1.17 Require that area municipal official plans provide criteria to address potential land use compatibility impacts when considering small-scale landscape industry uses within Major Open Space Areas.

7.1.18 Require an amendment to this Plan for the consideration of large-scale landscaping operations that entail the mixing of paper bio solids or sewage sludge for the purposes of manufacturing a product, the manufacturing of garden supplies, on-site retailing, large-scale modification of terrain, vegetation or both, or large-scale building and structures.

Oak Ridges Moraine Areas

The Oak Ridges Moraine is a 160-kilometre natural ridge (approximately 60 kilometres within Durham Region) that forms part of Ontario's Greenbelt. The Moraine is an attractive landscape that the region's residents and visitors enjoy for its recreational opportunities. It provides clean drinking water, plant and animal habitat, agricultural land and aggregate resources. The Moraine also plays a significant role in climate change adaptation and mitigation through carbon sinks found in the Moraine's agricultural lands and other natural areas.

The Oak Ridges Moraine Conservation Plan defines the boundary of the Moraine and sets out land use and resource management direction for protecting the Moraine's land and water.

Figure 15. – Map of Oak Ridges Moraine:



It is the policy of Council to:

7.1.19 Limit new permitted uses within areas of the Oak Ridges Moraine, as shown on Map 2b, to:

a) within Natural Core Areas: conservation and resource management, uses accessory to existing residential uses, infrastructure, low-intensity recreational uses and unserviced parks, agricultural uses and accessory uses, as well as on-farm diversified uses and agriculture-related uses in Oak Ridges Moraine Prime Agricultural Areas, provided they meet the policies of the Oak Ridges Moraine Conservation Plan;

b) within Natural Linkage Areas: uses identified in a) above, as well as mineral aggregate operations, wayside pits and accessory uses, provided they meet the policies of the Oak Ridges Moraine Conservation Plan; and

c) within Countryside Areas: uses identified in a) and b) above, as well as agriculture-related uses and on-farm diversified uses, small-scale commercial, industrial, institutional uses and major recreational uses, consistent with the policies of this Plan.

7.1.20 Prohibit small scale commercial, industrial, institutional and major recreational uses and unserviced parks within Oak Ridges Moraine Prime Agricultural Areas, in accordance with the Oak Ridges Moraine Conservation Plan.

Unserviced Park refers to a park that provides recreational opportunities and facilities, including playing fields, but without outdoor lighting, accessory commercial facilities, and paved parking lots or permanent water or sewer facilities.

It is the policy of Council to:

7.1.21 Support opportunities for minor residential infill and small-scale industrial, commercial and institutional uses in Hamlets on the Oak Ridges Moraine.

7.1.22 Encourage a range of residential, commercial, industrial and institutional uses in the portion of the Uxbridge Urban Area within Settlement Areas on the Oak Ridges Moraine. The policies of the Township of Uxbridge Official Plan and this Plan shall guide development, subject to the applicable policies of the Oak Ridges Moraine Conservation Plan.

7.1.23 Prohibit new or upgrading of existing infrastructure within Oak Ridges Moraine Prime Agricultural Areas, Natural Core Areas, Natural Linkage Areas, key natural heritage features, and key hydrologic features and their associated vegetation protection zones, unless appropriate studies have been completed to the satisfaction of the Region and other applicable agencies, in accordance with the Oak Ridges Moraine Conservation Plan.

7.1.24 Require an agricultural impact assessment for the development of infrastructure or mineral aggregate operations in Oak Ridges Moraine Prime Agricultural Areas that demonstrates there will be no negative impacts to the Oak Ridges Moraine prime agricultural area or that such impacts will be minimized and mitigated.

7.1.25 Prohibit the opening of a road within an unopened road allowance on the Oak Ridges Moraine unless the requirements of the Oak Ridges Moraine Conservation Plan are fulfilled.

7.1.26 Consider major recreational uses within Countryside Areas only by amendment to this Plan and conformity with the Oak Ridges Moraine Conservation Plan, including demonstrating that the use will have no adverse impacts on surrounding agricultural operations or that any such impacts will be minimized and mitigated.

7.1.27 Prohibit development and site alteration within key natural heritage features and/or key hydrologic features and their related minimum vegetation protection zones. Conservation and resource management, low-intensity recreational uses, and development and site alteration within the habitat of endangered and threatened species may be permitted, in accordance with the policies of the Oak Ridges Moraine Conservation Plan.

7.1.28 Prohibit new agricultural uses and/or agriculture-related uses within key natural heritage features and/or key hydrologic features. Agricultural uses, other than those associated with on-farm buildings and structures, are permitted within the minimum vegetation protection zone, but not within the feature itself.

7.1.29 Permit mineral aggregate operations or wayside pits within a key natural heritage feature only if the feature is a significant woodland occupied by young plantations or early successional habitat, and the requirements and studies of the Oak Ridges Moraine Conservation Plan are fulfilled to the satisfaction of the Region and other relevant agencies.

7.1.30 Require that an environmental impact study, in accordance with Policy 7.4.15, shall include a natural heritage and/or a hydrological evaluation, as detailed in the Oak Ridges Moraine Conservation Plan, where new development or site alteration is proposed within the minimum area of influence surrounding a key natural heritage feature and/or key hydrologic feature.

7.1.31 Permit new buildings or structures for agricultural uses, agricultural-related uses, or on-farm diversified uses, without the requirement of a natural heritage or hydrological evaluation, only if they are located a minimum of 30 metres from the key natural heritage feature and/or key hydrologic features and are carried out in accordance with best management practices to protect or restore the feature and its ecological functions.

7.1.32 Require that applications for development or site alteration be reviewed to ensure that planning and construction practices maintain connectivity between key natural heritage features, key hydrologic features and adjacent lands within Natural Core Areas and Natural Linkages Areas.

7.1.33 Require that development or site alteration in an area of natural and scientific interest (earth science), and/or related minimum area of influence shall be accompanied by an earth science heritage evaluation as outlined in the Oak Ridges Moraine Conservation Plan.

7.1.34 Prohibit major development on the Oak Ridges Moraine unless all applicable studies and requirements of the Oak Ridges Moraine Conservation Plan have been completed to the satisfaction of the Region and relevant approval authorities.

7.1.35 Prohibit development and site alteration in a subwatershed, excluding the Uxbridge Urban Area, if it would cause the total percentage of the subwatershed area to have an impervious surface exceeding 10%, or any lower percentage specified in an approved watershed plan or subwatershed plan.

7.1.36 Require that development or site alteration in a landform conservation area, shown on Map 2h, be accompanied by an appropriate study as outlined by the Oak Ridges Moraine Conservation Plan. Mineral aggregate operations are exempt from these study requirements; however, they must demonstrate that the site will be rehabilitated to establish a landform character that is consistent with the landform patterns of adjacent lands and that the long-term ecological integrity of the site will be maintained, restored or improved.

Landform Conservation Areas refer to areas with significant landform character. Category 1 and Category 2 landform conservation areas are shown on maps entitled “Landform Conservation Areas of the Oak Ridges Moraine”, numbered 1, 2, 3 and 4 of the Ministry of Northern Development, Mines, Natural Resources and Forestry.

It is the policy of Council to:

7.1.37 Permit area municipalities to be more restrictive in their official plans or zoning by-laws, except as limited by the Oak Ridges Moraine Conservation Plan (i.e., regarding mineral aggregate operations, wayside pits and agricultural uses).

Waterfront Areas

Waterfront Areas along the shorelines of Lake Ontario, Lake Scugog and Lake Simcoe include sensitive environmental features and shoreline areas, as well as areas meant to provide residents and visitors with access to enjoy the recreational opportunities the waterfronts provide, including the Lake Ontario portion of the Great Lakes Waterfront Trail.

It is the policy of Council to:

7.1.38 Require that the extent, location and detailed land uses of the Waterfront Areas be detailed within area municipal official plans.

7.1.39 Ensure that Waterfront Areas are maintained as a continuous system and generally developed as places for environmental protection and the recreational enjoyment of residents and visitors.

7.1.40 Protect for public access to Waterfront Areas for their ecological, cultural, or recreational value, including through land acquisition.

7.1.41 Ensure protection and enhancement of natural areas within Waterfront Areas in their natural states. These areas may be used for observation, passive recreation and educational purposes, where appropriate.

7.1.42 Require that proposals for development and redevelopment within Waterfront Areas demonstrate:

a) no negative impact on key natural heritage features or key hydrologic features;

b) no negative impact on the flood risk associated with recorded high lake levels and avoidance of the shoreline hazard limit;

c) protection of wildlife habitat and aquatic resources;

d) maintenance of connections between natural areas; and

e) provisions for public access to the waterfront.

7.1.43 Ensure that through the conduct of environmental impact studies for development along the Lake Ontario waterfront that the following are addressed:

a) impact on the shoreline, creeks, wetlands and near-shore wildlife habitat and aquatic characteristics;

b) opportunities for the appropriate portions of the subject lands to be included in a natural corridor system along the waterfront and creek valleys;

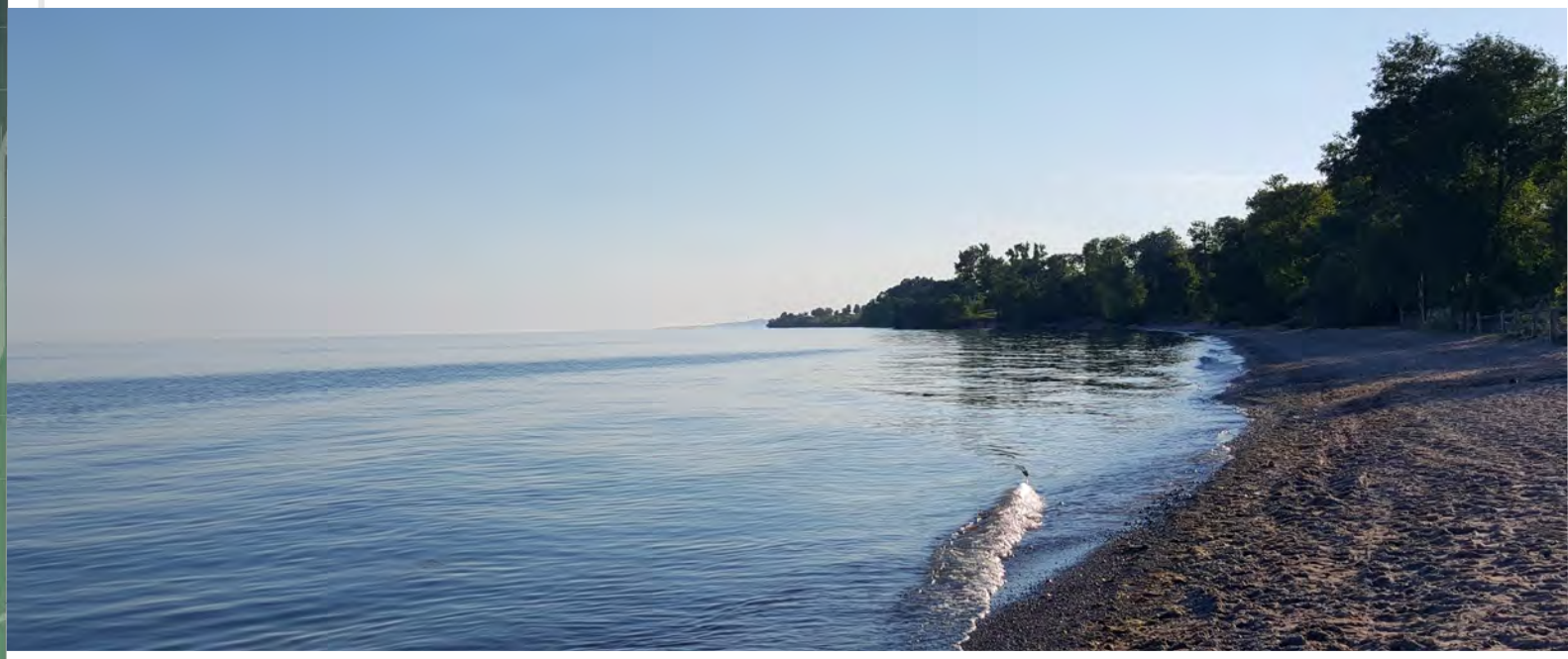
c) impact on lake water quality; and

d) the acceptability of soil quality (as determined by the provincial or federal authority having jurisdiction) if the development proposal involves lakefilling.

7.1.44 Support ongoing development of a continuous and coordinated Lake Ontario waterfront trail that also connects with other trails for the purpose of forming a region-wide trail network.

7.1.45 Require that the review of area municipal official plans and development proposals in proximity to the Trent Severn Waterway, particularly waterfront development, include consideration for protection and enhancement of the waterway and the comments of appropriate waterway authorities.

7.1.46 Encourage the area municipalities to include policies within their official plans and zoning by-laws to identify and regulate sites within Waterfront Areas that are of particular interest for tourism and recreation, consistent with the intent of the Waterfront Areas designation.



7.2 Greenbelt Urban River Valleys

Greenbelt Urban River Valleys are major valley systems, identified and protected by the provincial Greenbelt. These valley systems include watercourses and coastal wetlands that weave through the Urban Areas of the region's southern municipalities and link the Greenbelt to Lake Ontario. They are a key component of the long-term health of the region's natural environment.

Greenbelt Urban River Valleys include lands containing natural and hydrological features and lands designated within area municipal official plans for parks, open space, recreation, conservation and environmental protection. The policies of this section apply only to publicly owned lands within the Greenbelt Urban River Valleys designation.

Objective:

i. Promote the protection, maintenance and enhancement of natural features and functions within Greenbelt Urban River Valleys.

Policies:

It is the policy of Council to:

7.2.1 Identify Greenbelt Urban River Valleys on Map 2b.

7.2.2 Acknowledge that the Greenbelt Urban River Valley policies of the Greenbelt Plan apply to publicly owned lands within Greenbelt Urban River Valleys and that these areas are predominately used for parks, open space, recreation, conservation and environmental protection, in accordance with the Greenbelt Plan. Greenbelt Urban River Valleys may contain wetlands and natural hazards where certain new land uses or development may not be appropriate, to ensure public safety and contribute to resilience.

7.2.3 Ensure that privately owned land within the Greenbelt Urban Valleys designation comply with the policies of this Plan, including natural heritage system policies.

7.2.4 Permit existing, expanded and new infrastructure within Greenbelt Urban River Valleys only if approved under the Environmental Assessment Act, or a similar approval and if it supports the needs of adjacent Settlement Areas or projected growth and economic development and the goals and objectives of the Greenbelt Plan.

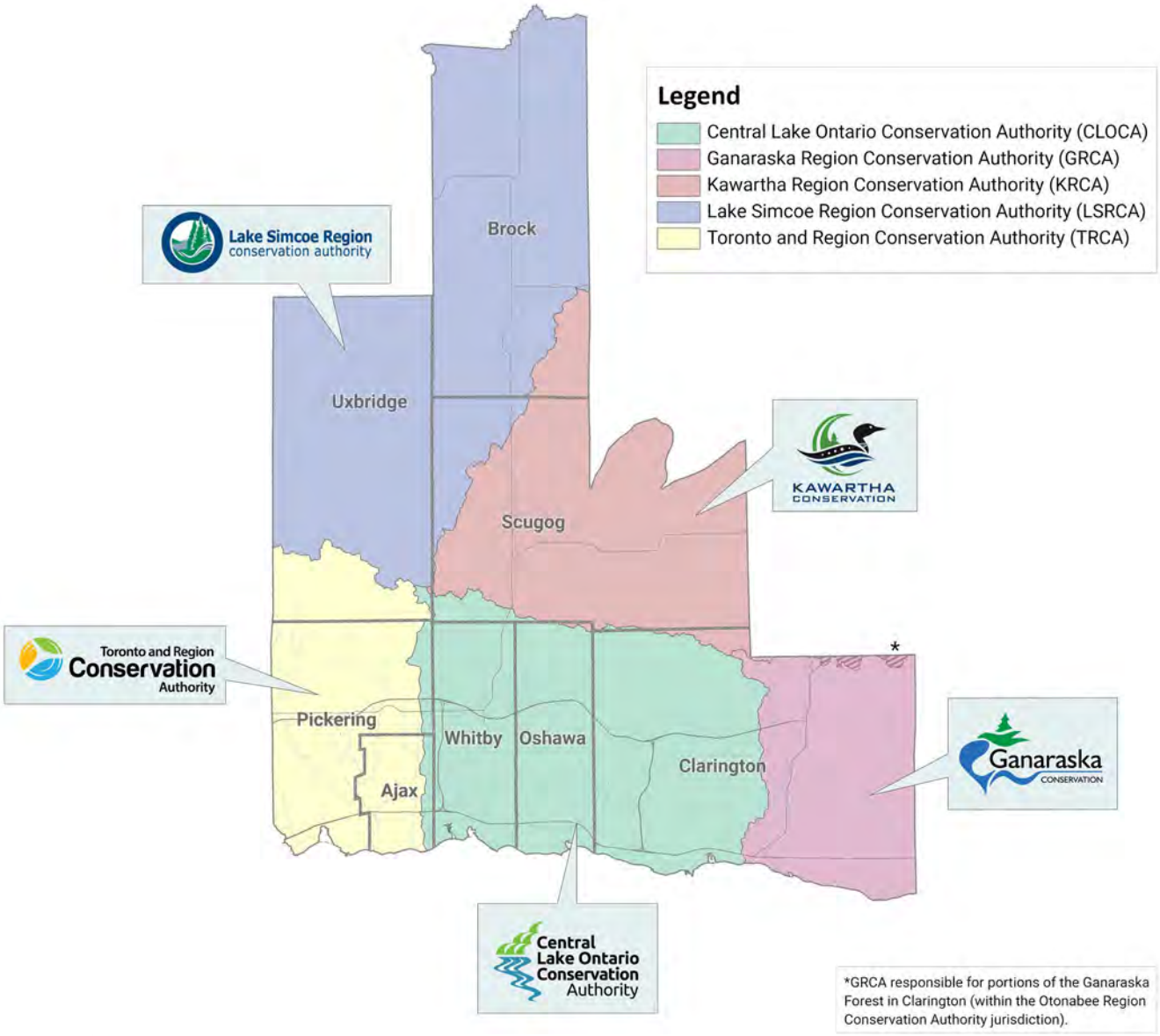
7.2.5 Promote planning and design that ensures the ecological form and function of the region's Greenbelt Urban River Valleys are maintained and/or enhanced.

7.2.6 Encourage the transfer to privately owned lands within Greenbelt Urban River Valleys into public ownership through acquisition, land securement or gratuitous conveyance.

7.3 Watershed Planning

Watersheds include all the land that collects water into a common waterbody such as a creek, pond or lake, and are recognized as the most ecologically meaningful scale for integrated and long-term planning. Watershed plans provide a framework that includes goals, objectives, targets and management recommendations for the protection of water resources, the management of human activities, land, water, aquatic life and resources within a watershed and for the assessment of cumulative, cross-jurisdictional and cross-watershed impacts.

Figure 16. – Conservation Authority jurisdictions in Durham:



Objective:

i. Support the preparation and implementation of watershed plans to protect, enhance and restore the quality and quantity of the region's water resources and natural heritage features.

Policies:

It is the policy of Council to:

7.3.1 Ensure that watershed plans are prepared and updated on a priority basis recognizing development pressures, environmental urgency and fiscal constraints, in accordance with currently accepted practices and applicable provincial guidance, including consideration for:

a) the impacts of a changing climate on the water resources system;

b) targets and goals of the Great Lakes Protection Act and applicable Great Lakes strategies and agreements; and

c) cross-jurisdictional and cross-watershed impacts.

7.3.2 Require the completion of appropriate studies that address the relevant components of a watershed plan to the satisfaction of the Region or the area municipality, in consultation with the conservation authority. In the case of an application to designate a new or expanding Aggregate Resource Extraction Area, the policies of Section 6.7, other relevant policies of this Plan and the requirements of the Aggregate Resources Act shall satisfy this policy.

7.3.3 Support the implementation of watershed plans to inform:

a) the identification of water resources systems and protection, enhancement and restoration of water quality and quantity;

b) the long-term protection, enhancement and restoration of key natural heritage features, key hydrologic features and key hydrologic areas and their functions;

c) the identification of watershed-scale natural heritage systems, linkages and natural cover targets; and

d) decisions on allocation of growth and planning for water, wastewater and stormwater infrastructure.

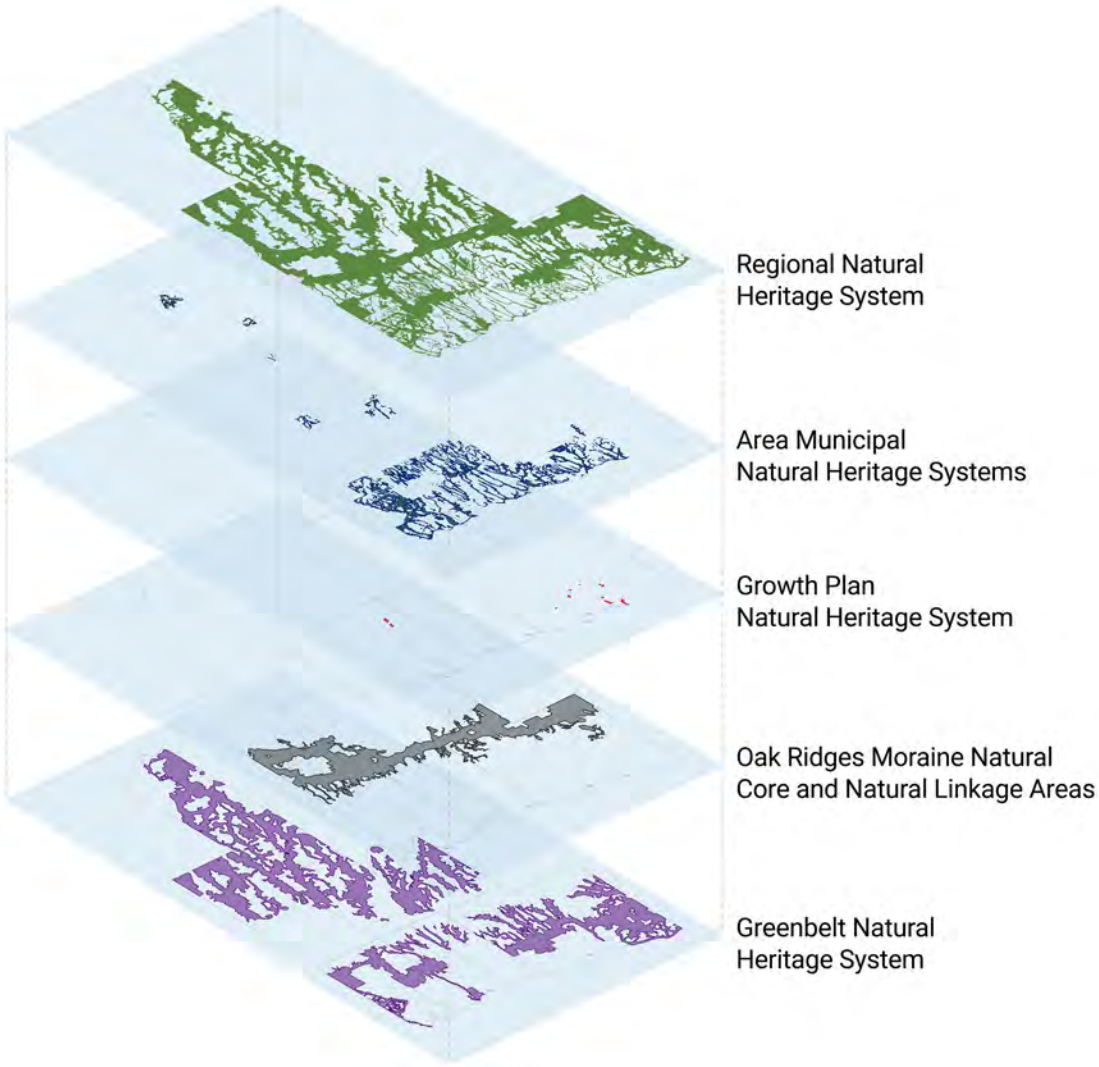
7.3.4 Ensure that, where applicable, watershed plans and their components meet the requirements of the Oak Ridges Moraine Conservation Plan, the Lake Simcoe Protection Plan and Greenbelt Plan.

7.4 Regional Natural Heritage System

The regional natural heritage system is an overlay that identifies a system of core natural features and the land and water that links these core features together. Protecting, enhancing and restoring this system supports the long-term ecological integrity and climate change resiliency of the region.

Enhancement opportunity areas are potential linkage areas, adjacent to the regional natural heritage system, where the system can be enhanced through voluntary stewardship and restoration efforts.

Figure 17. – Illustration of the components that comprise the regional natural heritage system:



Objective:

i. Ensure the identification, protection, restoration and enhancement of the regional natural heritage system and its natural heritage and hydrologic features and functions.

Policies:

It is the policy of Council to:

7.4.1 Identify a regional natural heritage system as an overlay, shown on Map 2a, comprised of the Oak Ridges Moraine Natural Core Areas and Natural Linkage Areas, Greenbelt Natural Heritage System, Growth Plan Natural Heritage System, area municipal natural heritage systems, key natural heritage features and key hydrologic features and functions and the linkage areas that connect these features in a system.

7.4.2 Permit refinements to the regional natural heritage system, outside of provincial natural heritage system areas, through the secondary planning process and/or approved planning applications, without an amendment to this Plan. Such refinements shall be supported by appropriate technical studies and must be in accordance with applicable provincial plans and the policies of this Plan.

7.4.3 Require policies that protect the regional natural heritage system as well as those that identify enhancement areas and linkage areas as part of area municipal official plans, where appropriate.

Linkage areas consist of natural areas and features to support the migration of flora and fauna, as well as the movement of pedestrians. For example, the Rouge-Duffins Wildlife Corridor in the City of Pickering is a natural linkage between the Rouge and Duffins valley systems.

It is the policy of Council to:

7.4.4 Prohibit development and site alteration within the regional natural heritage system, except as permitted by the applicable provincial plans including:

a) legally existing uses that conform to area municipal official plans and zoning by-laws;

b) new buildings and structures and the full range of uses for existing and new agricultural uses, agricultural-related uses and on-farm diversified uses and normal farm practices, subject to the key natural heritage features policies in this section;

c) naturalized stormwater management systems and facilities and passive recreational uses if an approved environmental impact study demonstrates that construction will have no negative impact;

d) new infrastructure if authorized through an Environmental Assessment or if no reasonable alternative location exists and an environmental impact study demonstrates that construction will have no negative impact; and

e) notwithstanding a) to d) above, stewardship, conservation, restoration and remediation undertakings, and flood and erosion control projects may be permitted if they are demonstrated to be necessary in the public interest and after all alternatives have been considered.

7.4.5 Require an environmental impact study for development and site alteration within 120 metres of the natural heritage system.

7.4.6 Maintain hedgerows within the regional natural heritage system where they serve an important linkage and/or habitat function, as determined by an approved site-specific study.

7.4.7 Support the achievement of targeted natural heritage systems, identified within watershed plans, by encouraging stewardship, restoration and related efforts within enhancement opportunity areas, as conceptually shown on Map 2a. Enhancement opportunity areas are subject to refinement by the area municipalities, in consultation with the conservation authorities and once restored, may be added to the regional natural heritage system.

7.4.8 Partner with the conservation authorities, area municipalities, Indigenous communities and other organizations to target restoration and enhancement initiatives within areas of the regional natural heritage system and enhancement opportunity areas with the greatest vulnerability to the impacts of a changing climate.

7.4.9 Consider cross-jurisdictional impacts when reviewing applications for development and site alteration in recognition that the regional natural heritage system is connected to the natural heritage systems of adjacent municipalities.

Key Natural Heritage Features & Key Hydrologic Features

Key natural heritage features and key hydrologic features form the basis of the regional natural heritage system and include:

- wetlands;

- significant woodlands;
- significant valleylands;
- habitat of endangered and threatened species;
- fish habitat;
- significant wildlife habitat;
- life science areas and earth science areas of natural and scientific interest;
- sand barrens, savannahs and tallgrass prairies;
- alvars;
- lakes and their littoral zones;
- permanent and intermittent streams;
- kettle lakes;
- seepage areas and springs;
- Lake Simcoe Shoreline; and
- natural areas abutting Lake Simcoe.

These features are subject to policies in the Provincial Policy Statement, Oak Ridges Moraine Conservation Plan, Greenbelt Plan, Growth Plan and Lake Simcoe Protection Plan, as specified in Table 7. The policies of these provincial plans work together with the policies of this Plan and area municipal official plans to protect, restore and enhance features and the linkages between them to ensure the region's long-term ecological integrity.

It is the policy of Council to:

7.4.10 Require that area municipalities identify individual key natural heritage features, key hydrologic features and associated minimum vegetation protection zones within their official plans and zoning by-laws, informed by watershed plans and environmental impact studies that are prepared as part of development applications.

7.4.11 Prohibit development or site alteration in key natural heritage features and/or key hydrologic features, including any associated vegetation protection zone, with the exception of:

a) forest, fish and wildlife management;

b) stewardship, conservation, restoration and remediation undertakings, and flood or erosion control projects demonstrated to be necessary in the public interest and after all alternatives have been considered;

c) infrastructure, subject to the policies of the Greenbelt Plan, Growth Plan, Lake Simcoe Protection Plan and this Plan;

d) minor recreational uses such as trails, minimal numbers of footbridges, picnic facilities or similar structures, unserviced camping on public and institutional land, and existing uses;

e) agriculture, in accordance with Policies 7.4.12 and 11.3.5;

f) retrofits of existing stormwater management works where no other alternative exists, not including the establishment of new stormwater management works;

g) aggregate extraction, in accordance with Policies 6.7.6 and 6.7.14; or

h) expansions or alterations to existing buildings and structures for agricultural uses, agricultural-related uses, or on-farm diversified uses and expansions to an existing residential dwelling, in accordance with the Growth Plan.

7.4.12 Require that new buildings and structures used for agriculture within the Greenbelt Natural Heritage System provide a 30 metre vegetation protection zone from a key natural heritage feature or key hydrologic feature. This vegetation protection zone may consist of natural self-sustaining vegetation or agricultural crops if the land is, and will continue to be, used for agricultural purposes. However, best management practices should be pursued to protect and/or restore key hydrologic features and functions.

7.4.13 Require an environmental impact study, in accordance with Policy 7.4.15 or a natural heritage/hydrologic evaluation, for any development or site alteration outside of Urban Areas and Rural Settlements within 120 metres of a key natural heritage feature or key hydrologic feature (except where the only feature is habitat of endangered and/or threatened species) to identify a vegetation protection zone which:

a) applies minimum distance as determined by the area municipality, and examines if it is sufficient to protect the feature and its functions from the impacts of the proposed change and associated activities that may occur before, during and after construction;

b) will restore or enhance the feature and/or its function, where possible; and

c) will maintain and restore natural self-sustaining vegetation.

7.4.14 Require that for areas along the Lake Simcoe shoreline:

a) the vegetation protection zone shall be a minimum of 30 metres (or larger, if determined by an appropriate study) in shoreline Residential Areas and 100 metres for the remaining shoreline;

b) a natural heritage evaluation shall be required for any development or site alteration within 120 metres of shoreline built-up areas; and

c) an environmental impact study shall be required for any development or site alteration within 240 metres of the shoreline, outside of existing settlement areas, to ensure that development or site alteration will maintain, and to the extent possible, enhance or restore functional wildlife corridors between key natural heritage features, key hydrologic features and the Lake Simcoe shoreline.

7.4.15 Require that any proposal for development or site alteration in proximity to key natural heritage features or key hydrologic features include an environmental impact study as part of a complete application. The Region, in consultation with the area municipality, the conservation authority having jurisdiction if a conservation authority permit will be required and the Lake Simcoe Region Conservation Authority where applicable and applicant, may select and retain a qualified environmental consultant to peer review the study at the applicant's expense. Such a study shall apply to the area to be developed, or may be expanded to include additional lands, as may be deemed necessary by the Region, in consultation with the area municipality, the Lake Simcoe Region Conservation Authority where applicable and any other appropriate agency, and it shall address the following:

a) the location and nature of the development;

b) the mapping of the location and extent of the environmental conditions, which may include key natural heritage features or key hydrologic features;

c) the degree of sensitivity of the environmental conditions and an evaluation of such conditions;

d) assess the significance of the key natural heritage features and key hydrologic features, where applicable;

e) an assessment of the potential impacts including cumulative impacts on the environment;

f) the need for any measures to protect, improve and restore and/or mitigate negative impacts to key natural heritage features or key hydrologic features and functions and the surrounding environment, and definitions of such measures;

g) recommendations for appropriate vegetation protection zones, if larger than area municipal minimum widths, between the area of development and/or site alteration;

h) assess wildland fire risk due to the presence of hazardous forest types for wildland fire;

i) the need for measures to prevent the introduction and/or spread of invasive species, in accordance with Section 7.7;

j) applicable environmental considerations of the Lake Simcoe Protection Plan and/or Greenbelt Plan;

k) the requirements of a natural heritage evaluation and/or a hydrological evaluation, as detailed in the Oak Ridges Moraine Conservation Plan, in accordance with Policy 7.1.30, if applicable; and

l) any other matters deemed necessary by Council.

7.4.16 Require the preparation of an environmental impact study for aggregate resource extraction proposals, that addresses the relevant requirements of this Plan and as required by the Aggregate Resources Act. The Region, in consultation with the area municipality, may select and retain a qualified environmental consultant to peer review the study at the expense of the applicant.

7.4.17 Not require an environmental impact study for developments which satisfy the provisions of the Environmental Assessment Act, except in cases where the Integration Provision of the Municipal Engineers Association Municipal Class Environmental Assessment is utilized.

7.4.18 Ensure that if portions of key natural heritage features or key hydrologic features are damaged or destroyed by unauthorized development or site alteration, these features, functions and/or landform will continue to be subject to all relevant key natural heritage features or key hydrologic features policies of this Plan, and the lands will be restored as part of any development approval process.

Woodlands & Wetlands

Woodlands and wetlands play a critical role within the region's natural environment by providing environmental, economic and social benefits such as erosion and flood prevention, hydrological nutrient cycling, provision of clean air and long-term storage of carbon, provision of wildlife habitat, outdoor recreational opportunities and the sustainable harvest of woodland products.

It is the policy of Council to:

7.4.19 Encourage increases in woodland cover to achieve a long-term, aspirational target minimum of 40% of Durham's total land area. Watershed plans shall be utilized to assist in establishing associated targets for a watershed or smaller geographic areas and to identify the most suitable areas for enhanced woodland coverage.

7.4.20 Administer, update and implement a Regional Woodland By-law for woodlands over one hectare in size to prohibit or regulate the destruction or injury of trees.

7.4.21 Encourage area municipalities to develop tree and/or woodland conservation by-laws, in conformity with the Municipal Act, for woodlands not covered by the Regional Woodland Conservation By-law.

7.4.22 Prohibit development and site alteration within significant woodlands, as verified by an appropriate site-specific study, such as an environment impact study. Notwithstanding, mineral aggregate operations may be permitted within significant woodlands provided the applicable policy requirements of provincial plans and policies are satisfied.

7.4.23 Encourage area municipalities to identify locally significant woodlands for protection within their official plans.

7.4.24 Require an environmental impact study for development and site alteration that may have an impact on cultural woodlands to demonstrate that there will be no negative impact on the woodland.

Cultural woodlands refer to an area of land at least 0.2 hectares in size with any treed vegetation community with a canopy crown cover of over 35%, but less than 60% of the ground, determinable by aerial photography.

It is the policy of Council to:

7.4.25 Encourage the use of good forestry management practices to protect and enhance existing woodlands.

7.4.26 Maintain wetland area and the ecological and hydrological functions they provide, and enhance wetland cover through stewardship and restoration, where possible.

7.4.27 Prohibit development and site alteration within provincially significant wetlands, significant coastal wetlands and wetlands within provincial natural heritage system areas, in accordance with Policies 7.4.10 to 7.4.18. Notwithstanding, mineral aggregate operations may be permitted within non-significant wetlands, provided the applicable policy requirements of provincial plans and policies are satisfied.

7.4.28 Prohibit development and site alteration within 120 metres of wetlands, unless an approved environmental impact study and wetland water balance risk evaluation demonstrates that there will be no negative impact on the wetland or its ecological functions. Development and site alteration may be permitted within the vegetation protection zone, in accordance with Policies 7.4.10 to 7.4.18.

7.4.29 Partner with area municipalities, Indigenous communities, conservation authorities and other stakeholders in the restoration and enhancement of wetland and woodland area and function, especially in areas particularly vulnerable to the impacts of a changing climate.



7.5 Water Resources System

The water resources system in the region is made up of key hydrologic features, key hydrologic areas and their functions. Hydrologic features and areas include wetlands, lakes, aquifers and groundwater recharge and discharge areas that supply the region's drinking water and play a critical role in the natural environment.

Objectives:

i. Ensure the quality and quantity of the region's water resources and maintain, restore and enhance hydrologic functions of the water resources system.

ii. Ensure the protection of the region's water quality by regulating land uses within areas of aquifer vulnerability.

iii. Ensure that municipal water quality and quantity is protected from contamination and incompatible land uses.

Policies:

It is the policy of Council to:

7.5.1 Identify a water resources system, including key hydrologic features and key hydrologic areas, as shown on Maps 2c, 2d and 2e. Area municipalities shall further refine these features and areas within their official plans, as appropriate. Updates to key hydrologic areas mapping shall not require an amendment to this Plan.

7.5.2 Participate in coordinated efforts to study and manage water resources, in collaboration with the province, area municipalities, conservation authorities, Indigenous communities, adjacent municipalities and other stakeholders.

7.5.3 Promote and support initiatives related to the effective use, conservation and management of water resources.

7.5.4 Encourage development that protects, improves and restores hydrological features, areas and their functions and minimizes direct alteration to groundwater flows.

7.5.5 Require that formerly piped or buried watercourses, including tile drainage systems, on former agricultural lands that are brought into the Urban Area Boundary be restored at the surface, wherever possible.

7.5.6 Collaborate with the province, conservation authorities and source protection authorities to protect against potential negative impacts of development on water quality and quantity, including cross-jurisdictional and cross-watershed impacts.

7.5.7 Require that development applications demonstrate that lakes, permanent and/or intermittent streams and associated riparian areas be retained in a natural state or rehabilitated and that alterations to natural drainage systems and sediments entering a permanent and/or intermittent stream or lake will be prevented or minimized.

7.5.8 Discourage alterations to watercourses and permanent and/or intermittent streams. Minor adjustments to watercourses and permanent and/or intermittent streams may be considered by the conservation authority having jurisdiction in accordance with regulations under the Conservation Authorities Act.

7.5.9 Require that development in areas where water resources could be significantly impacted demonstrate through an appropriate study that water quality and quantity will be protected, improved, or restored.

7.5.10 Require that development applications that have the potential to impact water quantity, such as those that require a Permit to Take Water under the Ontario Water Resources Act (with the exception of applications for wetland restoration projects, domestic usage and livestock operations), be accompanied by a study verifying that there is a sufficient water supply to support the proposed use and, on a cumulative sustainable basis, confirm that there will be no negative impact on surrounding water users and the natural environment.

7.5.11 Require that an application to establish or expand a major recreational use within the Lake Simcoe watershed be accompanied by a recreational water use plan.

7.5.12 Require development on a lot where there is an abandoned well or borehole demonstrates to the satisfaction of the area municipality, that actions have been taken to decommission the well or borehole, in accordance with provincial requirements.

7.5.13 Require that area municipalities include policies and appropriate designations within their official plans, informed by watershed planning, that provide for the long-term protection of key hydrologic features, key hydrologic areas, and their functions.

7.5.14 Encourage the use of best management practices, including green infrastructure and low impact development, to support the protection, and where possible, enhancement and restoration of hydrologic functions of key hydrologic features and key hydrologic areas.

7.5.15 Permit development and site alteration, including major development within key hydrologic areas in the Greenbelt Protected Countryside, only where it has been demonstrated that hydrologic functions, including groundwater and surface water quality and quantity, of these areas will be protected, and where possible, improved and restored, in accordance with the policies this Plan and the Greenbelt Plan. The requirements of this policy do not apply to new or expanding buildings or structures for agriculture uses, agricultural-related uses or on-farm diversified uses, where the total impervious surface does not exceed 10% of the lot.

7.5.16 Ensure that new and expanded Regional infrastructure avoid key hydrologic areas unless the need has been demonstrated and there is no reasonable alternative. If avoidance is not possible, ensure that planning, design and construction practices minimize negative impacts on the hydrologic functions of these areas.

7.5.17 Encourage area municipalities to include policies within their official plans to maintain the size, diversity and connectivity of the Lake Iroquois Shoreline's key natural heritage features and key hydrologic features, areas and functions.

Aquifer Vulnerability

Vulnerable aquifers are those that are particularly susceptible to contamination. For example, from road salt, manure, pesticides, and leaching chemicals and fluids. The Clean Water Act and Oak Ridges Moraine Conservation Plan identify the locations of vulnerable aquifers and outline policies for their protection that municipalities and the province must implement.

It is the policy of Council to:

7.5.18 Identify highly vulnerable aquifers across the region and areas of high aquifer vulnerability on the Oak Ridges Moraine, shown on Map 2g. Additional areas may be identified through updates to source water protection plans or watershed studies.

7.5.19 Require that area municipalities detail highly vulnerable aquifers and areas of high aquifer vulnerability within their official plans, the location and boundaries of which shall be refined through the preparation of watershed plans or similar studies.

7.5.20 Protect highly vulnerable aquifers and areas of high aquifer vulnerability, when considering new development or site alteration by implementing the relevant requirements of the applicable source water protection plan and by prohibiting uses considered to be high risk to groundwater, as identified in Table 3 outside of designated Urban Areas. A hydrogeological investigation may also be required to assess whether other uses not included in Table 3 will be a potential risk to groundwater within highly vulnerable aquifers and areas of high aquifer vulnerability thereby requiring potential prohibitions, restrictions and/or mitigation.

7.5.21 Require a containment management plan for applications to permit high-risk land uses within in a highly vulnerable aquifer or area of high aquifer vulnerability.

7.5.22 Encourage the use of best management practices for existing land uses considered to be high risk to groundwater or those that involve the handling and/or storage of Dense Non-Aqueous Phase Liquid or Organic Solvents that are located within highly vulnerable aquifers or areas of high aquifer vulnerability.

7.5.23 Encourage area municipalities to require measures that reduce salt application, which may include a salt management plan, for development within highly vulnerable aquifers and areas of high aquifer vulnerability, recognizing that maintaining public safety is paramount.

7.5.24 Encourage restrictions for the transportation of chemicals and volatile materials along haulage routes through highly vulnerable aquifers and areas of high aquifer vulnerability.

Drinking Water Source Protection

The Region operates 12 drinking water systems across the eight area municipalities. These systems include surface water (such as Lake Ontario and Lake Simcoe) and ground water sources (such as wells). After treatment, drinking water is distributed across the region though a system of underground pipes.

The province introduced the Clean Water Act in 2006 which mandated the preparation of assessment reports and source protection plans. Source protection plans focus on protecting water at the source before it enters the drinking water treatment plant.

The policies of this Plan implement applicable policies of the Trent Source Protection Plan, Ganaraska Source Protection Plan, South Georgian Bay Lake Simcoe Source Protection Plan and the Credit Valley Toronto and Region and Central Lake Ontario Source Protection Plan. The policies of this section must be read in conjunction with the policies and mapping of the applicable source protection plan.

It is the policy of Council to:

7.5.25 Identify the boundaries of applicable source protection plans and locations of intake protection zones and wellhead protection areas on Map 2f.

7.5.26 The exact boundaries of wellhead protection areas, intake protection zones and their vulnerability scores are found in the source protection plans, which may be updated from time to time. Updates to this Plan to reflect changes in source protection plan mapping are permitted without an amendment.

7.5.27 Require that area municipal official plans and zoning by-laws include policies and detailed mapping to implement the policies of this Plan and the applicable source protection plan.

7.5.28 Require that all Planning Act applications within wellhead protection areas or intake protection zones, submitted on or after the effective date of the applicable source protection plan, conform to the policies of this Plan and the applicable source protection plan. In the event of conflict between this Plan and the source protection plan, source protection policies shall prevail.

7.5.29 Prohibit or restrict development that poses a threat to the quality and/or quantity of municipal drinking water supplies within wellhead protection areas and intake protection zones, in accordance with Tables 3 and 4, other policies of this Plan and the source protection plans.

7.5.30 Require a Section 59 Notice under the Clean Water Act, issued by the Risk Management Official, as part of a complete application for development within a wellhead protection area and/or intake protection zone – 1 (excluding the intake protection zone – 1 within the Trent Conservation Coalition Source Protection Region).

The requirement for a **Section 59 Notice** under the Clean Water Act ensures that the Risk Management Official has assessed proposed activities within vulnerable areas, before the municipality issues a building permit or planning approvals, to prevent the unintentional approval of activities that are a significant threat to municipal drinking water.

The Risk Management Official refers to the official, appointed under Part IV of the Clean Water Act, 2006, responsible for making decisions about risk management plans and risk assessments and must meet the prescribed criteria in the regulations under the Clean Water Act, 2006.

It is the policy of Council to:

7.5.31 Require that development that includes a small onsite private sewage disposal system within wellhead protection areas, with a vulnerability score of 10, comply with the following:

a) where feasible, both existing and future uses are required to connect to municipal sanitary services;

b) new private onsite sewage systems shall be designed and constructed in accordance with the standards of the Ontario Building Code. Lot creation, where permitted outside of wellhead protection area – A shall adhere to regional and provincial guidelines for lot sizing. The study requirements of Ministry of the Environment, Conservation and Parks Guidelines D-5-4 shall apply, regardless of the number of lots being proposed; and

c) require that vacant lots of record within the Credit Valley, Toronto and Region and Central Lake Ontario Source Protection Plan area, be subject to site plan control to ensure that new private onsite sewage systems including replacement beds are located outside of wellhead protection area – A and B.

7.5.32 Prohibit the establishment of large (greater than 10,000 litres) septic systems within wellhead protection areas with a vulnerability score of 10, unless the proponent can demonstrate that the proposal will meet the requirements of the applicable source protection plan.

7.5.33 Prohibit the establishment of stormwater management facilities and associated discharge within wellhead protection areas with a vulnerability score of 10 or any intake protection zone, unless the proponent can demonstrate the proposal will meet the requirements of the applicable source protection plan.

7.5.34 Ensure that new sewage system infrastructure, including sanitary sewers and related pipes, are located outside of wellhead protection areas and any intake protection zone wherever possible, and comply with additional requirements of the applicable source protection plan.

7.5.35 Prohibit the establishment of sewage storage and treatment facilities, including associate discharge within wellhead protection area – A, with a vulnerability score of 8 to 10 and those activities plus industrial effluent discharges within any intake protection zone, unless the requirements of the applicable source protection plan are met.

7.5.36 Ensure development that proposes the construction of impervious surfaces within wellhead protection areas with a vulnerability score of 10 considers the impact of the application of road salt in accordance with the policies of the applicable source protection plan.

7.5.37 Prohibit new parking lots greater than 2,000 square meters within wellhead protection area – A within the Credit Valley, Toronto and Region and Central Lake Ontario Source Protection Plan Area. Where new roads or parking lots are proposed within wellhead protection area – B with a vulnerability score of 10, a salt management plan is required as part of a complete application.

7.5.38 Encourage restrictions on the transportation of chemicals and volatile materials along haulage routes through wellhead protection areas.

A **salt management plan** should include, but not be limited to mitigation measures regarding design of parking lots, roadways and sidewalks to minimize the need for repeat application of road salt, such as reducing ponding in parking areas; and directing stormwater discharge outside of vulnerable areas, where possible.

It is the policy of Council to:

7.5.39 Require that new development within the wellhead protection area – Quantity 1/Quantity 2, as shown on Map 2f, demonstrate that pre-development water recharge will be maintained to the greatest extent possible through best management practices such as low impact development.

7.5.40 Require that development applications to facilitate major development for residential, commercial, industrial and institutional uses, north of the downgradient line within the wellhead protection area – Quantity 1/Quantity 2, as shown on Map 2f, provide a water balance study demonstrating that pre-development recharge will be maintained to the greatest extent feasible through best management practices such as low impact development, minimizing impervious surfaces and lot level infiltration. Where pre-development recharge rates cannot be maintained, offsite compensation may be considered.

7.5.41 Permit development or site alteration that includes a Permission to Take Water within wellhead protection area – Quantity 1/Quantity 2, only where approval for the Permission to Take Water has been issued by the Ministry of the Environment, Conservation and Parks.

7.5.42 Permit Settlement Area Boundary Expansions, in accordance with Section 5.7, within the wellhead protection area – Quantity 1/Quantity 2, only where:

a) it has been demonstrated that the recharge functions of significant groundwater recharge area will be maintained;

b) it has been demonstrated that the aquifer has sufficient capacity;

c) the expansion will not have an adverse effect on the ability of the aquifer to meet water supply requirements for current and planned capacity; and

d) that the hydrological integrity of the municipal wells will be maintained.

7.5.43 Prohibit geothermal wells within wellhead protection area – A and B with a vulnerability score of 8 to 10 and ensure that geothermal systems locate above municipal aquifers within wellhead protection areas.

7.6 Natural & Human Made Hazards

Natural hazards such as flooding, erosion and slope failures, dynamic beaches and wildland fire have the potential to cause significant harm to public health and safety when people and property locate in areas where these natural processes occur. In addition, the impacts of a changing climate have the capacity to increase the rate and severity of natural hazards.

Objective:

i. **Promote a coordinated approach to regulating development and site alteration within natural hazard lands to ensure public health and safety, protect property and mitigate risks associated with a changing climate.**

Policies:

It is the policy of Council to:

7.6.1 Direct development away from natural hazard lands or human-made hazards.

7.6.2 Direct intensification, including through change in use, lot creation or additional units, away from natural hazard lands, unless permitted within a Floodplain Special Policy Area described within an area municipal official plan.

7.6.3 Prohibit, unless permitted by provincial policies or regulations, development and site alteration within:

a) the dynamic beach hazard;

b) areas that would be rendered inaccessible to people and vehicles during times of flooding hazards, erosion hazards and/or dynamic beach hazards, unless it has been demonstrated that the site has safe access appropriate for the nature of the development and the natural hazard; and

c) a floodway regardless of whether the area of inundation contains high points of land not subject to flooding.

Dynamic Beach Hazard refers to areas of inherently unstable accumulations of shoreline sediments along the Great Lakes – St. Lawrence River System and large inland lakes, as identified by provincial standards, as amended from time to time. The dynamic beach hazard limit consists of the flooding hazard limit plus a dynamic beach allowance.

It is the policy of Council to:

7.6.4 Recognize Floodplain Special Policy Areas as identified within area municipal official plans.

7.6.5 Prohibit development of institutional uses, essential emergency service uses, and uses associated with the disposal, manufacture, treatment, or storage of hazardous substances within natural hazard lands.

7.6.6 Support policies and programs of the conservation authorities that represent best practices in shoreline management, such as those identified in established shoreline management plans.

7.6.7 Require area municipalities to update their official plans and zoning by-laws to reflect mapping and policy recommendations from completed flood plain, erosion, slope stability studies and shoreline management plans to ensure effective regulation of development and site alteration within natural hazard lands.

7.6.8 Support studies that guide the long-term protection of the Lake Ontario waterfront to protect property and infrastructure from flooding and erosion, and collaborate with area municipalities and conservation authorities on implementation of mitigation measures identified in such studies.

7.6.9 Collaborate with area municipalities and conservation authorities to ensure that watershed plans, and other strategies and initiatives consider the impacts of a changing climate that increase the risks associated with natural hazards and provide recommendations to mitigate such risks.

7.6.10 Encourage the transfer of natural hazard lands to public agencies through the development approvals process.

7.6.11 Require area municipalities to ensure hazardous forest types for wildland fire are considered through an environmental impact study when development is proposed in or adjacent to areas at risk for wildland fire.

7.6.12 Require area municipalities to include policies in their official plans to direct development outside of lands that are unsafe for development due to the presence of hazardous forest types for wildland fire, unless provincial wildland fire assessment and mitigation standards are applied.

7.6.12.1 Wildland fire mitigation measures shall not be permitted in significant wetlands and significant coastal wetlands.

7.6.12.2 Wildland fire mitigation measures shall not be permitted in significant woodlands, significant valleylands, significant wildlife habitat, significant areas of natural and scientific interest, coastal wetlands and fish habitat as well as adjacent lands unless it has been demonstrated that there will be no negative impacts on the natural features or their ecological functions.

7.6.13 Require area municipalities to ensure the necessary measures are in place to address and mitigate known hazards for development on, abutting or adjacent to lands affected by mine hazards; oil, gas, and salt hazards; and former mineral mining operations, mineral aggregate operations or petroleum resource operations.

7.6.14 Encourage area municipalities to partner with conservation authorities to identify remediation and mitigation opportunities within natural hazard lands.

7.7 Environmental Stewardship

Environmental stewardship includes active participation in conservation efforts and collaborative planning by the Region, area municipalities, conservation authorities, Indigenous communities, local organizations, the province and residents to restore and enhance the natural environment. Stewardship of the natural environment is necessary to ensure the sustainability of the region's communities.

Objectives:

i. Promote the protection, restoration and enhancement of the region's natural environment through environmental stewardship initiatives.

ii. Promote invasive species management strategies to reduce the introduction and spread of invasive species.

iii. Promote the increase of public ownership of natural heritage and natural hazard lands through land securement.

Policies:

It is the policy of Council to:

7.7.1 Seek partnerships with area municipalities, Indigenous communities, conservation authorities, provincial agencies and other organizations in the stewardship of land and water resources.

7.7.2 Recognize the importance of traditional ecological knowledge in understanding the natural environment, including cumulative impacts, by establishing and maintaining relations with Indigenous communities to facilitate the sharing of traditional ecological knowledge.

7.7.3 Investigate and facilitate the sharing of traditional ecological knowledge with the highest standards of practice, with consideration for ownership, control, access and possession (OCAP) principles that establish how First Nations data should be collected, protected, used and/or shared in relation to the use of traditional ecological knowledge.

7.7.4 Encourage area municipalities to include environmental stewardship policies within their official plans.

7.7.5 Work with area municipalities, Indigenous communities, conservation authorities, the province, school boards, post-secondary institutions and other stakeholders to provide education to support environmental stewardship as it relates to:

a) urban agriculture and community gardens;

b) waste management, including recycling and composting, in accordance with Section 4.2;

c) invasive species management;

d) low impact development and design;

e) farmland restoration, including hedgerows, riparian buffers, stream crossing alternatives, culvert replacements and wetland restoration;

f) wildlife connectivity and habitat protection;

g) shoreline restoration; and

h) low carbon lifestyles and behaviours.

7.7.6 Support the inclusion of environmental stewardship initiatives as part of trail building and maintenance.

Invasive Species Management

Invasive species are non-native plants, animals, insects and other micro-organisms that spread when introduced outside of their natural distribution and cause serious and often irreversible damage to ecosystems, the economy and society.

While many invasive species are introduced by humans, the impacts of a changing climate contributes to the spread of invasive species within our communities.

Figure 18. – Common invasive species in Ontario:



It is the policy of Council to:

7.7.7 Collaborate with area municipalities, Indigenous communities, conservation authorities, provincial agencies and other organizations in carrying out invasive species management, including ongoing monitoring of invasive species, and assisting in the development of invasive species management plans, where appropriate.

7.7.8 Require that development applications adjacent to key natural heritage features demonstrate, as part of an environmental impact study, safeguards against the introduction and spread of invasive species during construction.

7.7.9 Discourage new developments and redevelopments from utilizing non-native plants and require the inclusion of native and drought tolerant vegetation, where appropriate.

7.7.10 Commit to the consideration of planting native species on regionally owned properties and along transportation and utility corridors, as opportunities arise.

Land Securement

Securing interests in land, through purchases, donations, conservation easements, and other methods help municipalities and conservation authorities protect natural heritage features and environmentally significant areas.

It is the policy of Council to:

7.7.11 Support the use of various land securement tools as a means of protecting and enhancing the region's natural environment.

7.7.12 Support the acquisition of land in appropriate locations by area municipalities and/or conservation authorities for natural heritage conservation purposes, in accordance with Policy 11.3.23.

7.7.13 Pursue funding opportunities to support land securement for conservation purposes, based on the following considerations:

a) location within the regional natural heritage system and enhancement opportunity areas, key natural heritage features, key hydrologic features, and natural hazard lands;

b) establishment of a regional trail network;

c) damaged or degraded areas;

d) nature and immediacy of threats to an area;

e) proximity of an area to existing property in public ownership;

f) the overall cost of purchase and long-term management of an area; and

g) any other consideration identified through a Council approved land securement strategy.





Chapter 8

Connected Transportation System

Chapter 8. Connected Transportation System

The Region has a Connected Transportation System that supports healthy and complete communities, offering residents and businesses practical and efficient mobility options for trips to work, school and other destinations within and beyond Durham Region. The Transportation System supports a range of travel modes using transportation facilities such as roads, railways, sidewalks, trails, public transit, commuter and other parking lots, harbours, marinas and airports.

The bond between land use and transportation includes connectivity between different modes of travel, and compact and mixed land use patterns that encourage the use of sustainable modes such as walking, cycling and public transit. A Connected Transportation System helps to reduce the number of vehicle trips in the system and carbon emissions. Providing opportunities for more options on how to travel helps create safe and convenient movement of people of all ages and abilities. It also allows for more efficient goods movement to support economic development and fulfill the needs of residents and businesses.

Goals:

I. **Provide a connected Transportation System that is integrated, safe, efficient, reliable and fiscally sustainable to meet existing and future needs of the region's residents and businesses.**

II. **Strategically invest in the Transportation System by providing a range of accessible travel options, including low carbon mobility choices for residents of all ages and abilities.**

III. **Design and construct transportation infrastructure to reduce GHG emissions, mitigate the effects of the Transportation System on the natural environment and climate, and to be more resilient by adapting and/or mitigating the effects of climate change on the Transportation System.**

IV. **Facilitate the movement of people and goods through a complete streets approach to accommodate all modes of transportation, and strengthen the inter-dependency between transportation and land use.**

8.1 Transit Priority Network

As Durham grows and intensifies, public transit will take on a much greater role in meeting travel demand needs. Expanding the transit system will provide Durham residents with more convenient access to jobs and services within and outside of the region. Public transit supports complete and compact communities by focusing higher levels of transit service where urban densities are currently or planned to be the most concentrated.

The Transit Priority Network forms the backbone of the region's transit network and is intended to provide fast, frequent and direct service to Urban Growth Centres, Regional Centres, Rapid Transit Corridors, Protected Major Transit Station Areas and other major destinations across Durham Region and within the Greater Golden Horseshoe.

Objectives:

i. Enhance the role of transit in creating efficient, compact and complete communities, and supporting increased densities within Urban Areas.

ii. Support an integrated and coordinated long-term framework to plan for reliable, accessible and convenient transit services and infrastructure across the region.

iii. Increase the availability of transit and its share of overall trips, especially during morning and afternoon peak periods.

iv. Support access to transit services for all Durham residents through demand responsive services, advanced technologies, active transportation connections and improved integration with other transit service providers.

Policies:

It is the policy of Council to:

8.1.1 Support the planning, design and operation of an integrated and coordinated Transit Priority Network, as designated on Map 3a.

8.1.2 Provide appropriate inter-regional and inter-municipal service through the Transit Priority Network, consisting of following elements:

a) Rapid Transit Spine: planned to provide dedicated transit lanes in most arterial road sections and intersect with local transit services;

b) High Frequency Transit Network: consists of buses in planned High Occupancy Vehicle (HOV) lanes, or buses in mixed traffic, with transit signal priority at major intersections and other measures to ensure fast and reliable transit service. Planned HOV lanes may be converted to dedicated bus lanes as growth in ridership warrants;

c) Other Transit Connection: facilitates longer-distance trips, providing direct links between smaller Urban and Rural Areas and connecting these areas to Commuter Stations, Rapid Transit Spines, High Frequency Transit Network or Freeway Transit;

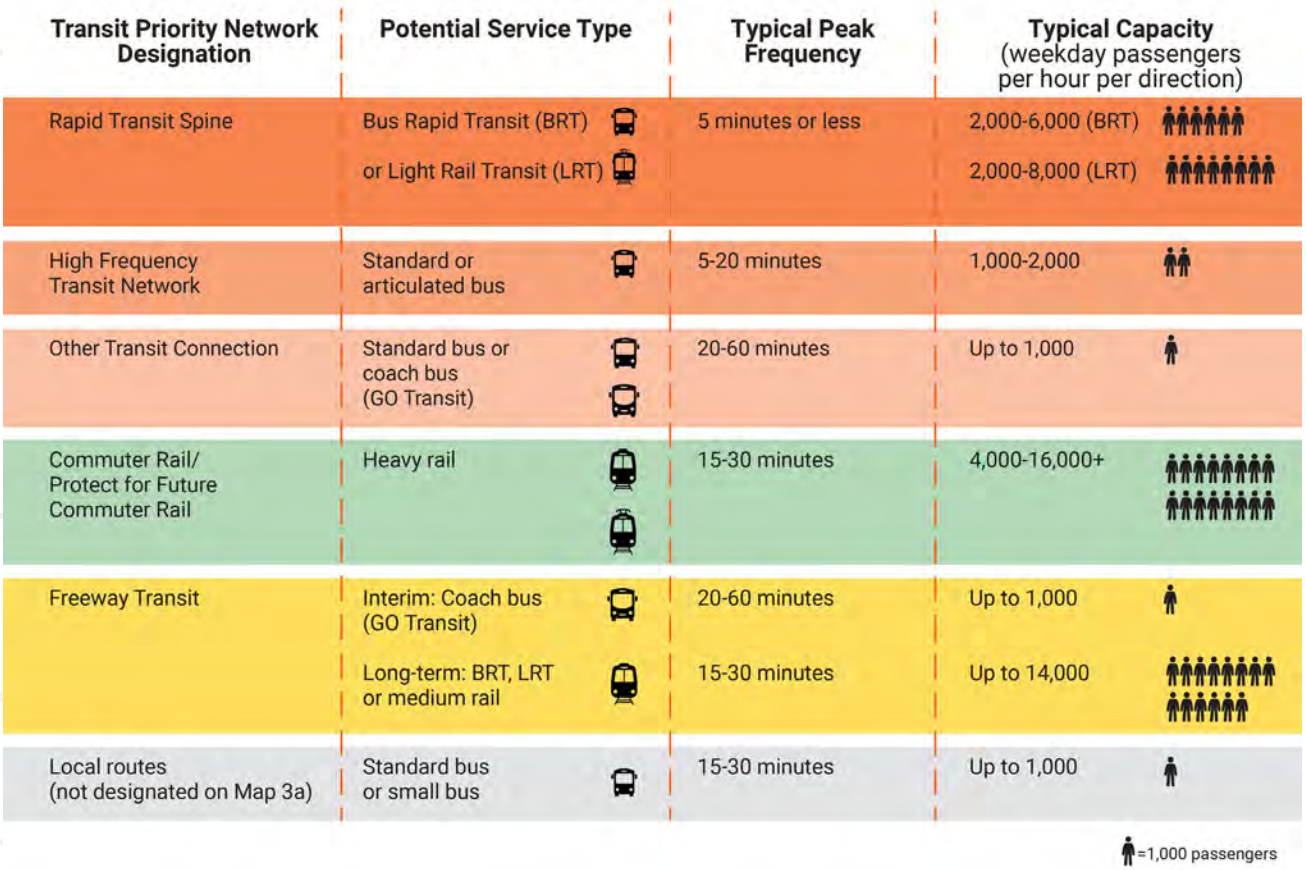
d) Commuter Rail: carries passengers at high rates of speed over longer distances and links to Commuter Stations within Protected Major Transit Station Areas, providing transfer points to other transit services and transportation modes;

e) Protect for Future Commuter Rail: corridors that identify future connections on existing rail corridors; and

f) Freeway Transit: facilitate long-distance inter-regional and inter-municipal transit trips within the Highway 407, 412 and 418 rights-of-way. The designation of Freeway Transit supports the implementation of frequent bus service with transit terminals within dedicated commuter parking lots at interchanges, which is planned to evolve to a dedicated transitway facility beside the freeway in the long-term.



Figure 19. – Transit Priority Network Characteristics:



It is the policy of Council to:

8.1.3 Achieve transit-oriented development within Strategic Growth Areas to support increased transit use and higher levels of service, achieved through the following principles and in accordance with Policy 5.2.8:

a) design arterial roads, through a complete streets approach, to help control traffic speeds while promoting safe and attractive environments for active transportation and transit use;

b) enhance mobility to and from transit services including more frequent intersections and pedestrian crossings where feasible;

c) maintain and encourage on-street parking in historic downtowns and on certain Type C Arterials, as specified in Table 5;

d) provide facilities which support non-auto modes including Commuter Stations, transit terminals with potential drop off facilities and bus loops, bus bays, bus shelters, bike racks, walkways, trails and other pedestrian and cycling facilities;

e) encourage provisions for alternative development standards, including reduced minimum parking requirements, potential redevelopment of existing surface parking and the establishment of maximum parking requirements for both privately initiated development applications and area municipal zoning by-laws, which are tailored to the level of transit service proposed; and

f) create and apply a regional transit-oriented development guideline to be used for reviewing development applications within Strategic Growth Areas, in collaboration with the area municipalities.

8.1.4 Achieve transit-supportive development for existing and future transit services within Urban Areas outside of Strategic Growth Areas, particularly along Regional Corridors served by the High Frequency Transit Network, through the following principles:

a) create an urban grid system of street and walkway patterns, and active transportation connections, connecting bus stops to active transportation;

b) support active places and streetscapes, with a wide range and mix of medium and high-density uses, including orienting buildings towards the street to reduce walking distances to transit facilities;

c) limit surface parking, especially in front of buildings, and supporting the potential redevelopment of existing surface parking where appropriate; and

d) provide facilities which support non-auto modes including: bus bays, bus shelters, bike racks, walkways, trails and other pedestrian and cycling facilities.

8.1.5 Create a network of Commuter Stations, terminals and bus stops within Urban Areas that allow for 80% of residents and workers to be within a reasonable walking distance (500 metres, representing a five-minute walk) from the nearest one.

8.1.6 Provide suitable transit services to newly developing areas as early as possible, including demand responsive services, as technically and financially feasible.

8.1.7 Support the implementation of the Lakeshore East GO rail service to Bowmanville, including the development of Transit Oriented Communities within the Protected Major Transit Station Areas and GO rail service to the Seaton community within the Pickering Urban Area, as indicated on Map 3a.

8.1.8 Support the investigation of further extensions of rail passenger service and stations along existing rail corridors, highway and hydro corridor rights-of-way, including the CPR Havelock Line for VIA Rail High Frequency Rail and the Metrolinx-owned Uxbridge Line.

8.1.9 Encourage and work with Metrolinx, provincial, municipal and federal governments to plan for improved inter-regional transit connections, including Freeway Transit and Other Transit Connections designated on Map 3a.

8.1.10 Integrate or protect for future transit terminals identified in the Durham Transportation Master Plan and/or Durham Region Transit service plans, through the development application review process.

8.1.11 Implement transit stops for local routes located internal to or abutting a development when sidewalks are constructed, and making them a direct responsibility of the developer to construct or fund as a condition of development approval.

8.1.12 Adapt to emerging technologies and different types of service that improve transit operations, availability, user experience and provide seamless access to the transit system for passengers.

8.2 Active Transportation

Increasing active transportation as a mode of travel, particularly walking and cycling, contributes to personal well-being, encourages social interaction, and improves access to transit and destinations for persons of all ages and abilities.

Active transportation infrastructure is a shared responsibility between the region and area municipalities.

Objectives:

i. Promote the importance of active transportation in achieving healthy and complete communities that support quality of life and help municipalities maximize their investments in infrastructure.

ii. Support a reduced reliance on automobiles, and single-occupant vehicles in particular, and support access to transit through active transportation modes for work, school and other utilitarian trips.

iii. Ensure a safe and integrated network of active transportation facilities that support increased densities within Urban Areas and provide enhanced recreational and tourist access to green spaces and rural areas.



Policies:

It is the policy of Council to:

8.2.1 Implement the Regional Active Transportation Network designated on Map 3d, in cooperation with the area municipalities, conservation authorities and the Provincial Ministry of Transportation (MTO).

8.2.2 Implement a Regional Cycling Plan, in cooperation with the area municipalities, and update it on a regular basis. The Regional Cycling Plan will:

a) recognize that cycling facilities form part of a balanced, multi-modal transportation system;

b) establish a network of on and off-road cycling facilities across the region;

c) provide policies and programs to address matters of encouragement, enforcement, education, engineering and funding; and

d) recommend actions and a proactive phasing approach for the implementation of the Regional Cycling Plan's policies, programs and cycling network, in association with area municipal and conservation authority projects and activities.

8.2.3 Construct a safe, direct, comfortable, attractive and convenient active transportation network to serve the needs of people of all ages and abilities, and reduce barriers for access, working with the area municipalities in accordance with agreed principles of jurisdiction and cost-sharing to:

a) ensure pedestrian and cycling access to Commuter Stations, bus terminals and stops;

b) promote neighbourhood walkability and the integration of cycling facilities;

c) address accessibility requirements in the design of new or reconstructed pedestrian and cycling facilities; and

d) prioritize improvements in areas of high need including Strategic Growth Areas and Durham's Priority Neighbourhoods, in areas with existing or projected high volumes of pedestrians and/or cyclists, and near amenities that are frequented by seniors or students.

8.2.4 Establish and implement a central regional east-west active transportation corridor, referred to as the Durham Meadoway, primarily through the Gatineau Hydro Corridor in partnership with area municipalities, conservation authorities and utility providers.

8.2.5 Promote the integration of different modes of transportation through cycling and transit-supportive facilities such as weather-protected bike racks and secured bike storage at Commuter Stations, bus terminals and stops.

8.2.6 Recognize and support the role of the Region to ensure the safe, year-round operation of cycling and transit facilities through design, signage, enforcement and maintenance, in collaboration with the area municipalities.

8.2.7 Implement road safety measures in accordance with the Region's Vision Zero Strategic Road Safety Action Plan in the design of facilities to support active transportation, including measures to control traffic speeds while promoting safe and attractive environments for vulnerable road users (e.g. pedestrians, cyclists and users of power-assisted devices).

The **Durham Region Vision Zero Strategic Road Safety Action Plan** (SRSAP), approved by Regional Council in 2019, is an overall strategy to reduce motor vehicle fatalities and injuries within the region. Vision Zero is a road safety concept that originated in Sweden in 1997 and has been adopted in various forms around the world. The core mandate of Vision Zero is that in recognizing that while humans make mistakes, no loss of life resulting from a motor vehicle collision is acceptable. The road system needs to keep people moving, but it must also be designed to protect people at every turn. This protection can take one of two forms: preventing collisions from occurring or designing the road network to minimize the consequences of collisions that do occur.

As a guiding principle, safety is prioritized over factors upon which decisions were traditionally made such as cost, speed, delay, level of service, and convenience. The vision for the SRSAP is that zero people are killed or injured across all modes of transportation, and that as a stepping stone, the near-term goal is that there is a minimum 10% reduction of fatal and injury collisions within five years (2019-2023).

It is the policy of Council to:

8.2.8 Encourage area municipalities to enhance active transportation environments, and to:

a) provide and coordinate informational signage and wayfinding systems to support exploration and travel, in collaboration with the Region;

b) support extending new active transportation facilities into new development areas as early as possible; and

c) ensure that bicycle parking is incorporated into new developments and existing public facilities.

8.2.9 Pursue grant opportunities in partnership with the federal and provincial governments, and other funding sources, for implementing active transportation facilities and programs.

8.3 Transportation Demand Management

Transportation Demand Management (TDM) is a set of measures intended to reduce morning and afternoon peak vehicular demand on the transportation network by encouraging people to use sustainable travel options such as active transportation, transit, carpooling, or by providing flexible work arrangements that allow people to work from home or commute at different times. Given the limited ability to expand the capacity of the road network, effective TDM measures will be critical to maintain or improve mobility while achieving the Plan's objectives for increased density in Urban Areas.

Objectives:

i. **Promote Transportation Demand Management to help reduce average trip distances and peak hour auto travel and increase the mode share of active transportation and transit.**

ii. **Promote Transportation Demand Management measures in the development review process, appropriate for the type, scale and land use context in which the development is proposed.**

iii. **Support investments that advance active transportation, transit, goods movement and overall safety over those that primarily benefit single-occupant vehicle capacity.**

Policies:

It is the policy of Council to:

8.3.1 Prepare a comprehensive regional TDM program as part of an effort to reduce single occupant vehicle dependency, curb growth in automobile trips overall, and help reduce the impacts of a changing climate by encouraging and supporting:

a) employers to promote carpooling, flexible work arrangements including working at home, commuting by bike and providing transit passes or fare discounts;

b) Durham residents to carpool and use transit services, through the use of technology and promotional materials;

c) school boards within Durham to increase student travel using active transportation and transit, in collaboration with affiliated transportation consortiums and Durham Region Transit;

d) the establishment, implementation and operation of bike share or auto share programs by the Region and/or public or private sector service providers that integrate with public transit; and

e) commuter lots for carpooling, including the provision of dedicated carpool parking spaces at public community facilities in the region's smaller urban and rural areas.

Active and Sustainable School Travel (ASST) programs aim to increase the proportion of youth walking, biking, wheeling and taking transit – assisting with the implementation of the Regional Cycling Plan's programs, as well as supporting school boards to increase student travel using active transportation, in accordance with Policies 8.2.2 d) and 8.3.1 c).

ASST programs focus on creating safer environments for school-aged travelers of all abilities and fostering healthier and more sustainable transportation habits. Creating environments that support ASST requires actions, including:

- developing programs, resources, and policies to promote active transportation and provide road safety education to all road users;
- implementing safety enhancements and traffic calming measures to support walking and cycling; and
- pursuing joint outcomes and between various departments and external organizations, including school boards, police and non-governmental organizations.

It is the policy of Council to:

8.3.2 Implement regional TDM guidelines for new development as part of the development application process, in collaboration with the area municipalities. The TDM guidelines will:

a) identify the scope of TDM measures that should be implemented depending on the location, scale and type of development being proposed;

b) integrate the review and identification of TDM measures as part of a transportation impact study, where required; and

c) support the application of TDM measures in exchange for reduced parking standards in appropriate locations.

8.3.3 Support commuters by including end of trip active transportation facilities, such as showers and change rooms, for office, commercial and industrial developments, consistent with the TDM guidelines identified in Policy 8.3.2.

8.3.4 Encourage area municipalities to implement parking management policies and zoning by-laws in consultation with the Region and related agencies to support the implementation of TDM measures that detail:

a) minimum and maximum parking requirements that reflect the walking distance to transit and complementary uses;

b) shared parking requirements, where possible, reflecting variances in parking demand between complementary uses on a time-of-day, weekday/weekend and monthly basis;

c) on-street parking requirements;

d) site designs that orient main building entrances to face the public street, provides a pedestrian-friendly urban form and discourages the placement of surface parking spaces between the main building entrance and the major street, where appropriate;

e) the design of surface parking lots to enable further development; and

f) preferential locations for carpooling and car-sharing spaces and bicycle storage requirements.

8.3.5 Encourage urban design measures that facilitate the use of active transportation and transit.

8.3.6 Support the implementation of Mobility as a Service (MaaS) technologies that improve the efficiency of transportation infrastructure, reduce energy, resource consumption and carbon emissions.

Mobility-as-a-Service (MaaS) describes a shift away from personally owned modes of transportation and towards mobility solutions that are consumed as a service. MaaS typically requires some type of transportation/mobility aggregator to bring together all of the mobility options and approaches within a community (public transit, bikeshare, carshare, rideshare, microtransit) and provide an integrated platform for users to plan trips, monitor progress, and pay for the services used, either through a subscription package or as an individual trip.

It is the policy of Council to:

8.3.7 Work with the province to investigate the feasibility of implementing dedicated commuter parking lots along Highways 407, 412 and 418 as identified through Policy 8.1.2, and along other provincial highways, to support carpooling and inter-regional transit use.

8.3.8 Investigate the need for a regional parking strategy and parking agency, in partnership with Metrolinx and the area municipalities, to support TDM measures with a focus on parking within Strategic Growth Areas.

8.4 Road Network & Design

This Plan provides for the protection and development of an integrated hierarchy of roads comprised of freeways, arterial, collector and local roads. The road network is under the jurisdiction of the province, region and area municipalities, and neighbouring municipalities for certain boundary roads.

While the focus of this Plan is on policies that pertain to the planning and design of the arterial road network, the overall road network is the most important component of the transportation system. It provides the framework for urban growth and development, while facilitating the safe and convenient movement of goods and people, within and to/from destinations outside of the region. Policy decisions for road network planning and design also have an important influence on overall community climate resilience and GHG emissions.

Applying a complete streets approach to the planning and design of the road network can improve safety, comfort, access and mobility for all road users, especially pedestrians and cyclists, transit riders and goods movement, while continuing to effectively accommodate cars, emergency services and maintenance operations. A complete streets approach aims to ensure that the design of roads is appropriate for their intended role and function in the context of the adjacent existing and planned land uses to serve the needs of residents and businesses. Planning for the road network also requires a long-term view, by identifying appropriate right-of-way for future road improvements and protecting for new arterial roads.

Objectives:

i. Ensure the optimization of transportation infrastructure along transit and transportation corridors to support the achievement of complete communities, including accommodating more compact built form and enabling development that is low carbon and climate resilient.

ii. **Ensure the road network maintains the historic grid system of roads to support the desirable urban form, the movement of people by active transportation, transit and the automobile, and to facilitate the efficient movement of goods.**

iii. **Promote greater efficiencies on the road network through technologies that enhance and optimize traffic operations, and targeted road improvements or modifications within the available right-of-way.**

iv. **Ensure the protection of freeway and arterial road corridors from uses which may jeopardize the implementation and operation of such corridors.**

Policies:

It is the policy of Council to:

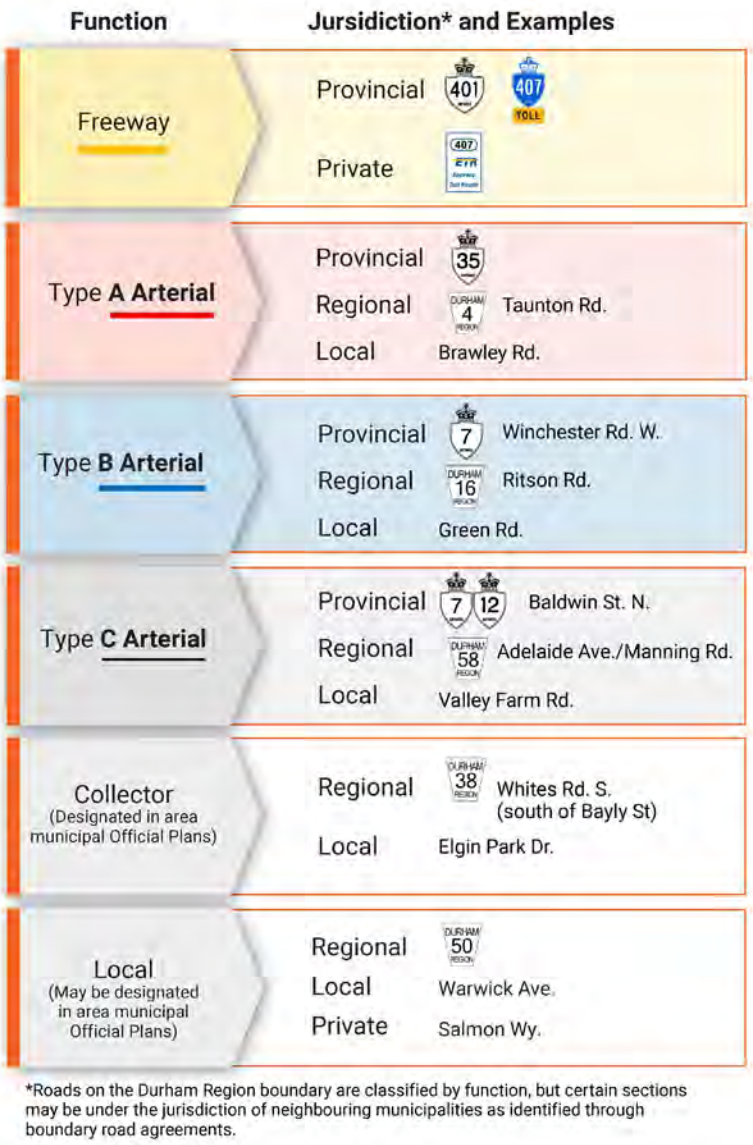
8.4.1 Identify an integrated hierarchy of roads comprised of freeways, Type A, Type B and Type C Arterial roads within the region on Map 3b, without regard to present or future jurisdiction. This Plan does not imply that Regional Council will assume jurisdiction over roads shown on Map 3b which are not currently under the jurisdiction of the Region. Changes in road jurisdiction do not require an amendment to this Plan.

8.4.2 Encourage area municipalities to designate a grid network of collector roads in their official plans.

8.4.3 Recognize that the alignments of freeways and arterial roads designated on Map 3b are approximate. The design and construction of these roads shall take place after more detailed planning and engineering studies have been carried out. Any change to the alignment of the designated freeways and arterial roads that is in keeping with the goals and intent of this Plan shall not require an amendment to this Plan.



Figure 20. – Arterial road classifications:



It is the policy of Council to:

8.4.4 Design Type A, Type B and Type C Arterial roads according to accepted planning, urban design and traffic engineering principles and in accordance with a complete streets approach, subject to site specific conditions, including:

a) provision of transit-related improvements as designated on Map 3a;

b) the provision of active transportation facilities as designated on Map 3d and identified in the current Regional Cycling Plan and area municipal active transportation plans;

c) the implementation of Arterial Road Criteria and Regional Road Right-of-Way Requirements as specified in Tables 5 and 6;

d) the integration of safe road crossing locations for pedestrians and cyclists between arterial road intersections where appropriate and feasible;

e) the provision of appropriate turning radii at intersections to facilitate commercial vehicle turning movements, where needed; and

f) the implementation of pavement structure upgrades to eliminate seasonal weight restrictions for goods movement, particularly for roads identified on Map 3c.

8.4.5 Protect the designation of arterial roads on Map 3b by requiring any proposals to delete any section of arterial road submitted by an area municipality or development application to be supported by a transportation study. The transportation study must set a specific study area in consultation with the Region and demonstrate that:

a) construction of the subject section of arterial road is not feasible due to environmental or physical constraints;

b) deletion of the arterial road does not have an adverse impact on connectivity for transit, active transportation or vehicular capacity, including the long-term operations of surrounding major intersections (by 2051 or a 20-year period, whichever is longer); and

c) alternative(s) to the arterial road deletion are presented, with supporting rationale, to ensure sufficient long-term connectivity.

8.4.6 Encourage area municipalities to ensure that a designated grid network of collector roads or streets that support connectivity within and between developments, including the accommodation of transit and active transportation facilities, be included in their respective official plans. If a designated collector road is to be deleted or modified from an area municipal official plan through the development review process, the Region may request additional study to ensure that the transportation impacts do not unduly affect the adjacent arterial road network.

8.4.7 Require lands be dedicated for road widenings through the approval of development applications abutting arterial roads designated on Map 3b. The dedication of land shall be determined based on the following:

a) the extent of the right-of-way that may be required in accordance with Policy 8.4.4;

b) right-of-way requirements identified through an Environmental Assessment study, corridor study or other similar planning process;

c) generally taking widenings equally on either side of the centre line of existing roads, except where equal widenings are impractical due to factors including, but not limited to topography, grade separations, channelization, road alignment or existing development;

d) the need for sufficient right-of-way to accommodate features such as grading, utilities, active transportation facilities, transit facilities, landscaping, stormwater management infrastructure, noise attenuation installations, medians, traffic signals or other traffic control devices, roundabouts, auxiliary lanes, bridges, interchanges, and intersection sight triangles including at intersections of an arterial road and a railway. The extent of the widening shall be based on the specific characteristics of the location and shall be determined in accordance with accepted engineering design criteria; and

e) the need to provide active transportation and transit facilities.

8.4.8 Recognize the importance of the current and planned expansions to the provincial highway system, in planning for continued economic development, supporting goods movement, and accommodating inter-regional transit.

8.4.9 Support improvements to the provincial highway network such as:

a) the expansion of Highway 401, including the construction of new or improved interchanges;

b) the extension of Highway 404 and the related widenings of Highways 12 and 48;

c) improvements to Highways 7, 7A, 7/12, 35 and 35/115; and

d) realignment of the Highway 7/12 intersection at Thickson Road may be updated without amendment to this Plan.

8.4.10 Recognize that although provincial highways are designated on Map 3b, these highways are under the jurisdiction of MTO, which has sole responsibility for such matters as standards, design criteria and widening requirements.

8.4.10.1 Ensure MTO is consulted on all proposed development that is adjacent to or in the vicinity of provincial highways within MTOs permit control area under the Public Transportation and Highway Improvement Act.

8.4.11 Support the further study of Conceptual Future Interchanges to improve freeway access and support development, in consultation with MTO, on Highways 401 and 407 as designated on Map 3b.

8.4.12 Recognize the need to improve east-west transportation linkages at the west Durham boundary and continue to explore opportunities with the affected jurisdictions to enhance inter-regional connections between Durham Region and municipalities to the west. This will be achieved by:

a) advocating the importance of inter-regional transportation improvements such as the widening of Steeles Avenue (west of Beare Road) and Highway 7 (west of Brock Road); and

b) despite policies regarding the Rouge National Urban Park precluding additional inter-regional arterial road connections south of Steeles Avenue, protecting for the Alexander Knox Road (realigned Whitevale Road) in the City of Pickering to 14th Avenue in York Region and collaborating with the affected municipalities to ensure that the proposed road connection is implemented.

8.4.13 Reduce the impacts of arterial road traffic through Hamlets and historic downtowns, including road design and/or operational measures to reduce traffic speeds and/or volumes and to improve safety and comfort for active transportation. A by-pass may also be considered as a potential solution. Prior to designating new by-passes of arterial roads within this Plan, a by-pass study will be undertaken in consultation with affected stakeholders to demonstrate the feasibility of the by-pass and to examine:

a) the need for the by-pass;

b) alternatives to the by-pass;

c) the transportation, land use, environmental, socio-economic and cultural heritage impacts associated with each alternative, including the status quo;

d) a vision and design considerations for the preferred alternative;

e) a detailed cost-benefit analysis for the preferred alternative; and

f) an implementation plan.

8.4.14 Advance the need to improve east-west transportation linkages south of Highway 401 and grade separations north-south across Highway 401.

8.4.15 Recognize the importance of Waterfront Areas for providing public access to the waterfront and open spaces. As such, the potential for an east-west connection between South Blair Street and Thickson Road, south of Victoria Street in the Town of Whitby, will be considered in conjunction with any proposal to redevelop the existing uses in the Employment Area north of Ronald C. Deeth Park.

8.5 Goods Movement

The Transportation System in Durham is planned to ensure adequate provision for all modes of goods movement, including road, rail, air, marine and intermodal facilities. Having an efficient, continuous, connected and sustainable network for goods movement is integral to the Region's economic competitiveness and future growth.

Objectives:

i. Promote the importance of the freeway and arterial road network for goods movement, in both Urban and Rural Areas.

ii. Promote key nodes of goods movement such as existing and future airports, ports and Employment Areas and supporting their role and function.

iii. Ensure the long-term operation and economic role of road, air, rail and marine facilities for goods movement is protected.

iv. Ensure that goods movement facilities and sensitive land uses are appropriately designed, buffered and/or separated from each other to mitigate noise and vibration impacts to adjacent land uses.

Policies:

It is the policy of Council to:

8.5.1 Identify a Strategic Goods Movement Network, as contained in Map 3c, which identifies preferred haul routes that are planned to accommodate commercial vehicles on a year-round basis, and which link major generators of traffic.

8.5.2 Recognize that infrastructure to support the implementation of the Strategic Goods Movement Network will be considered as part of the annual capital works program, in accordance with Section 4.4.

8.5.3 Apply a complete streets approach that balances the need for goods movement with other transportation modes in planning new infrastructure on the Strategic Goods Movement Network, particularly in Employment Areas and along freeway access routes.

8.5.4 Recognize that, notwithstanding policy 8.5.1, all Regional roads allow for commercial vehicles, except where restrictions are necessary due to pavement or bridge structural capacity and when seasonal weight restrictions are in effect.

8.5.5 Utilize freight-supportive design guidelines as part of the development review process, which help facilitate efficient goods movement while mitigating negative impacts on adjacent sensitive land uses.

Freight-supportive, in regard to land use patterns, refers to transportation systems and facilities that facilitate the movement of goods. This includes policies or programs intended to support efficient freight movement through the planning, design and operation of land use and transportation systems. Approaches may be recommended in guidelines developed by the province or based on municipal approaches that achieve the same objectives.

It is the policy of Council to:

8.5.6 Support low and zero carbon re-fuelling facilities for freight and goods movement in the region.

8.5.7 Require, in consideration of development applications adjacent to railways, a landscape buffer of a size to be determined by the provincial government and/or the council of the respective area municipality, in consultation with the appropriate railway authority.

8.5.8 Protect for future grade separations at railway crossings for arterial roads, as identified in the Durham Transportation Master Plan.

8.5.9 Undertake a detailed study to establish the required transportation system improvements to support the development of the future airport on the federal lands in Pickering and any Employment Area uses within proximity to the federal lands, including connectivity to the Strategic Goods Movement Network and inter-regional transit service.

8.5.10 Acknowledge the 1997 Agreement between the City of Oshawa and federal government that guarantees the operation of the Oshawa Executive Airport for 50 years unless a new airport on the federal lands in Pickering opens, in which case Oshawa has committed to continue operating the Executive Airport until at least 2033. Should the Oshawa Executive Airport cease operation, the policies of Section 5.1, as well as the extension of Stevenson Road and Beatrice Street shown on Map 3b, shall apply to this area without amendment to this Plan.

8.5.11 Recognize that area municipal councils may, at their sole discretion, allow for licensed aircraft landing strips in the respective zoning by-laws, provided that such are compatible with the intent of this Plan, subject to federal approval.

8.5.12 Support the Port of Oshawa as a commercial publicly owned port facility under the Hamilton-Oshawa Port Authority, including maintaining and enhancing the Strategic Goods Movement Network that serves the port.

8.5.13 Recognize the St. Marys Cement Dock in the Municipality of Clarington as a private port facility and support its connection to the Strategic Goods Movement Network.

8.5.14 Support investigations and monitoring by the federal and provincial governments to examine measures to improve the level of safety associated with the transportation of dangerous goods.

8.5.15 Develop coordinated, consistent and comprehensive emergency response plans to address incidents related to the transportation of dangerous goods.

8.5.16 Investigate the technical feasibility of designating a heavy vehicle only lane along Highways 401, 412 and 418 in partnership with MTO and area municipalities through the Region to ease congestion, facilitate the efficient movement of freight and goods and reduce GHG emissions.

8.5.17 Support the reduction of tolls on Highway 407 for commercial vehicles to increase its use as a component of the Strategic Goods Movement Network and help divert long-distance truck trips away from the Regional road system.

8.5.18 Plan for agriculture and freight and goods movement hubs to position Durham as an eastern logistics gateway to Quebec, eastern provinces and upper United States.

8.6 Environmental & Community Impacts

The objectives and policies in this section seek to mitigate the impacts of transportation infrastructure on communities, the environment and climate, and the impacts of a changing climate on transportation infrastructure through studies, design considerations and implementation measures to achieve the vision of a connected Transportation System and meet the commitments of the Region's Climate Emergency Declaration, referenced in Section 3.2.

Objectives:

i. **Ensure that the adverse effects that the Transportation System has on the natural environment, noise, climate and sensitive land uses are avoided, minimized or mitigated.**

ii. **Ensure that the adverse effects of climate change on the Transportation System are assessed and that its resilience is improved to maintain the desired level of service.**

iii. **Ensure the transportation network design creates appealing streetscapes, enhances safety and creates compatibility with adjacent land uses.**

iv. **Support Environmental Assessments for secondary plans and corridor studies to review the need for new or upgraded transportation infrastructure in a comprehensive manner, including the identification of road alignments and corridor protection.**

Policies:

It is the policy of Council to:

8.6.1 Review development applications abutting or adjacent to arterial roads, with regard to provincial, regional and other area municipal guidelines where applicable.

8.6.2 Promote connectivity and permeability to the arterial road for active transportation in the consideration of development applications abutting arterial roads where access opportunities are limited, including development patterns that:

a) minimize the amount of reverse lot frontage along the arterial road;

b) promote alternatives to reverse lot frontage where direct frontage is not feasible, such as window streets, laneways and cul-de-sacs adjacent to the arterial road;

c) provide noise attenuation walls or fencing, where applicable, along the side yard of lots adjacent to the arterial road; and

d) establish direct visual and pedestrian connections from proposed land uses and/or local streets and to the arterial road.

8.6.3 Implement a street network through the development review process that supports access to emergency services and municipal waste collection services.

8.6.4 Assess the need for and development of corridor plans, in conjunction with the area municipalities, which may be a component of a Municipal Class Environmental Assessment study for major road works or significant development applications or planning studies. Such corridor plans will provide a vision for the development along the Regional Road over time and shall address:

a) the transportation environment, including present and future mobility and access requirements;

b) adjacent land uses and the future built environment; and

c) streetscaping and the public realm.

8.6.5 Advocate that area municipalities apply the Municipal Class Environmental Assessment study process as part of an integrated approach with the Planning Act process in the preparation of secondary plans, or in advance of the secondary plan process, in identifying new, realigned or upgraded arterial and collector roads.

8.6.6 Require area municipalities to evaluate and identify preferred alignments for new arterial and collector roads needs in a comprehensive manner under the Municipal Class Environmental Assessment process to minimize environmental impacts while achieving the optimal solution from a transportation perspective.

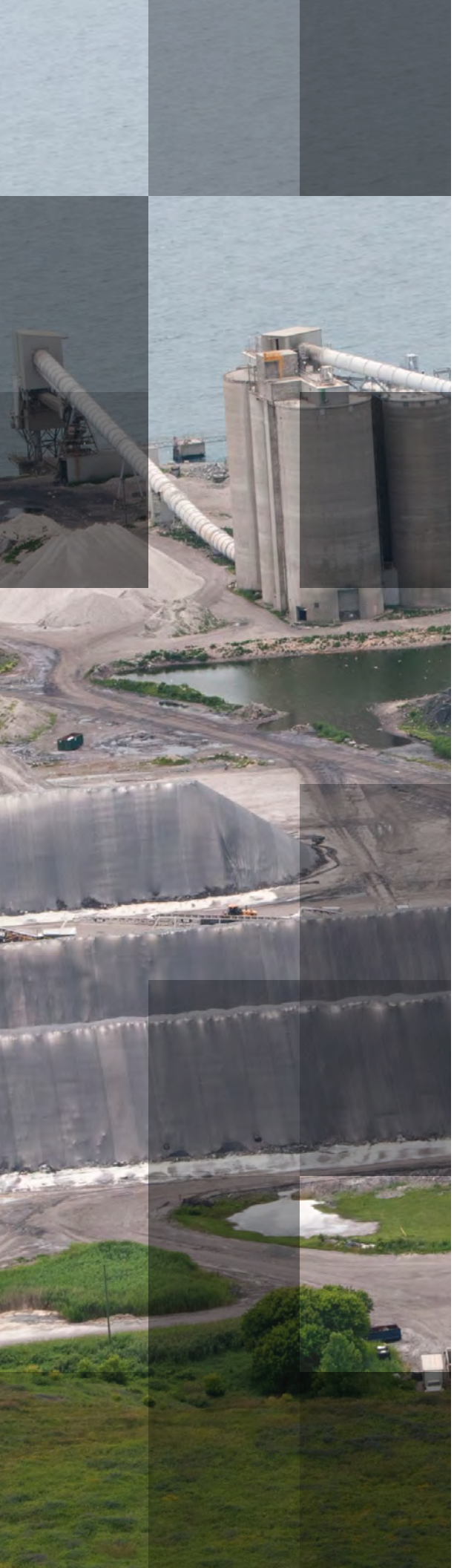
8.6.7 Protect arterial road corridors where a development application or site plan is contingent upon road improvements that are subject to a Municipal Class Environmental Assessment study or a corridor plan, as determined by the Region in conjunction with the area municipality. The development application shall not be approved until the Municipal Class Environmental Assessment study or corridor plan are completed to the extent required to assess the development application.

8.6.8 Assess infrastructure risks and vulnerabilities, including those caused by the impacts of a changing climate, and identify actions and investments to address these challenges. These actions and investments may be identified as part of municipal asset management planning in accordance with Section 4.4.

8.6.9 Ensure that new or modified watercourse crossing structures, planned through the Municipal Class Environmental Assessment process and/or detailed design studies for roads and other transportation infrastructure, address natural heritage system functional considerations in the siting and design of crossings. These considerations include the avoidance and mitigation of flood risk, geotechnical risk from slope instability and geomorphic risk from watercourse channel migration over time.



Supporting Sections



Chapter 9

Site Specific Policies

Supporting Sections

Chapter 9. Site Specific Policies

There are many sites throughout the region that require recognition of their distinct land use characteristics and specific opportunities for future development.

The current and proposed uses of these site specific areas vary, however it is recognized that all levels of government will need to work together as these sites are developed. Each site has been identified in this Plan and each requires specific consideration.

Goal:

I. Identify and subsequently study site specific areas that warrant special policies to ensure such site specific areas are developed appropriately in relation to their individual plans, proposals and limitations.

9.1 Special Study Areas

Special Study Areas are sites that are identified as requiring specific guidance and policy as they navigate the development process. This is intended to ensure that the sites are appropriately developed in relation to federal, provincial, regional and area municipal plans and servicing requirements.

Objective:

i. Ensure further analysis of Special Study Areas, after which appropriate designations shall be recognized in this Plan.

Policies:

It is the policy of Council to:

9.1.1 Require that Special Study Areas be designated on Map 1.

9.1.2 Ensure that until such time as appropriate amendments have been adopted for a Special Study Area, the existing zoning by-laws that apply to the Special Study Area may remain in force, or may be amended, provided that such by-laws allow only uses, such as agricultural and/or temporary uses, in accordance with the provisions of the Planning Act and this Plan, and provided that such uses, if developed, will not prejudice the conclusions and recommendations of the intended studies for the following sites:

a) Special Study Area 1 applies to lands compiled by the federal government for the development of a potential future airport in Pickering and complementary uses.

b) Special Study Area 2 applies to lands designated as Waterfront Area south of Highway 401, west of Courtice Road/Courtice Shores Drive, east of Darlington Provincial Park and north of the Lake Ontario shoreline in the Municipality of Clarington. An amendment to this Plan to allow the development of a mixed-use community shall be subject to satisfaction of the following:

i) land use compatibility considerations, due to the proximity of existing Regional facilities including future expansions, planned Regional facilities, railways, transportation and related infrastructure has been addressed to the satisfaction of the Region;

ii) Transportation connections and access/egress has been addressed to the satisfaction of the Region, the Municipality of Clarington and CN Rail; and

iii) An agreement has been executed for the conveyance of land for a public Waterfront Park with the Municipality of Clarington.

c) Special Study Area 3 recognizes the Special Policy Area identified in accordance with the Provincial Policy Statement that applies to lands within the Rapid Transit Corridor, along Highway 2, that are west of Duffins Creek in Ajax and Pickering comprised of historical development within the floodplain. Any proposed land use changes, redevelopment and/or intensification, above and beyond existing area municipal official plan permissions within this area requires approval from the Ministry of Municipal Affairs and Housing and the Ministry of Northern Development, Mines, Natural Resources and Forestry. The lands may be developed in accordance with the Rapid Transit Corridor policies, without amendment to this Plan, if a required future study determines certain lands would no longer be subject to flooding and are provided with safe ingress and egress in times of flooding, in consultation with the Toronto and Region Conservation Authority, City of Pickering, Town of Ajax and the Region and provided the necessary provincial procedures are followed and approvals are granted.

9.2 Specific Policy Areas

There are four designated Specific Policy Areas in this Plan. These areas are all unique and require distinct policy frameworks to ensure the goals and challenges of these areas are met.

Policies:

It is the policy of Council to:

9.2.1 Identify Specific Policy Areas on Map 1.

Specific Policy Area A – Seaton Urban Area & Duffins Rouge Agricultural Preserve

It is the policy of Council to:

9.2.2 Support the development and protection of land in the Seaton Urban Area in accordance with this Plan and the City of Pickering Official Plan.

9.2.3 Acknowledge that the Natural Heritage System is based on the premise that natural features and functions can be protected while also providing a place for recreation, learning, mental and spiritual regeneration, interaction and movement. The Natural Heritage System has been delineated in the Pickering Official Plan to the satisfaction of the Ministry of Northern Development, Mines, Natural Resources and Forestry.

9.2.4 Designate Major Open Space Areas within the Seaton Urban Area in accordance with the Seaton Natural Heritage System, that is consistent with the approved neighborhood plans.

9.2.5 Develop the Seaton Urban Area based on the following:

a) the provision of a range of housing and employment that accommodates the population and employment forecasts included in Section 1.1 of this Plan;

b) the provision of linkages for pedestrians and cyclists between neighbourhoods and communities, internally and externally, and to the public transit system;

c) the provision of employment opportunities along Highway 407, concurrent with residential development; and

d) the provision of infrastructure, both internal and external to the Seaton Urban Area, in conjunction with the phasing of development.

9.2.6 In addition to the applicable policies of the Greenbelt Plan and the implementing policy framework set out in this Plan, lands within the Duffins Rouge Agricultural Preserve are also subject to the Duffins Rouge Agricultural Preserve Act, 2023.

Specific Policy Area B – St. Marys Cement

It is the policy of Council to:

9.2.7 Recognize this area is owned by St. Marys Cement and that, notwithstanding any policy in this Plan to the contrary, it is the policy of this Plan that a cement plant, ready-mix batching plant, asphalt plant, truck terminal, and an aggregate operation and ancillary uses in accordance with Section 6.7, construction and industrial uses and a commercial docking facility and ancillary uses thereto, are permitted, and shall be subject to the following:

a) prior to the expansion of the existing dock facilities, the owner shall obtain all necessary approvals from the Federal and Provincial Governments, in consultation with the Region and the Municipality of Clarington, and may be required to enter into a development agreement with the Region;

b) preparation of a waterfront plan in collaboration with the Municipality of Clarington, federal and provincial governments, that will determine future uses for the area after rehabilitation, and the possibility of establishing a regional harbour facility; and

c) in the course of preparing a waterfront plan, alternatives for a continuous open space linkage around the site shall be provided, in consultation with the area municipality, the owner, Hydro One Networks Inc., Ontario Power Generation and Canadian National Railway.



Specific Policy Area C – Port Granby Project and Nature Reserve

It is the policy of Council to:

9.2.8 Recognize this area contains the site of the Port Granby Nuclear Waste Management Facility that is operated under license from the Canadian Nuclear Safety Commission. This area shall be subject to the following:

a) notwithstanding any other provisions of this Plan to the contrary, until such time as the facility has been decommissioned and the site rendered safe for uses permitted within the Waterfront Areas designation, no uses shall be permitted on the site that could be affected by the waste management facility;

b) Regional Council shall encourage the Canadian Nuclear Safety Commission to:

i) expedite the removal of all waste from the existing waste management facility;

ii) render the area safe;

iii) rehabilitate the site in such a manner as to permit the uses designated in this Plan;

iv) support the establishment of the nature reserve proposed by the Municipality of Clarington and the Ganaraska Region Conservation Authority; and

c) Regional Council shall consult with the Ministry of the Environment and Climate Change, Environment Canada and the Canadian Nuclear Safety Commission for the purpose of determining which uses could eventually be permitted in this area in the course of preparing a waterfront plan, in accordance with Section 7.1 of this Plan.

Specific Policy Area D – Rouge National Urban Park

It is the policy of Council to:

9.2.9 Recognize this site as the Rouge National Urban Park (RNUP), which is owned and operated by Parks Canada. The boundaries of Specific Policy Area D are shown on Map 1.

9.2.10 Permit land uses within the Rouge National Urban Park in accordance with the Greenbelt Plan and the RNUP Management Plan.

9.2.11 Encourage adjacent land uses outside of the park to have consideration for connections to the active transportation network, compatibility with the RNUP Management Plan and support identified actions related to planning along the park periphery.

Specific Policy Area E – Uxbridge

It is the policy of Council to:

9.2.12 Apply this policy to lands within the Uxbridge Urban Area. Development on these lands shall be subject to the availability of servicing capacity. The capacity of municipal services is limited and will be regularly monitored to ensure that development approvals do not exceed available capacity. To manage development in an orderly and sequential manner that efficiently uses existing infrastructure, the Region shall continue to encourage infill development within the Uxbridge Urban Area in accordance with the relevant policies of the area municipal official plan.



Chapter 10

Policy Exceptions

Chapter 10. Policy Exceptions

The following policies are permitted by exception to this Plan, through amendment or otherwise.[2] Policy exceptions are organized by Plan chapters.

10.1 Healthy Communities

Complete Communities

It is the policy of Council to:

10.1.1 Permit, notwithstanding Policy 3.3.19, a place of worship at the northeast corner of Hancock Road and Bloor Street in the Municipality of Clarington.

10.2 Supportive Infrastructure

Municipal Servicing

It is the policy of Council to:

10.2.1 Permit the extension of sanitary sewage facilities, notwithstanding Section 4.1, to the Highway 401 automotive service centre/restaurant located on Lots 18, 19 and 20, Concession 1, former Township of Clarke, Municipality of Clarington, Assessment #18-17-030-020-064-00-0001.

10.2.2 Permit the extension of sanitary sewage and water facilities, notwithstanding Section 4.1, to the Ajax Municipal Recreation facility located on Part of Lot 2, Concession 3, (Part 1, 40R-10901), Town of Ajax, Assessment #18-05-010-010-12900-0000.

10.2.3 Permit the extension of sanitary sewage facilities, notwithstanding Section 4.1, to the Deer Creek Golf Course clubhouse, including a banquet facility limited to a maximum seating capacity for 900 persons, and to the 27-unit "Country Residential Subdivision 30". These are the only facilities that are permitted to be connected to the sanitary sewer. Extension of sanitary sewers shall be through the smallest sized pipe that meets Regional servicing standards capable of servicing the above-noted facilities.

[2] Policy exceptions will be incorporated into the respective area municipal official plans, where still applicable.

10.2.4 Permit the extension of sanitary sewage and water facilities, notwithstanding Section 4.1, to the Durham Regional Police Service facility located at the southwest corner of Highway 2 and Maple Grove Road. Properties outside the limits of the Greenbelt Plan and abutting the municipal services may connect subject to all financial and technical requirements being met as determined by the Regional Works Department.

10.2.5 Ensure the development of the Durham Regional Police Service facility on full municipal services noted in Policy 10.2.4 shall be subject to the fulfillment of the following conditions to the satisfaction of the approval authorities:

a) submission of a site plan application to the satisfaction of the Municipality of Clarington;

b) submission of a permit for development within the regulatory floodplain to the satisfaction of the Central Lake Ontario Conservation Authority;

c) submission of a signed Record of Site Condition (RSC) to the Ministry of the Environment, Conservation and Parks (MECP) for the subject lands. The RSC must be to the satisfaction of the Region and the Municipality of Clarington and MECP; and

d) submission of a Recommendation Letter from the Ministry of Heritage, Sport, Tourism and Culture Industries confirming all archaeological resource concerns have been met including licensing and resource conservation requirements, to the satisfaction of the Region and the Municipality of Clarington.

10.2.6 Permit a privately owned and operated communal system for water supply and sanitary sewage services, notwithstanding Section 4.1, to service up to 125 hamlet residential dwellings and hamlet institutional/ commercial uses in the northeast quadrant of the Hamlet of Coppins Corners, and a golf course with associated driving range and clubhouse facilities, in the Township of Uxbridge, as described in Policy 7.1.13. Approval of the communal water and wastewater systems by the Region or Province is required. If Regional approval is established, the Owner shall enter into a “Responsibility Agreement” to the satisfaction of the Region. Approval of a permit to take water by the Ministry of the Environment, Conservation and Parks is also required.

10.2.7 Permit residential development on municipal water and private sewage disposal systems on the lands bounded by the Canadian Pacific Railway, Lynde Creek, Bonacord Avenue and the residential dwellings fronting on Cochrane Street in the Town of Whitby, subject to satisfactory agreements, the inclusion of appropriate provisions in the respective restricted area zoning by-law, compliance with the standards of the Ministry of the Environment, Conservation and Parks, as amended from time to time, and as administered by the Medical Officer of Health or otherwise, and any other conditions as deemed desirable by the Regional Council and the Council of the respective area municipality.

10.2.8 Permit the Plans of Subdivision 18T-74256, 18T-75506, 18T-75514 and 18T-76029 in the Township of Scugog, and 18T-77009 in the Township of Uxbridge, to be developed, subject to adequate private drilled wells and private sewage disposal systems, satisfactory subdivision agreements, zoning by-laws, and any other conditions as deemed desirable by the Regional Council and the Council of the respective area municipality.

10.2.9 Notwithstanding any other provision in the Plan to the contrary, properties within Part of Lots 34, Concession 7, former Township of Uxbridge, Township of Uxbridge which are abutting the gravity portion of the sanitary sewer easement leading from the St. John's Training School in the Township of Uxbridge, and identified in the 1986 Assessment Roll Book as #18-29-050-010-39100, #18-29-050-010-39200, #18-29-050-010-39300, #18-29-050-010-39310, #18-29-050-010-39320, #18-29-050-010-39325, #18-29-050-010-40200 and #18-29-050-010-40300, may be permitted to connect to an existing sanitary sewer service, subject to the following:

a) the connection is made for an existing lot of record as noted above;

b) the connection is for the servicing of a single detached dwelling;

c) the feasibility of allowing the connection to an existing sanitary sewer;

d) the connection does not require any extensions to the existing sanitary sewer system;

e) the capacity of the sanitary sewer system is not unduly affected;

f) the property owner may, at the discretion of the Region, be required to enter into an agreement with the Region in respect to sanitary sewer connections; and

g) such other conditions as Council deems necessary.

Waste Management

It is the policy of Council to:

10.2.10 Permit, notwithstanding Section 4.2 and any other provision of this Plan to the contrary, a parcel of land approximately 24 hectares in size within Part of Lots 22 and 23, Broken Front Concession, Town of Whitby, for the disposal of automobile shredder by-product material produced on site is permitted, subject to Gerdau Ameristeel or subsequent landowners satisfying the provision of:

a) adequate financial assurances for the perpetual maintenance and environmental safety of the site in accordance with Environmental Assessment Act;

b) remedial measures and payment to the Region for any costs associated with the treatment of leachate from the proposed berm arising from exceeding the Region's Sewer Use By-law;

c) public access being provided through a waterfront trail over the open space lands south of the landfill site, to the satisfaction of the Region, the Town of Whitby and other agencies having jurisdiction;

d) on-going environmental monitoring to address potential impacts on ground water, surface water, air, and soil conditions surrounding the subject site, and to ensure the landscaped aesthetic of the waste disposal site is maintained; and

e) conditions of the Environmental Assessment and Environmental Compliance for a landfill site as issued by the Ministry of the Environment, Conservation and Parks.

10.3 Vibrant Urban System

Community Areas

It is the policy of Council to:

10.3.1 Require, upon the submission of a development application, a servicing solution for the lands east of Laidlaw Street South/Sideroad 18, south of the Beaver River Wetland Trail. Any lands to be developed on the basis of private sewage disposal systems must be on the basis of appropriately sized lots to accommodate such systems in accordance with the Region's lot sizing policy and the South Georgian Bay Lake Simcoe Source Protection Plan. This will require existing vacant lots to be merged and/or the submission of a new plan of subdivision.

10.3.2 Require upon submission of an application to permit development on lands north of Simcoe Street and east of Holy Family Catholic Elementary School within Parts of Lots 12 and 13, Concession 5, former Township of Thorah, within the Beaverton Urban Area, the proponent to submit a study addressing land use compatibility with the existing farm located on the south side of Simcoe Street. Such a study may include a recommended phasing of development and other mitigation measures.

10.3.3 The lands known municipally as Part of Lots 21 and 22 Concession 8 in the former Township of Reach, in the Township of Scugog, Assessment numbers 182001000818846 and 182001000818800 are within the Urban Area Boundary and designated as Community Areas. Prior to any development on these lands proceeding, the following conditions shall be satisfied:

a) Sufficient water supply and quality is confirmed through a hydrogeological study which shall demonstrate adherence to provincial D-Series Guidelines and the Region of Durham Lot Sizing Policy. The study shall be peer reviewed to the satisfaction of the Region; and

b) Demonstration that the Minimum Distance Separation formula is complied with.

Employment Areas

It is the policy of Council to:

10.3.4 Permit, notwithstanding Section 5.5, a grocery store of up approximately 2,000 square metres on a 1.3 hectare portion of land located on the south side of Bayly Street, east of Shoal Point Road, municipally known as Part of Lot 4 Range 3 Broken Front Concession Former Township of Pickering, in the Town of Ajax, Assessment #180504001801604.

10.3.5 Permit, notwithstanding Section 5.5, additional uses including but not limited to certain residential, retail, entertainment, and personal service uses, in accordance with the provisions of Ministers Zoning Order 607/20 as amended by Ministers Zoning Order 515-21 on lands located at the northwest corner of Bayly Street and Church Street and a portion of the lands at the northeast corner of Squires Beach Road and Tribro Studios Avenue. In the event of any conflict between this Plan and the referenced Minister's Zoning Orders, the provisions of the Minister's Zoning Orders shall prevail.

10.3.6 Permit, notwithstanding Policy 5.5.12, major retail uses may be considered along the north side of Taunton Road West between Goodman and Oshawa Creeks in the City of Oshawa provided:

a) a transportation impact study is prepared and submitted to the Region for its approval; and

b) the development is in accordance with Section 5.3.

10.3.7 Permit, notwithstanding Section 5.5, retail warehouses may be considered on locations adjacent to Champlain Avenue between the Oshawa/Whitby boundary and the CN/CP interconnection in the City of Oshawa provided:

a) a transportation impact study is prepared and submitted to the Region for its approval which:

i) demonstrates that sufficient road and intersection turning movement capacity would exist to support the development;

ii) demonstrates that the additional traffic volumes generated by the development will conform to the function and classification of Champlain Avenue and other arterial roads in the network;

iii) demonstrates that the Region's arterial road network operating principles and policies are not compromised by the traffic impacts of the development;

iv) recommends mitigating measures acceptable to the Region;

b) the cost of any required improvements to the regional road system shall be the responsibility of the applicant; and

c) the relevant provisions of Chapter 8 are complied with.

10.3.8 Notwithstanding the policies of this Plan to the contrary, and in accordance with Section 8.1, an integrated, higher density, mixed-use development including residential, office, commercial and business park uses, is permitted within the area bounded by Victoria Street, Gordon Street, Montecorte Street and Nordeagle Avenue in the Town of Whitby. The extent and scale of development shall be detailed in the area municipal official plan. Implementation of this policy shall require the completion of studies to the satisfaction of the Region and Town to support an amendment to the area municipal official plan, which shall address the following:

a) the determination of an appropriate range of permitted uses within the mixed-use development area that are compatible with uses on adjacent lands that are existing and permitted in accordance with Section 5.5;

b) the compatibility of land uses, which shall include the provision of a transition area between any residential or other sensitive uses and Employment Area uses adjacent to the mixed-use development area. The transition area may include the parcel immediately north of Nordeagle Avenue, identified as Assessment #18-09-020-002-70445;

c) an analysis of the appropriate height, density, massing and built form for the mixed-use development area, and the delineation of the boundaries of the transition area;

d) an urban design plan;

e) an analysis of the impacts on the surrounding community, including traffic, noise, environment, air quality and market;

f) a phasing plan to address the availability of servicing; and

g) any other relevant matters and policies of this Plan.

10.3.9 Permit, notwithstanding Policies 5.5.12, 5.5.20 and 5.5.21 or any other policies of this Plan to the contrary, the retailing of goods and services and personal service uses, including single uses in excess of 500 square metres, and major retail uses may also be permitted on the northern 4 hectares of a parcel of land fronting Rossland Road East and Harwood Avenue North, municipally known as 1 Rossland Road East, being Part of Lot 7, Concession 2, in the former Township of Pickering, in the Town of Ajax, identified as Assessment #18-05-020-015-01400. The inclusion of appropriate designations, policies and provisions to reflect the conversion of the above-noted lands to permit commercial uses beyond those otherwise permitted in Employment Areas shall be further detailed in the area municipal official plan and zoning by-law.

Major Open Space Areas

10.3.10 Permit Community Area uses on the developable portion of the lands known municipally as 5055 Baldwin Street South and referred to as Lyndebrook Golf Course, subject to the location and form of development being reviewed and approved to the satisfaction of the Town of Whitby and the Central Lake Ontario Conservation Authority.

10.4 Thriving Rural System

Prime Agricultural Areas

It is the policy of Council to:

10.4.1 Permit the following golf course, which has been considered by amendment to this Plan:

a) a 9-hole expansion to an existing 18-hole golf course is permitted on the north side of King Street, west of the Port Perry Urban Area, identified as Assessment #18-20-010-004-23600 in Lots 14 & 15, Concession 5, in the Township of Scugog, subject to the approval of a Permit to Take Water by the Ministry of Environment, Conservation and Parks; and

b) a golf driving range, mini-putt, clubhouse and accessory uses are permitted on the northeast corner of Taunton Road and Holt Road, within part of Lot 20, Concession 5, former Township of Darlington, known as 5075 Holt Road, Assessment #18-17-010-130-17700 within the Municipality of Clarington.

10.4.2 Notwithstanding Section 6.3, a grain milling, blending and storage facility, including the accessory sales of finished products, is permitted on lands located on the east side of York Durham Line, south of Regional Highway 47, identified as Assessment 18-29-010-001-10200 in Part of Lot 12 Concession 1, in the Township of Uxbridge.

10.4.3 Notwithstanding any other provision of this Plan, a new landfill site for soil remediation and processing uses, including soil screening, sampling, crushing and treatment is permitted within existing buildings on the lands located on the north side of Prouse Road and the east side of York Durham Line, north of Regional Highway 47, identified as Assessment 18-29-010-002-02000 in Part of Lots 16 and 17 Concession 1, in the Township of Uxbridge. The uses shall be subject to the fulfillment of the following conditions to the satisfaction of the approval authorities:

a) the establishment of a site-specific baseline and surveillance monitoring program funded by the proponent to the satisfaction of the Region of Durham, the Township of Uxbridge and the Lake Simcoe Region Conservation Authority. The baseline program shall be established before the site is used for soil treatment purposes. Both water levels and water quality samples will be collected that reflect the contaminants of concern to be treated. The surveillance monitoring and reporting program shall include surface water from the two on-site drainage ponds, groundwater, and 2-year stormwater event runoff, water quality sampling and water level measurement analysis. The surveillance monitoring and reporting program shall be undertaken by a Qualified Person and begin before the soil remediation use begins, and continue for the duration of the soil remediation operations on the site;

b) before the soil remediation use begins, the locations of all of the storage and processing facilities for the proposed use will be checked in the field to verify that they are outside the 10-year time of travel of the Wellhead Protection Area as identified in Map 2f of this Plan;

c) an upgrade of the existing sewage system be completed prior to the commencement of the proposed uses; and

d) an Environmental Compliance Approval for the proposed soil remediation and processing activities shall be obtained from the Ministry of the Environment, Conservation and Parks prior to commencement of the facility and the ECA's conditions and requirements shall be implemented.

10.4.4 Permit the following severances, which have been considered by amendment to this Plan prior to Policy 6.4.8 coming into force:

a) a 0.8-hectare retirement lot, severed from an original 20-hectare market garden farming operation, identified as Assessment #18-29-030-006-00100-0000 located in Part of Lot 22, Concession 5, former Township of Scott, Township of Uxbridge;

b) a 0.73-hectare retirement lot, severed from a 22-hectare agricultural parcel, identified as Assessment #18-29-010-001-16600-0000, located in Part of Lots 6 and 7, Concession 2, former Township of Uxbridge, Township of Uxbridge; and

c) notwithstanding the policies of this plan, the creation of a 0.4-hectare retirement lot, may be severed from a 95.8-hectare agricultural parcel in those portions of Part Lot 14, Concession 4, identified as Assessment #18-20-010-004-15800, former Township of Reach, Township of Scugog.

10.4.5 Permit the following lot line adjustment, notwithstanding Policy 6.4.9, considered by amendment to this Plan for the conveyance of a 4-hectare parcel from a 39-hectare farm, identified as Assessment #18-01-030-007-29910, located in Part Lots 9 and 10, Concession 7, former Township of Pickering, City of Pickering, to a 1.7-hectare residential lot identified as Assessment #18-01-030-007-30000, located in Part Lot 10, Concession 7, former Township of Pickering, City of Pickering.

10.4.6 Permit the severance, notwithstanding Policy 6.4.5, of the surplus dwelling from the farm parcel identified as Assessment #18-17-010-160-14300-0000, without requiring consolidation of said parcel with the abutting farm parcel identified as Assessment #18-17-010-160-144-00-0000, located in Lots 25 and 26, Concession 7, former Township of Darlington, Municipality of Clarington. No further severance shall be permitted from the parcel identified as Assessment #18-17-010-160-14300-0000.

10.4.7 Permit, notwithstanding Section 6.3, limited rural non-farm residential development, in accordance with the applicable provisions of Policy 6.5.16, in the following locations:

a) on a parcel located on the west side of Regional Road 2, on the south side of Harper Road, identified as Assessment #18-20-010-009-02100-0000, within Part of Lot 21, Concession 9, former Township of Reach, Township of Scugog, to a maximum of 3 additional dwellings; and

b) at the intersection of Regional Road 7 (Island Road) and Demara Road/Stephenson Point Road (Scugog Centre) within Part of Lots 3 and 4, Concessions 9 and 10, former Scugog Island, now the Township of Scugog.

10.4.8 Permit, notwithstanding Section 6.3, limited rural non-farm residential development in the following locations:

a) on a parcel located on the north side of Scugog Line 12 and on the west side of Brunon Avenue, identified as Assessment #18-20-010-009-17017-0000, within Part of Lot 24, Concession 12, former Township of Reach, Township of Scugog; and

b) a 0.5-hectare lot, severed from a 27-hectare farm, identified as Assessment #18-20-010-009-16000 located in Part of Lot 24, Concession 12, former Township of Reach, Township of Scugog.

10.4.9 Permit, notwithstanding Section 6.3, a transport truck terminal on the north portion of the 51-hectare lot identified as Assessment #18-39 010-004-02900-0000 located in Part of Lots 14 and 15, Concession 4, former Township of Thorah, Township of Brock.

10.4.10 Permit the severance, notwithstanding Policy 6.4.4, of a 25-hectare parcel for agricultural uses from lands identified as Assessment #18-39-050-008-254-00-000 and #18-39-050-008-256-00-000, located in Part of Lot 21 and 22, Concession 9, Township of Brock.

10.4.11 Permit, notwithstanding Section 6.3, a woodworking and wood finishing business on a 1.11-hectare parcel on Part of Lot 1, Concession 8, being Part 3, Plan 40R-7607, identified as Assessment #18-39-040-002-26905, Township of Brock.

10.4.12 Permit the severance, notwithstanding the policies of this Plan, of the veterinary clinic from the remaining parcel identified as Assessment #18-39-010-004-00400 in Lot 11, Concession 4, former Township of Thorah, Township of Brock.

10.4.13 Permit, notwithstanding Section 6.3, the retail sale of fish pond and garden equipment accessory to a fish breeding and sales operation on the 3 hectare portion of the 24-hectare property identified as Assessment #18-20-010-002-12500, in Lot 8, Concession 7, former Reach Township, Township of Scugog. Appropriate provisions shall be incorporated in the implementing zoning by-law to limit the scale of the retail component and restrict products to those directly related with the breeding operation.

10.4.14 Permit a small scale pitch and putt as an accessory use to a farm and winery operation on lands located on Part of Lot 10, Concession 6, former Township of Darlington, Municipality of Clarington, and identified by Assessment Roll #18-17-010-110-08600-0000.

10.4.15 Permit, notwithstanding Policy 6.4.4, the creation of a parcel of less than 40 hectares for agricultural uses in those portions of Part Lot 32, Concession 2, identified as Assessment #18-29-020-003-22000, former Township of Scott, Township of Uxbridge.

10.4.16 Permit the following uses, notwithstanding any other provision of this Plan to the contrary, considered by amendment to this Plan for a grocery store and gas bar as an exception, subject to the provisions of regulations and standards in the Township of Brock zoning by-law on a 3.0 hectare parcel at the southwest corner of Beaver Avenue and Highway 12/48, consisting of Part of South Half of Lot 11, Concession 5 and Part of Block 1, Plan M-85, Geographic Township of Thorah, now in the Township of Brock.

10.4.17 Permit, notwithstanding Section 6.3, an organic material composting and wood waste processing facility with accessory sales of finished products, on lands located north of Baseline Road, west of Hancock Road, identified as Assessment #18-17-010-050-04325-0000, in Part Lot 27, Concession 1, former Township of Darlington, in the Municipality of Clarington. The accessory retail sale of finished products shall consist only of those produced on site from the facility.

10.4.18 Permit the severance, notwithstanding Policy 6.4.2, of the existing accessory dwelling rendered as surplus from a farm parcel identified as Assessment #18-29-030-007-27600 located in Part of Lot 37, Concession 4, Township of Uxbridge, subject to the inclusion of provisions in the zoning by-law to prohibit further severances and the construction of any new accessory dwelling on the retained parcel.

10.4.19 Permit, notwithstanding Section 7.1, the existing and potential expansion of a municipal recreational facility identified as the Audley Recreational Centre. This site is located at the south-east corner of Taunton Road East and Audley Road in Ajax and is identified as Assessment # 18-05-010-010-12900 and 18-05-010-010-12950.

10.4.20 Permit the following severances considered by amendment to this Plan in accordance with Policy 6.4.6:

a) a surplus farm dwelling as severed from a parcel identified as Assessment #18-20-040-020-24200-0000 located in Part Lots 11 and 12, Concession 6, former Township of Cartwright, Township of Scugog;

b) a surplus farm dwelling as severed from a parcel identified as Assessment #18-17-030-020-03600-0000 located in Part Lot 16, Concession 1, former Township of Clarke, Municipality of Clarington;

c) a surplus farm dwelling as severed from a parcel identified as Assessment #18-20-40-050-03700-0000 located in Part Lot 19, Concession 6, former Township of Cartwright, Township of Scugog;

d) a surplus farm dwelling as severed from a parcel identified as Assessment #18-17-030-030-30100-0000 located in Part of Lots 17 and 18, Concession 4, former Township of Clarke, Municipality of Clarington;

e) a surplus farm dwelling as severed from a parcel identified as Assessment #18-20-040-010-12100-0000 located in Part Lot 6, Concession 3, former Township of Cartwright, Township of Scugog. Prior to the approval of the related consent application, the zoning by-law shall be amended to prohibit the existing structure located 16 metres north of the subject dwelling from being used to house livestock;

f) surplus farm dwellings from the following parcels:

   i) one dwelling from Assessment #18-01-030-007-29910, located in Part Lots 9 and 10, Concession 7, former Township of Pickering, City of Pickering;

   ii) one dwelling from Assessment #18-01-030-007-21700, located in Part Lot 7, Concession 8, former Township of Pickering, City of Pickering;

   iii) two dwellings from Assessment #18-01-030-008-02500 located in Part Lots 7 and 8, Concession 6, former Township of Pickering, City of Pickering;

   No further dwellings shall be permitted on the aforementioned retained farm parcels and prior to the approval of the related consent applications:

   iv) the Minister's Zoning Order shall be amended to prohibit a residential dwelling as a permitted use on the retained farm parcels;

   v) farm parcels identified as Assessment #18-01-030-007-28400, #18-01-030-007-28500 and #18-01-030-007-28700, located in Part Lots 6 and 7, Concession 7, former Township of Pickering, City of Pickering, shall be merged;

g) a surplus farm dwelling and building, as severed from a parcel identified as Assessment #18-20-010-007-08010, located in Part Lot 24, Concession 1, former Township of Reach, Township of Scugog, subject to the inclusion of provisions in the zoning by-law to prohibit the building of any residential dwelling on the retained farm parcel;

h) a surplus farm dwelling and building, as severed from a parcel identified as Assessment #18-17-010-080-08350, located in Part Lot 9, Concession 4, former Township of Darlington, Municipality of Clarington;

No further dwellings shall be permitted on the aforementioned retained farm parcel and prior to the approval of a consent application:

i) two parcels of land identified as Assessment #18-17-010-080-08300 and #18-17-010-010-18900 shall be merged;

ii) a 0.3 metre reserve across the Mearns Avenue frontage of the retained farm parcel shall be dedicated to the Municipality of Clarington;

iii) the zoning by-law shall be amended to prohibit a residential dwelling as a permitted use on the retained farm parcel;

i) a surplus farm dwelling as severed from a parcel identified as Assessment #18-20-040-060-01600 in Lot 22, Concession 7, former Township of Cartwright, Township of Scugog, subject to the inclusion of provisions in the zoning by-law to prohibit further severances and the construction of a dwelling on the retained farm parcel;

j) a surplus farm dwelling as severed from a parcel identified as Assessment #18-39-040-002-23600 in Lot 9, Concession 7, former Brock Township, Township of Brock, subject to the inclusion of provisions in the zoning by-law to prohibit further severances and the construction of a dwelling on the retained farm parcel;

k) a surplus farm dwelling as severed from a parcel identified as Assessment #18-20-040-020-06400 located in Part Lot 21, Concession 4, former Township of Cartwright, Township of Scugog, subject to provisions in the zoning by-law to prohibit further severances and the construction of a dwelling on the retained farm parcel;

l) a surplus farm dwelling as severed from a parcel identified as Assessment #18-20-040-020-06900 located in Part Lot 24, Concession 4, former Township of Cartwright, Township of Scugog, subject to provisions in the zoning by-law to prohibit further severances and the construction of a dwelling on the retained farm parcel;

m) a surplus farm dwelling as severed from a parcel identified as Assessment #18-20-040-050-13610 located in Part Lot 17, Concession 8, former Township of Cartwright, Township of Scugog, subject to provisions in the zoning by-law to prohibit further severances and the construction of a dwelling on the retained farm parcel;

n) a surplus farm dwelling as severed from a parcel identified as Assessment #18-20-040-050-006-00 and #18-20-040-050-02450 located in Part Lot 16, Concession 6, former Township of Cartwright, Township of Scugog, subject to provisions in the zoning by-law to prohibit further severances and the construction of a dwelling on the retained farm parcel;

o) a surplus farm dwelling as severed from a parcel identified as Assessment Roll #18-17-010-160-12700 and #18-17-010-160-12800 located in Part of Lots 33 and 34, Concession 6, former Township of Darlington, Municipality of Clarington, subject to the inclusion of provisions in the zoning by-law to prohibit further severances and the construction of a dwelling on the retained farm parcel;

p) a surplus farm dwelling as severed from a parcel identified as Assessment Roll #18-17-030-010-03500 located in Part of Lot 8, Broken Front Concession, former Township of Clarke, Municipality of Clarington, subject to the inclusion of provisions in the zoning by-law to prohibit further severances and the construction of a dwelling on the retained farm parcel;

q) a surplus dwelling as severed from a parcel identified as Assessment #18-20-030-001-07400 located in Part of Lots 23 and 24, Concession 6, former Township of Reach, and Part Lot 1, Concession 7, former Township of Cartwright, in the Township of Scugog, subject to provisions in the zoning by-law to prohibit further severances and the construction of a dwelling on the retained farm parcel;

r) a surplus dwelling as severed from a parcel identified as Assessment #18-39-040-003-09900 located in Part of Lots 1 and 2, Concession 11, former Township of Brock, in the Township of Brock, subject to provisions in the zoning by-law to prohibit further severances and the construction of a dwelling on the retained farm parcel;

s) a surplus dwelling as severed from a parcel identified as Assessment #18-17-010-130-03800 located in Part of Lot 24, Concession 4, former Township of Darlington, Municipality of Clarington, subject to the inclusion of provisions in the zoning by-law to prohibit further severances and the construction of a dwelling on the retained farm parcel;

t) a surplus dwelling as severed from a parcel identified as Assessment #18-39-030-009-19400 located in Part of Lots 23 and 24, Concession 13, former Township of Brock, Township of Brock, subject to provisions in the zoning by-law to prohibit further severances and the construction of a new dwelling on the retained farm parcel;

u) a surplus dwelling as severed from a parcel identified as Assessment #18-39-010-005-23200 located in Part of Lot 5, Concession 9, former Township of Thorah, Township of Brock, subject to provisions in the zoning by-law to prohibit further severances and the construction of a new dwelling on the retained farm parcel;

v) a surplus dwelling and buildings as severed from a parcel identified as Assessment #18-39-040-001-29000 in Part of Lot 3,Concession 4, former Township of Brock, Township of Brock, subject to the inclusion of provisions in the zoning by-law to prohibit further severances and the construction of a dwelling on the retained farm parcel;

w) a surplus dwelling as severed from a parcel identified as Assessment #18-20-040-060-00400 located in Part of Lot 21, Concession 6, former Township of Cartwright, Township of Scugog, subject to provisions in the zoning by-law to prohibit further severances and the construction of a new dwelling on the retained farm parcel;

x) a surplus dwelling as severed from a parcel identified as Assessment #18-20-030-001-41000 located in Part of Lot 9, Concession 12, former Township of Cartwright, Township of Scugog, subject to provisions in the zoning by-law to prohibit further severances and the construction of a new dwelling on the retained farm parcel;

y) a surplus dwelling as severed from a parcel identified as Assessment #18-13-070-006-19300 in Part of Lots 10, 11 and 12, Concession 1, former Township of East Whitby, City of Oshawa, subject to the inclusion of provisions in the zoning by-law to prohibit further severances and the construction of any dwelling on the retained farm parcel;

z) a surplus dwelling as severed from a parcel identified as Assessment #18-20-040-020-01000 located in Part of Lot 9, Concession 4, former Township of Cartwright, Township of Scugog, subject to provisions in the zoning by-law to prohibit further severances and the construction of a new dwelling on the retained farm parcel;

aa) a surplus farm dwelling as severed from a parcel identified as Assessment #18-39-050-007-17600 located in Part of Lot 20, Concession 3, in the Township of Brock, subject to the inclusion of provisions in the zoning by-law to prohibit further severances and the construction of a dwelling on the retained farm parcel;

bb) a surplus farm dwelling as severed from a parcel identified as Assessment #18-39-040-003-04300 located in the east half of Lot 6, Concession 10, in the Township of Brock, subject to the inclusion of provisions in the zoning by-law to prohibit further severances and the construction of a dwelling on the retained farm parcel;

cc) a surplus farm dwelling as severed from a parcel identified as Assessment #18-39-010-003-15100 located in Part of Lot 7, Concession 5, former Township of Thorah, Township of Brock, subject to the inclusion of provisions in the zoning by-law to prohibit further severances and the construction of a dwelling on the retained farm parcel;

dd) a surplus farm dwelling as severed from a parcel identified as Assessment #18-39-040-004-00900 located in Part of Lots 11 and 12, Concession 2, former Township of Thorah, Township of Brock, subject to the inclusion of provisions in the zoning by-law to prohibit further severances and the construction of a dwelling on the retained farm parcel;

ee) a surplus farm dwelling as severed from a parcel identified as Assessment #18-39-030-004-15800 located in Part of south half of Lot 10, Concession 2, former Township of Thorah, Township of Brock, subject to the inclusion of provisions in the zoning by-law to prohibit further severances and the construction of a dwelling on the retained farm parcel;

ff) a surplus farm dwelling as severed from a parcel identified as Assessment #18-20-040-060-05500 located in Part Lot 23, Concession 10, former Township of Cartwright, Township of Scugog, subject to the inclusion of provisions in the zoning by-law to prohibit further severances and the construction of a dwelling on the retained farm parcel;

gg) a surplus farm dwelling as severed from a parcel identified as Assessment #18-20-040-020-25100 located in Part of Lot 13, Concession 6, former Township of Cartwright, Township of Scugog, subject to the inclusion of provisions in the zoning by-law to prohibit further severances and the construction of a dwelling on the retained farm parcel;

hh) a surplus dwelling as severed from the parcel identified as Assessment #18-39-040-002-4100 located in Part of Lots 10 and 11, Concession 9, former Township of Brock, in the Township of Brock, subject to the inclusion of provisions in the zoning by-law to prohibit further severances and the construction of any dwelling on the retained farm parcel;

ii) a surplus dwelling as severed from the parcels identified as Assessment #18-39-040-004-22500 and 18-39-040-004-2260 located in Part of Lot 17, Concession 2, former Township of Thorah, in the Township of Brock, subject to the inclusion of provisions in the zoning by-law to prohibit further severances and the construction of any dwelling on the retained farm parcel;

jj) a surplus dwelling as severed from the parcel identified as Assessment #18-39-040-003-1250 located in Part of Lots 4 and 5, Concession 11, in the Township of Brock, subject to the inclusion of provisions in the zoning by-law to prohibit further severances and the construction of any dwelling on the retained farm parcel;

kk) a surplus dwelling as severed from the parcel identified as Assessment #18-39-040-003-1310 in Part of Lot 6, Concession 11, in the Township of Brock, subject to the inclusion of provisions in the zoning by-law to prohibit further severances and the construction of any dwelling on the retained farm parcel;

ll) a surplus dwelling as severed from a parcel identified as Assessment #18-20-040-020-21900 located in Part of Lot 24, Concession 5, former Township of Cartwright, Township of Scugog, subject to the inclusion of provisions in the zoning by-law to prohibit further severances and the construction of a dwelling on the retained farm parcel;

mm) a surplus dwelling as severed from a parcel identified as Assessment #18-39-010-005-2740 in Part of Lot 9, Concession 9, Township of Brock, subject to the inclusion of provisions in the zoning by-law to prohibit further severances and the construction of a dwelling on the retained farm parcel;

nn) a surplus farm dwelling as severed from a parcel identified as Assessment #18-17-030-010-03300 located in Part of Lot 8, Broken Front Concession, former Township of Clarke, Municipality of Clarington, subject to the inclusion of provisions in the zoning by-law to prohibit further severances and the construction of a dwelling on the retained farm parcel;

oo) a surplus dwelling as severed from a parcel identified as Assessment #18-20-010-006-16200 in Part of Lot 12, Concession 14, Township of Scugog, subject to the inclusion of provisions in the zoning by-law to prohibit further severances and the construction of any new dwelling on the retained farm parcel;

pp) a surplus dwelling as severed from the parcel identified as Assessment #18-39-010-005-37500 located in Part of Lot 8, Concession 10, former Township of Thorah, in the Township of Brock, subject to the inclusion of provisions in the zoning by-law to prohibit: further severances; the construction of any dwelling on the retained parcel; and the use of the existing barn from housing livestock or removal of the barn;

qq) a surplus dwelling as severed from the parcel identified as Assessment #18-39-040-004-02300 located in Part of north half and Part of south half of Lot 15, Concession 1, former Township of Thorah, in the Township of Brock, subject to the inclusion of provisions in the zoning by-law to prohibit: further severances; the construction of any dwelling on the retained parcel; and the use of the existing barn from housing livestock;

rr) a surplus dwelling as severed from the parcel identified as Assessment #18-17-030-110-15300 located in Part of Lot 25, Broken Front Concession, former Township of Darlington, in the Municipality of Clarington, subject to the inclusion of provisions in the zoning by-law to prohibit: further severances; and the construction of any dwelling on the retained parcel;

ss) a surplus dwelling as severed from the parcel identified as Assessment #18-20-040-050 14900 located in Part of Lot 17, Concession 9, in the former Township of Cartwright, in the Township of Scugog, subject to the inclusion of provisions in the zoning by-law to prohibit further severances and the construction of any dwelling on the retained parcel;

tt) a surplus dwelling as severed from the parcel identified as Assessment #18-29-030-005-11400 located in Part of Lot 16, Concession 6, in the former Township of Scott, in the Township of Uxbridge, subject to the inclusion of provisions in the zoning by-law to prohibit further severances and the construction of any dwelling on the retained parcel;

uu) a surplus dwelling is severed from the parcel identified as Assessment #18-39-010-005-48100 located in Part of Lot 8, Concession 11, former Township of Thorah, in the Township of Brock, subject to the inclusion of provisions in the zoning by-law to prohibit: the construction of any dwelling on the retained parcel; and the use of the existing shed for housing livestock. In accordance with Provincial and Regional policies, no further severances of the property are permitted;

vv) a surplus dwelling is severed from the parcel identified as Assessment #18-39-030-004-00100 located in Part of Lot 1, Concession 1, former Township of Thorah, in the Township of Brock, subject to the inclusion of provisions in the zoning by-law to prohibit the construction of any dwelling on the retained parcel. In accordance with Provincial and Regional policies, no further severances of the property are permitted;

ww) a surplus dwelling is severed from the parcel identified as Assessment #18-39-050-008-08100 located in Part of Lot 22, Concession 6, in the Township of Brock, subject to the inclusion of provisions in the zoning by-law to prohibit further severances, the construction of any dwelling on the retained parcel; and the use of the existing shed for housing livestock;

xx) a surplus dwelling is severed from the 21.6 hectare parcel identified as Assessment #18-17-010-150-08900 located in Part of Lot 13, Concession 8, in the Municipality of Clarington, subject to the inclusion of provisions in the zoning by-law to prohibit further severances, and the construction of any dwelling on the retained parcel;

yy) a surplus dwelling is severed from the parcel identified as Assessment No. 18-39-030-004-06600 located in Part of Lot 9, Concession 1, in the Township of Brock, subject to the inclusion of provisions in the zoning by-law to prohibit further severances and the construction of any dwelling on the retained parcel;

zz) a surplus dwelling is severed from the parcel identified as Assessment No. 18-39-030-009-13600 and 18-39-030-003-20800 located in Part of Lot 23 Concession 12, in the Township of Brock, subject to the inclusion of provisions in the zoning by-law to prohibit further severances and the construction of any dwelling on the retained parcel;

aaa) a surplus dwelling is severed from the parcel identified as Assessment No. 18-17-030-050-12401 located in Part of Lot 27 Concession 5 (Former Township of Clarke), in the Municipality of Clarington subject to the inclusion of provisions in the zoning by-law to prohibit further severances and the construction of any dwelling on the retained parcel;

bbb) a surplus farm dwelling is severed from the parcel identified as Assessment No. 18-20- 040-030-00700 located in Part of Lot 12, Concession 7, former Township of Cartwright, in the Township of Scugog, subject to the inclusion of provisions in the zoning by-law to prohibit the establishment of any dwellings on the retained parcel. In accordance with Provincial and Regional policies, no further severances of the property are permitted;

ccc) a surplus dwelling is severed from a parcel identified as Assessment No. 1817 0101 302 8900 located in Part of Lot 28, Concession 6, Former Township of Darlington, Municipality of Clarington, subject to the inclusion of provisions in the zoning by-laws to prohibit further severances and construction of any new dwellings on the retained farm parcel;

ddd) a surplus farm dwelling is severed from the parcel identified as Assessment No. 18-17-010-080-19900 located in Part of Lots 17 and 18, Concession 4, former Township of Darlington, in the Municipality of Clarington, subject to the inclusion of provisions in the zoning by-law to prohibit the establishment of any dwellings on the retained parcel. In accordance with Provincial and Regional policies, no further severance of the property is permitted. A 5-metre access easement on the severed parcel shall be granted in favour of the retained farm parcel to provide access to Green Road;

eee) a surplus farm dwelling is severed from the parcel identified as Assessment No. 18-29-020-002-27400 located in Part of Lot 15, Concession 4, former Township of Scott, in the Township of Uxbridge, subject to the inclusion of provisions in the zoning by-law to prohibit the establishment of any dwellings on the retained parcel. No further severance of the property is permitted;

fff) a surplus farm dwelling rendered surplus from the parcel identified as Assessment No. 18-39-010-003-14300 located in Part of Lot 6, Concession 5, former Township of Thorah, in the Township of Brock, subject to the inclusion of the provisions in the zoning by-law to prohibit the establishment of any dwellings on the retained parcel in accordance with the Provincial and Regional policies, no further severance of the property is permitted;

ggg) a surplus farm dwelling is severed from the parcel identified as Assessment No. 18-39-050-005-28300 located in Part of Lots 17 and 18, Concession 7 in the Township of Brock, subject to the inclusion of provisions in the zoning by-law to prohibit the establishment of any dwellings on the retained parcel. In accordance with Provincial and Regional policies, no further severance of property is permitted;

hhh) a surplus farm dwelling rendered surplus from the parcel identified as Assessment No.18-17-010-110-06100 located in Part of Lots 7 and 8, Concession 6, former Township of Darlington, in the Municipality of Clarington, subject to the inclusion of the provisions in the zoning by-law to prohibit the construction of any new dwelling on the retained parcel; and the use of the existing barn for housing livestock. In accordance with Provincial and Regional policies, no further severances of the property are permitted; and

iii) a surplus farm dwelling rendered surplus from the parcel identified as Assessment No. 1817-030-080-13500 located in Part of Lot 1, Concession 5, in the Municipality of Clarington, subject to the inclusion of the provisions in the zoning by-law to prohibit the construction of any new dwelling on the retained parcel; and the use of the existing barn for housing livestock. In accordance with Provincial and Regional policies, no further severances of the property are permitted.

Rural Settlements

It is the policy of Council to:

10.4.21 Permit a country residential plan of subdivision on the lands described as Part of Lots 8 and 9, Concession 4, within the Township of Uxbridge, identified as Assessment #18-29-010-004-16600 and #18-29-010-004-16700.

10.4.22 Permit the following severances considered by amendment to this Plan for four 4-hectare non-farm residential lots, in the form of infilling, from two abutting 8-hectare rural residential properties, identified as Assessment #18-29-010-004-01210-0000 and #18-29-010-004-01220-0000, located in Part of Lot 2, Concession 3, former Township of Uxbridge, Township of Uxbridge.

10.4.23 Permit, notwithstanding any other provision of this Plan to the contrary, a maximum of 125 residential lots within the lands known as D.S. Park and identified as Part of Lot 18, Concession 5, former Township of Cartwright, Township of Scugog. Development approval and lot creation, including plans of subdivision and condominium, shall be in accordance with the following site-specific policies:

a) all lots are to be individually serviced by private drilled wells to the intermediate or deep aquifer providing a safe and potable water supply;

b) lots are to be serviced by private sewage disposal systems and shall be based on the following land use categories and private servicing standards:

i) residential with certificates of approval – the establishment of residential lots for plots with existing dwellings capable of year-round use, and serviced with private sanitary sewage systems with existing certificates of approval. Plots with environmental and/or physical constraints may be considered for residential lots, subject to meeting the requirements of the Kawartha Region Conservation Authority;

ii) residential without certificates of approval – plots with existing dwellings as defined above, but without certificates of approval, may be recognized as residential lots, subject to the capability of being serviced by private sewage disposal systems, in accordance with the Ontario Building Code requirements. Plots with environmental and/or physical constraints may be considered for residential lots, subject to meeting the requirements of the Kawartha Region Conservation Authority;

iii) future residential – vacant plots without physical or environmental constraints may be developed as residential lots, subject to the capability of being serviced by private sewage disposal systems, in accordance with Ontario Building Code requirements and the Region's lot sizing policy, including replacement area. Newer sewage treatment systems may also be considered. Restrictions on dwelling size and other means may be required to reduce daily sewage flows;

iv) recreational blocks – the creation of recreational blocks through the merger of plots with significant environmental and/or physical constraints. Buildings and/or structures are prohibited on these lands and only seasonal recreational uses, such as camping, are permitted. Lot creation for residential uses may also be considered in the future, subject to addressing environmental and/or physical constraints, and meeting private servicing requirements;

v) private open space – the creation of private open space blocks for lands owned by D.S. Park for private recreational activities, including the existing clubhouse, swimming area, and playing fields;

c) a condominium corporation shall be established to own and maintain all common elements, including the internal road network, community open space and park, and the central valley;

d) a conservation easement in favour of the Kawartha Region Conservation Authority shall be provided for the management and protection of natural heritage features within the central valley; and

e) all requirements of the Region, Township of Scugog, and the Kawartha Region Conservation Authority shall be satisfied prior to lot creation.

10.4.24 Permit, notwithstanding any policy within this Plan to the contrary, the development of up to 125 new hamlet residential dwellings and hamlet institutional/commercial uses in the northeast quadrant of the Hamlet of Coppins Corners on the basis of privately owned and operated communal water supply and sanitary sewage systems in accordance with Policy 10.2.6, provided that the proposal meets with the requirements of the Hamlet of Coppins Corners and Adjacent Lands Secondary Plan.

10.4.25 Notwithstanding any other provisions of this Plan, rural employment uses, consistent with Policy 6.5.22, although the subject site may be serviced with municipal water subject to Regional approval and required supporting studies, are permitted on 123 Regional Highway 47 (Part Lots 13 and 14, Concession 1, Assessment #18-29-010-002-001-00) Township of Uxbridge. Development shall only proceed by plan of subdivision and an amendment to the zoning by-law. In addition, site plan approval shall be required for each lot in the plan of subdivision to ensure that development is in conformity with the applicable policies of the Oak Ridges Moraine Conservation Plan. Development approval shall be in accordance with the following:

a) plans and supporting studies which address the applicable policies of Sections 20, 22, 23, 26, 43, 45, 46 and 47 the Oak Ridges Moraine Conservation Plan;

b) plans and supporting studies that address the Complete Application requirements set out in Table 1 of this Plan;

c) plans and supporting studies that address Section 3.16, Development Application Pre-Consultation and Submission Requirements of the Township of Uxbridge Official Plan and illustrate conformity with the applicable policies of the Region of Durham Official Plan and illustrate conformity with the Township of Uxbridge Official Plan; and

d) the subject site is located at the western gateway to the Township of Uxbridge, as such any buildings and sites shall be designed to the highest standards of urban design and sustainable development. In addition, the location and design of the parking areas and open storage shall ensure that their impact is minimized as much as possible, particularly along Regional Highway 47 where their location will be generally prohibited. To meet this criterion architectural control guidelines shall be developed as a condition of draft plan approval of the plan of subdivision.



Aggregate Resources

It is the policy of Council to:

10.4.26 Permit the following aggregate-related industrial uses listed below and identified on Map 4, in accordance with Policies 6.7.11 and 6.7.12:

Figure 21. – Aggregate-related industrial use exceptions table:

Aggregate Resource Extraction Area	Municipality	Location	Uses
20	Uxbridge	westerly portion of the property identified by the 1979 Assessment Roll Book #18-29-01-0-002-15200 in Part of Lot 19, Concession 2, former Township of Uxbridge	an asphalt plant and accessory uses directly related to the operation of the plant
36	Scugog	property identified as Assessment Roll Book #18-20-010-003-047, being Part of Lots 5 and 6, Concession 10, former Township of Reach	a contractors yard for heavy equipment and machinery
76	Clarington	Part Lots 1 & 2, Concession 9, former Township of Darlington	an aggregate transfer station
89	Uxbridge	property identified by the 1982 Assessment Roll Book #18-29-01-0-008-110, being Part of Lot 13, Concession 6, former Township of Uxbridge	an asphalt plant, concrete block manufacturing and concrete pipe manufacturing plant, and accessory uses directly related to the operation of the plants
91	Scugog	property identified by the 1980 Assessment Roll Book #18-20-01-0-004-008, being Part of Lot 10, Concession 1, former Township of Reach	an asphalt plant and accessory uses directly related to the operation of the plant, including the necessary berming, screening and landscaping
97	Clarington	property identified as Parts of Lots 12, 13, 14, 15, 16 & 17, B.F. Concession	a ready-mix cement manufacturing plant and a transportation depot and accessory uses related to the operation of the plant

1976 Regional Official Plan

The following policies are Rural System amendments made to the 1976 Regional Official Plan that remain in effect as exceptions to this Plan.

It is the policy of Council to:

10.4.27 Permit the following site specific land uses within the Major Open Space Area designation:

a) a motor vehicle repair garage and ancillary uses on a parcel approximately 0.5 hectare in size, located on the south side of Highway 48, within Part of Lot 1, Concession 10, former Township of Thorah, Township of Brock. Such use will be subject to satisfactory arrangements having been made with the Ministry of Transportation and being zoned in the respective restricted area by-law in a special zoning category for that use.

b) a furniture manufacturing use of a "dry" nature on a parcel approximately 2 hectares in size, being Part of Lot 3, Concession 14, former Township of Brock, being in the west part of the lands identified in the Assessment Roll Book as #18-29-040-003-372, subject to the site being zoned in the respective restricted area by-law in a special zoning category for that use. In addition, the applicant will be required to enter into a site plan agreement with the Township of Brock, pursuant to the Planning Act, which shall, among other things, regulate the use of a generator. Provision for an adequate vegetative buffer strip width along the boundary of Port Bolster Wetland shall be determined at the detailed site plan stage to the satisfaction of the Ministry of Northern Development, Mines, Natural Resources and Forestry.

10.4.28 Permit the following site specific land uses within the Prime Agricultural Area designation:

a) a warehouse for the storage of sporting goods and equipment and ancillary uses on a parcel approximately 6 hectares in size and identified in the 1986 Assessment Roll Book as #020-002-279-00-0000, more generally located within Part of Lot 15, Concession 4, former Township of Scott, Township of Uxbridge. Such uses will be subject to site plan agreements, pursuant to the Planning Act, and being zoned in the respective restricted area by-law in a special zoning category for that use;

b) a school bus storage and operation facility on a parcel approximately 0.33 hectare in size and identified in the 1986 Assessment Roll Book as #18-20-030-001-143-00, more generally described as located within Part of Lot 1, Concession 8, former Township of Scugog Island, Township of Scugog. Such use will be subject to being zoned in the respective restricted area by-law in a special zoning category for that use;

c) a road vehicle repair and service establishment, in addition to the currently permitted farm implement dealership and agricultural uses, on a 0.5 hectare portion of a property identified as #18-01-030-008-10200 in the 1986 Assessment Roll Book as being Part of Lot 4, Concession 6, City of Pickering. Such uses will be zoned in the respective restricted area by-law in a special zoning category for that use. In addition, the applicant may be required to enter into a site plan agreement with the City of Pickering pursuant to the Planning Act;

d) the display and sales of pre-engineered homes, excluding mobile homes, and ancillary uses, including an associated real estate office, on approximately 1.6 hectares of land, being Part of Part 1 of 40R1248 in Lot 10, Concession 9, former Township of Thorah, Township of Brock, subject to the following:

   i) the use being of an attractive and unobtrusive nature;

   ii) no outside storage being permitted;

   iii) satisfactory arrangements being made with the Ministry of Transportation;

   iv) a site plan agreement, pursuant to the Planning Act, being required by the Council having authority, in consultation with the Region, which shall include, in addition to any other conditions, provisions for site grading and placement of fill; siting and design of buildings; signs, landscaping, screening, fencing and lighting; parking; protection of the drainage ditch along the west side of the site from sedimentation and erosion; and the location of private wells and sewage disposal systems;

   v) the site being zoned in the respective zoning by-law as a Holding (H) Zone until the site plan agreement is finalized, after which the site will be in a special zoning category for that use;

e) the display of 3 modular homes on approximately 1 hectare of land, being Part of Lot 12, Concession 5, Township of Brock, being part of the lands identified in the Assessment Roll Book as #18-39-050-005-03425 subject to being zoned in the respective restricted area by-law, in a special zoning category for that use. In addition, the applicant may be required to enter into a site plan agreement with the Township of Brock pursuant to the Planning Act; and

f) a day care centre of approximately 290.3 square metres in size in the basement of an existing residence, being Part of Lot 32, Concession 5, former Township of Darlington, Municipality of Clarington, being part of the lands identified in the Assessment Roll Book as #18-17-010-160-04500-0000, subject to being zoned in the respective restricted area by-law in a special zoning category for that use. In addition, the applicant will be required to enter into a site plan agreement with the Municipality of Clarington pursuant to the Planning Act.

10.5 Protected Greenlands System

General Greenlands System Policies

It is the policy of Council to:

10.5.1 Permit, notwithstanding any other provisions of this Plan to the contrary, the following agri-business use that has been considered by amendment to this Plan:

a) a seed cleaning plant and warehouse for storage with wholesale and retail sale of seeds grown on-site and off-site, on a 4-hectare parcel of land to be created by consent, located at the southwest corner of Regional Road 19 and Regional Road 57, being Part of Lot 12, Concession 2, former Township of Cartwright, Township of Scugog. The accessory sale of farm equipment, such as feeding equipment, farm gates, hardware, tack, and general agricultural supplies shall also be permitted. These uses shall be zoned in a special zoning category for those uses. The Township of Scugog shall address the siting and height of buildings, parking areas, access, and noise and dust attenuation through the zoning, site plan, and building permit processes in consultation with the appropriate authorities.

10.5.2 Permit, notwithstanding any other provision of this Plan to the contrary, the creation of a lot containing a detached dwelling is permitted on lands municipally known as 55 Snowridge Court in the City of Oshawa. No further severances will be permitted for residential purposes from the remaining parcel and that this be registered on title.

10.5.3 Permit, notwithstanding any other provision of this Plan to the contrary, a retail store on a parcel of land municipally known as 5055 Simcoe Street North, as identified as Assessment #18-13-070-006-55000-0000, in the City of Oshawa, provided that:

a) the Provincial guidelines on potential contamination and decommissioning are to be addressed through the rezoning and site plan approval processes; and

b) a restriction is placed on the gross floor area of the retail store in the zoning by-law.

10.5.4 Permit, notwithstanding Policy 7.1.6, the following uses that have been considered by amendment to this Plan:

a) an auction sales business on a 31.5-hectare lot identified as Assessment #18-20-010-001-31400-0000, located in Part of Lot 4, Concession 5, former Township of Reach, Township of Scugog;

b) a topsoil processing operation on a parcel of land identified as Assessment Roll #18-09-010-036-25105, located at the northwest corner of Taunton Road and Halls Road, in the Town of Whitby, provided that:

i) the processing area is limited to 5.5 hectares (13.6 acres) of the 20-hectare (49.4-acre) site;

ii) incidental uses are restricted to bulk sale of topsoil and the storage and bulk sale of landscape aggregate, and the storage and sale of concrete and brick landscape products, and related materials;

iii) appropriate provisions are included in the Town of Whitby Official Plan and the implementing zoning by-law;

c) an existing employment area uses, including the development of rental storage units, on 0.9 hectare of property located on the north side of Regional Road 8 (Reach Street), described as Part of Lot 16, Concession 7, former Township of Reach, Township of Scugog; and

d) two residential lots, as infilling, on a 2.54-hectare (6.3-acre) property, identified as Assessment #18-13-070-006-554-00-0000, located in Part of Lot 10, Concession 9, former Township of East Whitby, City of Oshawa.

10.5.5 Permit the continuation of an existing autobody repair shop, in accordance with the area municipal zoning by-law, on the property municipally known as 3872 Courtice Road, legally described as Part of Lot 29, Concession 3, former Township of Darlington, Municipality of Clarington, subject to the following:

a) access restrictions to Courtice Road and the provision of a road widening across Pebblestone Road;

b) approval by the area municipality of amendments to its official plan and zoning by-law in conformity with this policy exception, and a site plan for the property; and

c) the execution and registration on title to the property of an agreement between the Region, the area municipality and the owner which provides, among other matters, that when the existing autobody and repair shop ceases to operate on the property, the property may be used only in accordance with the Major Open Space designation and the rural zoning provisions of the area municipality's zoning by-law.

10.5.6 Permit, notwithstanding any provision to the contrary, a surplus farm dwelling severance from a parcel identified as Assessment #18-20-030-050-21500 located in Part Lot 35, Concession 5, former Township of Clarke, Municipality of Clarington, subject to the inclusion of provisions in the zoning by-law to prohibit further severances and the construction of a dwelling on the retained farm parcel and the conveyance of road widenings across Taunton Road East (Regional Road 4) and Regional Road 42.

10.5.7 Permit, notwithstanding any other provision of this Plan to the contrary, an eating establishment and automobile gasoline bar on the lands located at the north-east corner of Highway 12 & 48 and Regional Road 15, being Part of Lot 10, Concession 5, former Township of Thorah, Township of Brock, and subject to the provisions of regulations and development standards in the Township of Brock zoning by-law.

10.5.8 Permit, notwithstanding any other provision of this Plan, a resort development consisting of hotel and fractional ownership/time share units is permitted on lands located on the south side of Portview Road along Lake Scugog, identified as Assessment #18-20-030-001-06300 and #18-20-030-001-06201 in Part of Lots 21 and 22, Concession 6, (Scugog Island) in the Township of Scugog. The development of such lands shall be subject to the fulfilment of the following conditions to the satisfaction of the approval authorities:

a) a Responsibility Agreement between the applicant and the Region of Durham. The Responsibility Agreement shall stipulate the conditions under which the services will be constructed, operated and maintained, as well as the action to be taken by the Region in the event of a default. The agreement also contains financial assurance provisions for the Region;

b) phasing of the resort development such that the first phase of the development contains no more than 115 units. Any future phase(s) of the development will be subject to the drilling of additional wells and a further hydrogeological assessment and peer review by the Region of Durham, Township of Scugog, and the Kawartha Region Conservation Authority;

c) approval of an official plan amendment, zoning by-law amendment, and site plan application to implement the resort development to the satisfaction of the Township of Scugog and the Region of Durham;

d) the establishment of a program to monitor and report on the quality and quantity of surface water and groundwater for a minimum of 5 years following construction to the satisfaction of the Region of Durham, Township of Scugog and Kawartha Region Conservation Authority;

e) Ministry of the Environment, Conservation and Parks (MECP) approval of a Municipal Class Environmental Assessment for the proposed water treatment plant and for the treatment of any sewage effluent;

f) Environmental Compliance Approval by the MECP of the sewage treatment facility, the Permit to Take Water, the proposed Storm Water Management System, and the standby power diesel generator for the proposed water treatment plant;

g) a monitoring and maintenance plan for stormwater management facilities by the MECP;

h) submission of a Stage 3 (and Stage 4 if required) Archaeological Assessment to the Ministry of Heritage, Sport, Tourism and Culture Industries (MHSTCI). No grading or other soil disturbances shall take place on the subject property prior to a letter of clearance from the MHSTCI;

i) submission and approval of an Endangered Species (butternut tree) analysis by the Ministry of Northern Development, Mines, Natural Resources and Forestry; and

j) written approval from Parks Canada (Trent-Severn Waterway) will be required prior to any shoreline or in-water works.

10.5.9 Permit, notwithstanding any other provision of this Plan, ancillary uses to the existing major recreational use including a hotel up to five storeys in height and an expanded parking area are permitted on lands located on the south side of Elgin Park Drive west of Concession 7, east of Howard Williams Court, identified as Assessment 18-29-040-009-00500 in Part of Lot 27 Concession 6, in the Township of Uxbridge. Prior to any development taking place, the following conditions shall be fulfilled to the satisfaction of the Region of Durham, the Township of Uxbridge, and the Lake Simcoe Region Conservation Authority:

a) that any negative impacts on identified natural heritage features and their functions as well as Species of Concern and Species at Risk will be properly mitigated; and

b) that any tree removal that occurs as a result of the development of the proposed hotel and expanded parking area will be compensated based on the requirements of the Ecological Offsetting Policy of the Lake Simcoe Region Conservation Authority.

10.6 Implementing the Plan

It is the policy of Council to:

10.6.1 Permit a single detached dwelling on existing lots of record created on or before July 14, 1976, notwithstanding any other provisions of this Plan, subject to such a lot complying with the provisions of the respective zoning by-law.

10.6.2 Apply the following policies to the Vanstone Mill lands in the Municipality of Clarington:

a) notwithstanding the outstanding referral of the lands located north of Highway 2, south of the CPR Line and west of the redefined floodline on the west side of Bowmanville Creek, these lands may be used for residential purposes; and

b) notwithstanding the outstanding referral of the lands lying on the north side of Highway 2, south of the CPR Line west of Scugog Street and east limit of the redefined floodline of the Bowmanville Creek, these lands may be designated in the Official Plan for the Municipality of Clarington as Regional Centre and used for such purposes.

10.6.3 Permit an 18-hole golf course, notwithstanding the outstanding deferral of the lands located on the west side of Regional Road 2, between Columbus Road and Howden Road, municipally known as 3622 Simcoe Street North, being Part of Lots 13, 14 and 15 and part of the road allowance between Lots 14 and 15, Concession 7, in the City of Oshawa, subject to the fulfillment of the following provisions:

a) a financial guarantee by means of a letter of credit to ensure the implementation of all remedial measures should a significant water supply problem arise with surrounding residents;

b) the implementation of an approved surface water and groundwater monitoring program, including an annual monitoring report prepared by the applicant, for a minimum of 3 years after construction;

c) the entering into an agreement with the Region for all required construction and costs associated with implementing a safe operating access to the subject lands; and

d) the implementation of measures, such as a construction management plan and a turf management plan, to ensure the golf course development will have minimal effect on the natural heritage features of the area.

1976 Regional Official Plan

The following policies are implementation-related amendments made to the 1976 Regional Official Plan that remain in effect as exceptions to this Plan.

It is the policy of Council to:

10.6.4 Permit a take-out restaurant and a convenience store on approximately 2.2 hectares situated on the southeast corner of Highway 2 and the 11th Line, in the Municipality of Clarington.

10.6.5 Permit recreational facilities in association with a private zoo, subject to satisfactory agreements with the Municipality of Clarington on approximately 4 hectares of land situated in the north half of Lot 25, Concession 5, former Township of Clarke, now in the Municipality of Clarington.

10.6.6 Permit a retail clearance centre for the sale of factory closeouts, similar in kind to clothing, hardware, auto accessories, household goods and furnishings, on approximately 1.7 hectares of land in Part of Lot 26, Concession 6, former Township of Clarke, Municipality of Clarington, and identified in the 1984 Assessment Roll as #18-17-03-0-050-25901. Development of the site will be subject to satisfactory agreements with the Municipality of Clarington.

10.6.7 Permit retail nursery, office and restaurant uses on approximately 2.47 hectares of land located at the southwest quadrant of Thickson Road South and Consumers Drive in the Town of Whitby, subject to satisfactory arrangements having been made with the Region with respect to servicing requirements, and the site being zoned to a special commercial zoning category in the respective zoning by-law.

10.6.8 Permit an office park comprised of predominantly corporate office uses, ancillary recreational and community uses, and a limited amount of retail and personal service uses, on the land designated Industrial Area, and located on the northeast corner of Church Street and Bayly Street, in the Town of Ajax, subject to the following provisions:

a) the office park shall not exceed a total of 88,255 square metres of floor space, and does not include the clubhouse serving the adjacent golf course;

b) the retail, personal service and non-corporate office uses may also be permitted as part of a permitted corporate office building, provided that the combined gross floor area of such uses does not exceed 10% of the gross floor area of the building, such that both uses are developed in conjunction with each other;

c) the gross floor area of all uses on this site shall be defined in the respective District Plan, and shall including phasing of development in conforming with this Plan;

d) the development of this site and adjacent Open Space System shall be subject to the inclusion of detailed policies in the respective District Plan, including design guidelines and the use of site plan controls; and

e) all development within this area shall proceed by a plan of subdivision.

10.6.9 Permit a commercial food supermarket on approximately 1.46 hectares of land located in Part of Lot 13, Concession 6, Township of Brock, being part of the lands identified in the Assessment Roll as #18-39-05-0-005-17400, subject to the development of the appropriate access to industrial lands behind the above identified lands.

10.6.10 Permit non-farm residential dwellings, subject to satisfactory agreements, appropriate zoning by-laws, and any other conditions, as deemed desirable by the Regional Council and the Council of the respective area municipality, in the following areas:

a) proposed Plan of Subdivision 18T-77037 in the Municipality of Clarington (a maximum of four lots);

b) Ontoro Boulevard Area in the Town of Ajax, subject to the inclusion of appropriate provisions in the District Plan;

c) the area bounded by Regional Road 31 (Westney Road) on the east, Greenwood Road on the south and west, and the Fifth Concession Road on the north in the Town of Ajax, subject to the inclusion of appropriate provisions in the District Plan;

d) one single dwelling on each of Parts 2 and 3, Plan 40R6763, located in Part of Lot 19, Concession 4, former Township of Uxbridge, Township of Uxbridge;

e) one additional lot on the property identified in the 1985 Assessment Roll Book as #18-09-010-0-043-290, more generally described as part of the north half of Lot 24, Concession 8, Town of Whitby;

f) seven additional lots on the property identified in Plan of Subdivision 18T86009, more generally described as being within the north half of Lot 22, Concession 2, former Township of Darlington, Municipality of Clarington;

g) four additional lots on the property identified in Plan of Subdivision 18T87036, more generally described as being within the north half of Lot 15, Concession 3, former Township of Darlington, Municipality of Clarington;

h) four additional lots on the property identified in the Assessment Roll Book as #182905001035000 within the existing residential cluster located within the south side of Beaver Road, generally located within Part of Lot 37, Concession 7, former Township of Uxbridge, Township of Uxbridge;

i) three lots on the two abutting properties identified in the Assessment Roll Book as #18-17-010-030-12200-0000 and #18-17-010-030-12300-0000, located on the northeast corner of Bloor Street and Holt Road, Part of Lot 20, Concession 2, former Township of Darlington, Municipality of Clarington;

j) in the cluster located at the intersection of Brawley Road East and Old Thickson Road (just east of Highways 7 and 12), Parts of Lots 20 and 21, Concessions 7 and 8, in the Town of Whitby;

k) two additional lots on the property identified in the Assessment Roll #18-17-030-060-08600 located on the west side of Leskard Road, generally located within Part of Lot 31, Concession 7, former Township of Clarke, Municipality of Clarington;

l) one lot on the property identified in the Assessment Roll as #18-29-030-004-01200-0000 located on Part of Lot 2, Concession 5, former Township of Scott, Township of Uxbridge;

m) one lot to be approximately four hectares in size on the property identified in the Assessment Roll Book as #18-39-040-001-149-20, more generally described as the south Part of Lot 5, Concession 2, former Township of Brock, Township of Brock, in recognition that this lot is infill as it is contained within a concentration of approximately 22 4-hectare lots and does not extend the strip development that presently exists; and

n) one replacement lot on the property identified in the 1989 Assessment Roll Book as #18-13-070-006-29400, more generally described as Part of Lot 14, Concession 8, in the City of Oshawa, subject to the melding of the property identified in the 1989 Assessment Roll Book as #18-13-070-006-27775, more generally described as Part of Lot 14, Concession 8, in the City of Oshawa, with an adjacent property.

10.6.11 Restrict development for the area immediately surrounding Wagner Lake, prior to the preparation and adoption of a development plan for the area, with the exception of the following:

a) residential development on existing lots of record, provided that the proposed dwelling unit is not situated in the floodplain and that the private water supply and waste disposal systems meet the standards of the MECP;

b) residential development on three residential lots located in Lot 13, Concession 7, being Parts 2, 3, and 4 of Reference Plan 40R-5987;

c) one additional lot for residential development on the property identified in the 1991 Assessment Roll as #18-29-030-005-175, more generally described as being on the east side of Wagner Road, Part of Lot 13, Concession 7, former Township of Scott, Township of Uxbridge; and

d) one lot for residential development being the property identified in the 1991 Assessment Roll as #18-29-030-004-342 more generally described as abutting the southern limit of Wagner Road, Part of Lot 12, Concession 7, former Township of Scott, Township of Uxbridge; provided that, as a condition of severance, the owner is required to satisfy the requirements of the Ministry of Northern Development, Mines, Natural Resources and Forestry with respect to the location of building envelopes and retention of natural features; and, no further extension of Wagner Road to the south, beyond the lot line separating Lots 12 and 13, Concession 7, former Township of Scott, Township of Uxbridge, or additional residential development, shall be permitted.

10.6.12 Permit an industrial/commercial development on lands totalling approximately 3.9 hectares located in Part of Lot 18, Concession 3, former Township of Uxbridge, Township of Uxbridge and situated at the northwest intersection of Highway 47 and Concession Road 4. As a condition for the development of such lands for industrial/commercial purposes, a site plan agreement pursuant to the Planning Act may be required by the Council having authority. Such agreement may generally include, in addition to any other conditions, provisions for site plan control including siting and design of buildings, landscaping buffers, signs, and servicing. Such uses will be subject to being zoned in the respective zoning by-law in a special zoning category for that use.

10.6.13 Permit an apartment complex on a private road on lands located in Part of Lot 34, Concession 2, on the south side of Highway 2, west of Farewell Creek, former Township of Darlington, Municipality of Clarington.

10.6.14 Permit Special Purpose Commercial uses, including a home improvement centre and accessory uses, on lands totalling approximately 2.19 hectares located in Part of Lots 25 and 26, Concession 5, Town of Whitby, and situated at the northwest intersection of Highway 12 and Spencers Road.



Chapter 11

Implementing the Plan

Chapter 11. Implementing the Plan

This chapter outlines a variety of implementation requirements, tools and resources intended to assist in the planning, preparation, review and approval of development applications and plans to ensure the Region achieves the strategic directions, goals, objectives and policies of this Plan.

Goal:

I. Effectively guide and inform the actions and decisions of all parties involved in implementing the policies of this Plan.

11.1 General Implementation Policies

Policies:

It is the policy of Council to:

11.1.1 Implement this Plan by utilizing the powers conferred upon it by the Planning Act, Municipal Act, Clean Water Act, Lake Simcoe Protection Act and such other statutes as may be applicable.

11.1.2 Implement the policies of this Plan wherever the Region has the legal jurisdiction to do so without intention to, in any way, infringe or be interpreted as in any way infringing on the statutory rights, powers or prerogatives of any other legal jurisdiction, except as the Region has the legal authority to do so.

11.1.3 Recognize that, in the interim before existing area municipal official plans can be amended to conform with this Plan, only those provisions of the existing area municipal official plan which are in conformity with this Plan shall remain in force and effect. For greater certainty, and notwithstanding any other provisions of this Plan, it is not the intent of this Plan to repeal any amendments to existing area municipal official plans which have been adopted by Council and are not yet in force.

Amendments to this Plan

It is the policy of Council to:

11.1.4 Amend this Plan as needed, from time to time, as the province issues policy statements, Minister's Zoning Orders and/or provincial plans under the Planning Act.

Pre-Consultation

It is the policy of Council to:

11.1.5 Require that applicants pre-consult with the Region, in accordance with the provisions of this Plan, prior to the submission of any development application for which the Region is a commenting authority.

Complete Applications

It is the policy of Council to:

11.1.6 Require any application submitted to the Region for comment in support of a development proposal be a complete application, accompanied by the appropriate fee, before any processing will begin.

11.1.7 Require the preparation and submission of background reports, studies, documents and materials, as set out in Table 1, with the application, to the satisfaction of the Region.

11.1.8 Reserve the right to require additional information should it be determined through the review process and/or peer review process that the submission is incomplete, inadequate or that further issues need to be addressed.

11.2 Consultation & Engagement

The Region may go beyond the minimum requirements as set out in the Planning Act for consultation and engagement, and expand on when and how enhanced opportunities for input are applied to the preparation of Regional studies, strategies and action plans.

Objectives:

i. Support ongoing consultation and engagement with individuals, groups and agencies to achieve consensus, whenever possible, on planning matters.

ii. Ensure the use of fair, open and accessible public consultation and engagement practices.

Policies:

It is the policy of Council to:

11.2.1 Encourage active participation from the public, stakeholders, and agencies, including strong cooperative relationships with the Region's area municipalities and conservation authorities.

11.2.2 Engage with Indigenous communities when considering land use matters and continue to build meaningful partnerships with Indigenous communities to facilitate knowledge sharing in land use planning processes.

11.2.3 Encourage the province to make financial resources available to Indigenous communities to support their participation in the planning process, such as the review of development applications, infrastructure decisions and watershed plans.

11.2.4 Ensure community input is considered in the planning and decision-making process.

11.2.5 Promote broad community awareness of planning issues and provide enhanced opportunities for input, including both traditional and innovative methods for engagement.

11.3 Development Review

Area municipal governments have the decision-making authority to approve, conditionally approve or reject a variety of development applications designed to manage growth in an orderly and efficient manner, such as zoning by-laws, site plans, plans of subdivision/condominium and severances.

Objective:

i. Support measures that assist in the development review process.

Policies:

Zoning By-laws

It is the policy of Council to:

11.3.1 Reserve the ability to enact by-laws to regulate the use of land lying within 45 metres from any limit of a regional road, as provided for by the Municipal Act.

11.3.2 Encourage the Councils of the area municipalities to establish an area municipal official plan policy and zoning by-law framework to implement inclusionary zoning in Protected Major Transit Station Areas in accordance with Ontario Regulation 232/18, and/or applicable community planning permit system areas in accordance with Ontario Regulation 173/16.

Holding Provisions

It is the policy of Council to:

11.3.3 Encourage area municipalities to pre-zone land using the holding ("H") symbol in conjunction with any use category, and indicate the use to which lands, buildings or structures may be put at such time in the future as the holding symbol is removed by amendment to the by-law.

11.3.4 Require that, prior to passing a by-law to remove the holding ("H") symbol, the Councils of the area municipalities ensure that:

a) the development is consistent with the orderly and phased development of the area municipality and the Region;

b) the owner has satisfied all the requirements of the area municipality and Region and entered into any necessary agreements in this regard; and

c) the owner has satisfied all the requirements of the Region with respect to the provision of water and sewage services, regional roads, and entered into any necessary agreements in this regard.

Legal Non-Conforming Uses

A legal non-conforming use, also referred to as a "grandfathered" use, can continue a particular land use that is no longer permitted under the current zoning by-laws.

The land use must have been established at a time when it was permitted under previous zoning permissions, or at a time that predates any zoning by-law, and must have been in continuous use since that time.

It is the policy of Council to:

11.3.5 Recognize that area municipalities may zone for the continuation, expansion or enlargement of legal non-conforming uses, or for minor variations to existing uses, provided that such uses:

a) have no adverse effect on the present uses of the surrounding lands or the implementation of the provisions of this Plan;

b) comply with provincial Minimum Distance Separation formulae, as amended by the province from time to time, if applicable;

c) are accessible by a public road which is maintained by the appropriate authority as open to traffic on a year-round basis and is of a standard of construction adequate to provide for the additional traffic generated by the proposed use;

d) are subject to any conditions that may be contained in an area municipal official plan;

e) where located on the Oak Ridges Moraine, were lawfully existing as of November 15, 2001, and where any expansion or enlargement thereto or variation to a similar use is implemented in conformity with Parts III and IV of the Oak Ridges Moraine Conservation Plan, which contains policies intended to maintain, improve or restore the ecological and hydrological integrity of the Moraine;

f) where located in the Protected Countryside of the Greenbelt Plan Area, were lawfully existing as of December 15, 2004, and where any expansion or enlargement thereto or variation to a similar use is implemented in conformity with the Greenbelt Plan. Lot creation associated with such uses shall not be granted;

g) permit the continuation of existing uses in place prior to June 2, 2009, in the Lake Simcoe watershed and ensure expansions, enlargement or variation to a similar use are implemented in conformity with the Lake Simcoe Protection Plan; and

h) comply with provincial Land Use Compatibility Guidelines, where applicable.

Site Plan Control

It is the policy of Council to:

11.3.6 Encourage the use of the site plan control provisions of the Planning Act to implement the policies and provisions of this Plan and the area municipal official plans to coordinate and enhance the physical development of the area municipality.

11.3.7 Require an area municipality to advise the Region upon receiving an application for development subject to site plan control abutting a road under the jurisdiction of the Region.

11.3.8 Require the owners of land proposed for development under site plan control to enter into one or more agreements under the Planning Act with the area municipality and/or Region, as necessary, to address all matters contained therein.

Subdivision & Condominium Approvals & Agreements

It is the policy of Council to:

11.3.9 Require the following conditions of approval attached to plans of subdivision pursuant to the Planning Act:

a) that the development complies with the provision of this Plan and the applicable area municipal official plans;

b) that the development can be supplied with adequate regional services to the satisfaction of Regional Council;

c) that the applicants enter into appropriate agreements with the Region and the area municipality, which may be registered against the title of the subject lands, and which may include such matters as regional services, financial requirements, regional and/or local road facilities, drainage, grading and landscaping, sidewalks, dedication of land for public uses, exclusive of parks and other requirements, to implement the provisions of this Plan and the applicable area municipal official plan;

d) that a lapsing date in accordance with Section 51(32) of the Planning Act be required for draft plans of subdivision;

e) that if approval of a draft plan of subdivision lapses, the policy objectives of Sections 5.1 and 5.4 shall be considered as a key component of the development review process for any new draft plan of subdivision; and

f) if a plan of subdivision or part thereof has been registered for eight years or more, and does not meet the growth management objectives of Section 5.1 and does not conform to the Policies of this Plan, Regional Council or the Councils of the area municipalities may use its authority under Section 50(4) of the Planning Act to deem it not to be a registered plan of subdivision.

Severances

It is the policy of Council to:

11.3.10 Grant only those severances which conform with the intent of this Plan and this Plan's designations, uses and policies, the zoning by-laws of the respective area municipality and in accordance with the Planning Act. Under no circumstances shall severances be granted that are contrary to this Plan and/or any area municipal official plan.

11.3.11 Discourage the creation of any lot in an area susceptible to flooding, erosion or any other physical or environmental constraint unless it can be clearly established that the proposed use does not have an adverse effect on such constraints, in accordance with Policy 7.6.3.

11.3.12 Apply the provincial Minimum Distance Separation formulae, as amended by the province from time to time, and the Environmental Protection Act and regulations to severances, where applicable.

11.3.13 Ensure all parcels of land are an adequate size for the use proposed, having regard to the topography of the land, the siting of proposed buildings and points of access. Where municipal services do not exist and are not to be provided for the development, regard shall be had to the suitability of the soil conditions to provide for an adequate potable private water supply, and for the installation of a satisfactory private sewage disposal system which complies with the standards of the Ministry of the Environment, Conservation and Parks and the Region.

11.3.14 Ensure all proposed lots have frontage upon, and access to, a public road maintained by the appropriate authority as open to traffic on a year-round basis and is of a standard of construction adequate to provide for the additional traffic generated by the proposed development.

11.3.15 Allow the creation of a land-locked parcel, notwithstanding Policy 11.3.14, provided the proposal is accompanied by an overall plan related to land assembly for a future subdivision indicating the approximate extent of the land assembly and provisions for future access.

11.3.16 In determining whether a plan of subdivision under the Planning Act is necessary, three additional lots may be considered as the maximum number of division by severance.

11.3.17 Ensure severances comply with the provisions of any site plan, subdivision or any other development agreements registered against the title of the subject lands.

11.3.18 Discourage severances in Employment Areas unless there exists an agreement registered on title between the owner and the Council of the respective area municipality and, where applicable, Regional Council, indicating the subdivision design and the provision of services for the lands affected.

11.3.19 Ensure that, notwithstanding Policy 11.3.18, any severances in Employment Areas comply with provincial Land Use Compatibility Guidelines.

11.3.20 Require that the approval of any application for severance for multiple residential, commercial or industrial uses be subject to the provisions of a site plan control agreement under the Planning Act, which has been entered into with the Council of the respective area municipality, and to the provisions of a servicing agreement, which has been entered into with the Region, and such agreements shall be registered on the title of the subject property.

11.3.21 Impose conditions on both the severed and retained parcels which may include but not to be limited to the:

a) fulfillment of financial requirements of the Region and/or area municipality;

b) dedication of lands to the area municipality for park purposes or, as an alternative, the payment of cash-in-lieu of such dedication may be accepted by the area municipality;

c) dedication of appropriate road widenings or one-foot reserves across the frontages of all proposed lots, where applicable;

d) limitation of time for the fulfillment of conditions of approval prior to the lapsing of the severance;

e) submission of a registered reference plan; and

f) in the case of surplus farm dwellings, that the retained farm parcel be zoned to prohibit any further severances and the establishment of any residential dwelling, in perpetuity.

11.3.22 Monitor severance activity within the Region on an annual basis.

11.3.23 Permit boundary adjustments or new lot creation to secure valued greenspace for natural heritage conservation purposes provided the severed parcel is zoned to permit only natural heritage conservation uses. However, consistent with other policies of this Plan, no new lot may be created for a residential dwelling in Prime Agricultural Areas or where development would negatively impact a key natural heritage and/or key hydrologic feature.

11.3.24 Refuse the creation of new lots within the Oak Ridges Moraine and Greenbelt Protected Countryside within or partially within a minimum vegetation protection zone of a key natural heritage feature and/or a key hydrologic feature, unless otherwise specified in this Plan.

11.3.25 Consider severances for agricultural and agriculture-related uses in Prime Agricultural Areas and Major Open Space Areas, generally in accordance with Section 6.2. Where applicable, such severance applications shall conform with the:

a) Oak Ridges Moraine Conservation Plan – which contains restrictive lot creation policies that are intended to maintain, improve or restore the ecological and hydrological integrity of the Moraine; and

b) Greenbelt Plan – which contains restrictive lot creation policies that are intended to support long-term agricultural production and economic activity and long-term sustainability of the natural heritage system within the Protected Countryside.

11.4 Planning Tools & Resources

There are a variety of supplemental legislative tools and resources available to regional and area municipal Councils to help achieve policy objectives. Many of the following tools can be implemented to effect change within site specific areas or on a region-wide basis.

Objectives:

i. Encourage area municipalities to adopt implementation tools to support the objectives and policies of this Plan.

ii. Ensure the Region utilizes a variety of tools and resources to implement the policies of this Plan.

iii. Support the acquisition of land in appropriate locations by municipalities and/or conservation authorities for natural heritage conservation.

iv. Support the acquisition or disposal of land in appropriate locations by the Region for community development purposes, including affordable housing.

Policies:

Community Improvement Areas

A Community Improvement Plan (CIP) is a tool that allows municipalities to direct funds or apply financial or other tools to implement policy objectives within a defined project area.

Regional Community Improvement Plans

It is the policy of Council to:

11.4.1 Enable community improvement by designating Community Improvement Project Areas through by-law for the purposes of adopting Regional Community Improvement Plans in accordance with the provisions of Section 28 of the Planning Act, where necessary.

11.4.2 Consider Regional Community Improvement Plans that may address the following:

a) affordable housing;

b) infrastructure that is within the Region's jurisdiction;

c) land and buildings within and adjacent to existing or planned transit corridors that have the potential to provide for higher density mixed-use development and redevelopment; or

d) other matters as the province may prescribe in accordance with the Planning Act.

Area Municipal Community Improvement Plans

It is the policy of Council to:

11.4.3 Encourage area municipalities to adopt Community Improvement Plans in accordance with the Planning Act, to stimulate the reuse, revitalization, redevelopment and rehabilitation of areas based on local needs and priorities.

11.4.4 Participate financially, or otherwise, in area municipal Community Improvement Plans subject to the Regional Revitalization Program guidelines and the Region's annual Business Plan and Budget process.

11.4.5 Focus the Region's participation in area municipal Community Improvement Plans on projects that contribute to advancing the goals of this Plan, based on eligibility requirements within the Regional Revitalization Program guidelines or other applicable guidelines.

Municipal Housing Facilities By-law

A Municipal Housing Facilities By-law (MHFB) is a type of Municipal Capital Facilities By-law which are legislated under Section 110 of the Municipal Act. An MHFB also permits municipalities to direct funds or apply financial or other tools to support affordable housing.

An MHFB allows a municipality to offer capital grants for affordable housing, as well as reduce or exempt eligible projects from the payment of property taxes and development charges.

It is the policy of Council to:

11.4.6 Support the development of new affordable housing by providing financial incentives through a Municipal Housing Facilities By-law in accordance with the provisions of Section 110 of the Municipal Act.

11.4.7 Encourage non-profit housing providers and for-profit developers to pursue other financial regional incentives, as well as funding opportunities offered by federal, provincial and/or area municipal levels of government to create new affordable housing.

Land Acquisition

It is the policy of Council to:

11.4.8 Acquire land to implement any feature of this Plan in accordance with the provisions of the Municipal Act or any other statute, if necessary.

11.4.9 Consider the acquisition of land by area municipalities, public agencies and utility providers for infrastructure to implement any feature of this Plan, in accordance with the policies of this Plan, applicable statutes, the Oak Ridges Moraine Conservation Plan and the Greenbelt Plan, where applicable.

Advisory Committees

It is the policy of Council to:

11.4.10 Establish and maintain Advisory Committees in areas where technical expertise, advice and/or representation from the public is beneficial to implementing the policies of this Plan.

11.4.11 Ensure the effective functioning and resourcing of these Advisory Committees by adopting terms of reference outlining their mandate, composition and requirements for reporting on an annual basis.

11.4.12 Consider the advice and recommendations of the Advisory Committees but is not bound by such recommendations.

Technical expertise and citizen engagement is encouraged and currently facilitated through the involvement of advisory committees on agriculture, environment and active transportation:

- Durham Agricultural Advisory Committee (DAAC);
- Durham Environment and Climate Advisory Committee (DECAC); and
- Durham Active Transportation Committee (DATC).

Implementation Guidelines

It is the policy of Council to:

11.4.13 Prepare guidelines, strategies and/or other supplemental materials, from time to time, to provide more detailed directions in the implementation of policies within this Plan.

11.5 Plan Review & Monitoring

Reviewing and monitoring the Regional Official Plan is a critical function of long-range planning. These activities help:

- measure the effectiveness of some or all the policies;
- identify emerging trends for additional review and research; and
- monitor the implementation of the Plan.

Overall, the purpose of reviewing and monitoring policies is to assess the Region's progress towards achieving the strategic directions of this Plan.

Objective:

i. Ensure regular review, monitoring and performance measurement is used to identify emerging trends and guide the successful implementation of this Plan.

Policies:

It is the policy of Council to:

11.5.1 Undertake a comprehensive review of this Plan as required, at any time to incorporate new objectives, policies and specific designations.

11.5.2 Review this Plan, in whole or in part, consistent with the Provincial Policy Statement to ensure that it continues to embody the policies of Regional Council and to ensure that it has regard for matters of provincial interest, conforms to provincial plans, and is consistent with the Provincial Policy Statements.

11.5.3 Monitor the following key indicators, in consultation with the area municipalities, on a regular basis:

a) population and employment forecasts;

b) region-wide intensification of built-up areas;

c) density of Strategic Growth Areas, as well as any key areas assigned a minimum density target, including:

i) Urban Growth Centres;

ii) Regional Centres;

iii) Protected Major Transit Station Areas; and

iv) Rapid Transit Corridors.

d) the range and mix of affordable and market-based housing options, including provisions associated with monitoring the Region's housing and homelessness plan;

e) employment densities, land supply and servicing status of Employment Areas; and

f) other key performance indicators, where appropriate.

11.5.4 Monitor the effect of new policies, implementing by-laws and projects within Protected Major Transit Station Areas, in consultation with the area municipalities, based on the:

a) amount, type and pace of development;

b) mix and density of land uses in the area;

c) reuse and demolition of existing buildings, including heritage buildings;

d) amount and type of employment;

e) overall population;

f) unit count and mix of housing types;

g) population to job ratio; and

h) parking spaces, loading facilities, transit improvements and active transportation infrastructure.





Chapter 12

Interpreting the Plan

Chapter 12. Interpreting the Plan

The policies of this Plan are to be read and interpreted in its entirety, and not be considered in isolation.

This Plan has been prepared in accordance with the relevant provincial policies and/or plans and the Region's own Strategic Plan and relevant service plans.

12.1 General Interpretation Policies

Policies:

It is the policy of Council to:

12.1.1 Ensure that where clarification is required for the interpretation of any policy in the Plan, reference shall be made to the objectives and, if necessary, the goals of the Plan.

Boundaries & Delineations

It is the policy of Council to:

12.1.2 Ensure that where the external boundaries of Urban Areas on Map 1 abut or are located immediately adjacent to roads, rights-of-way, railways, transmission lines, lot lines, concession lines and/or watercourses, it is intended that these boundaries shall coincide with such features. Where external boundaries abut roadways, boundaries generally coincide with the centre line of the road.

12.1.3 Clarify that, unless delineated and/or otherwise specified in this Plan, the internal boundaries and alignments of the components of the Urban Areas on Map 1 are approximate and are not intended to mark the exact location or extent of the designation of such components. Features such as arterial roads, railways, valleys, transmission lines or other clearly recognizable physical features may be considered when interpreting the intended boundaries of designations within the Urban Area. Where delineation is required by provincial policy and shown within this Plan, the exact internal boundaries shall be defined at such time as the area municipal official plans and zoning by-laws come into effect.

12.1.4 Ensure that, for the purposes of preparing zoning by-laws, the delineation of boundaries for Prime Agricultural Areas, Shoreline Residential Areas, Major Open Space Areas and Waterfront designations shall have regard for the various uses permitted in the respective designations, existing and future roads, other man-made features, property lines, rights-of-way, soil capability, topography, wooded areas, natural hazard lands and key natural heritage and key hydrologic features, in accordance with Map 1, which serves as a general indication of the boundary lines.

12.1.5 Delineate the boundaries of the Oak Ridges Moraine and Greenbelt Plan Area on Maps 1 and 2b, and any others where appropriate.

Areas Not Forming Part of this Plan

It is the policy of Council to:

12.1.6 Specify that this Plan may contain provisions for which approvals have not been granted by the Ministry of Municipal Affairs and Housing (Deferrals). Although such areas do identify the position of Regional Council, they do not form part of the approved Plan until or unless they receive approval from the Ministry of Municipal Affairs and Housing through further approved amendments to this Plan initiated by Regional Council.

12.1.7 Acknowledge that this Plan affects all lands within the boundary of the Regional Municipality of Durham, save and except for the lands within the boundary of the Mississaugas of Scugog Island First Nation and lands that are owned by the federal government.

12.1.8 Guide interpretation throughout this Plan using explanatory text, sidebars and illustrations, where appropriate. These components are provided for information only, intended to provide context and clarity to the numbered policies, and do not constitute part of this Plan.

Terminology

It is the policy of Council to:

12.1.9 Specify that terms appearing bookmarked (i.e. an underlined hyperlink) in this Plan, are defined in the Glossary, and are generally intended to be consistent with the definitions provided in provincial policy or plans. For specific applicability to any respective provincial policy or plan, regard should be given to that document.

12.1.10 Clarify that references to Envision Durham, the Plan, this Plan and the Regional Official Plan all refer to the Official Plan of the Regional Municipality of Durham.

12.1.11 Require area municipal official plans to refer to this Plan as the Durham Regional Official Plan.

12.1.12 Clarify that the Region, and Regional Council, in this Plan shall mean The Regional Municipality of Durham.



Glossary

Glossary

Active Transportation: means human-powered travel, including but not limited to, walking, cycling, inline skating and travel with the use of mobility aids, such as motorized wheelchairs or mobility scooters, and other power-assisted micromobility devices such as e-bikes and e-scooters moving at a comparable speed.

Additional Residential Unit: means a self-contained residential unit that is subordinate to a primary dwelling, in which both kitchen and bathroom facilities are provided. Additional residential units are recognized in provincial policy, and may include basement apartments, accessory dwelling units, microhomes, laneway suites, coach houses and garden suites.

Affordable Housing: means:

a) in the case of ownership housing, the least expensive of:

   i) housing for which the purchase price results in annual accommodation costs which do not exceed 30% of gross annual household income for low and moderate income households; or

   ii) housing for which the purchase price is at least 10% below the average purchase price of a resale unit in the Region; and

b) in the case of rental housing, the least expensive of:

   i) a unit for which the rent does not exceed 30% of gross annual household income for low and moderate income households; or

   ii) a unit for which the rent is at or below the average market rent of a unit in the Region.

Agricultural Condition: in regard to prime agricultural land, means a condition in which substantially the same areas and same average soil capability for agriculture are restored.

Agricultural Impact Assessment: means a study that evaluates the potential impacts of non-agricultural development on agricultural operations and the Agricultural System and recommends ways to avoid or, if avoidance is not possible, minimize and mitigate adverse impacts.

Agricultural System: means a system comprised of a group of inter-connected elements that collectively create a viable, thriving agricultural sector. It has two components:

a) An agricultural land base comprised of Prime Agricultural Areas, including specialty crop areas, and rural lands that together create a continuous productive land base for agriculture; and

b) An agri-food network which includes infrastructure, services and assets important to the viability of the agri-food sector.

Agricultural Uses: means the growing of crops, including nursery, biomass and horticultural crops; raising of livestock; raising of other animals for food, fur or fibre, including poultry and fish; aquaculture; apiaries; agro-forestry; maple syrup production; and associated on-farm buildings and structures, including, but not limited to livestock facilities, manure storages, value-retaining facilities and accommodation for full-time farm labour when the size and nature of the operation requires additional employment.

Agriculture-related Uses: means those farm related commercial and farm-related industrial uses that are directly related to farm operations in the area, support agriculture, benefit from being in close proximity to farm operations, and provide direct products and/or services to farm operations as a primary activity.

Agri-food Network: means, within the Agricultural System, a network that includes elements important to the viability of the agri-food sector such as regional infrastructure and transportation networks; on-farm buildings and infrastructure; agricultural services, farm markets, distributors and primary processing; and vibrant, agriculture-supportive communities.

Alternative Energy System: means a system that uses sources of energy or energy conversion processes to produce power, heat and/or cooling that significantly reduces the amount of harmful emissions to the environment (air, earth and water) when compared to conventional energy systems.

Alvars: means naturally open areas of thin or no soils over essentially flat limestone, dolostone or marble rock, supporting a sparse vegetative cover of mostly shrubs and herbs.

Archaeological Resources: includes artifacts, archaeological sites, marine archaeological sites, as defined under the Ontario Heritage Act. The identification and evaluation of such resources are based upon archaeological fieldwork undertaken in accordance with the Ontario Heritage Act.

Area of High Aquifer Vulnerability: on the Oak Ridges Moraine, means an area of high aquifer vulnerability as prescribed in the Oak Ridges Moraine Conservation Plan. Elsewhere, means lands whose uppermost aquifer is most vulnerable to contamination as a result of surface activities or sources, due to the thickness and permeability of the rock and soil above the aquifer. Vulnerability is expressed as an intrinsic susceptibility index calculated using methods established by the Ministry of the Environment, Conservation and Parks. Lands with an index value of less than 30 are considered to be of high vulnerability.

Area of Natural and Scientific Interest: means areas of land and water containing natural landscapes or features that have been identified as having life science or earth science values related to protection, scientific study or education. Earth science values refers to values that relate to the geological, soil and landform features (i.e. distinctive physical attributes of land such as slope, shape, elevation and relief) of the environment. Life science areas refer to areas that has been:

a) identified as having life science values (i.e. values that relate to the living component of the environment) related to protection, scientific study or education; and

b) further identified by the Ministry of Northern Development, Mines, Natural Resources and Forestry using evaluation procedures established by that Ministry, as amended from time to time.

Areas of Archaeological Potential: means areas with the likelihood to contain archaeological resources. Criteria to identify archaeological potential are established by the Province. The Ontario Heritage Act requires archaeological potential to be confirmed by a licensed archaeologist.

Brownfield Site: means an undeveloped or previously developed property that may be contaminated. They are usually, but not exclusively, former industrial or commercial properties that may be underutilized, derelict or vacant.

Built Heritage Resource: means a building, structure, monument, installation or any manufactured or constructed part or remnant that contributes to a property's cultural heritage value or interest as identified by a community, including an Indigenous community. Built heritage resources are located on property that may be designated under Parts IV or V of the Ontario Heritage Act, or that may be included on local, provincial, federal and/or international registers.

Community Hub: means a central location where residents may access a range of services in one place. Community hubs can include: social, health, retail, cultural, educational, recreational and other services and resources that support the daily needs of the community's residents.

Compact Built Form: means a land use pattern that encourages the efficient use of land, walkable neighbourhoods, mixed land uses (residential, retail, workplace and institutional**)** all within one neighbourhood), proximity to transit and reduced need for infrastructure. Compact built form can include detached and semi-detached houses on small lots as well as townhouses and walk-up apartments, multi-storey commercial developments, and apartments or offices above retail. Walkable neighbourhoods can be characterized by roads laid out in a well-connected network, destinations that are easily accessible by transit and active transportation, sidewalks with minimal interruptions for vehicle access, and a pedestrian-friendly environment along roads to encourage active transportation.

Complete Communities: means places such as mixed-use neighbourhoods or other areas within cities, towns and settlement areas that offer and support opportunities for people of all ages and abilities to conveniently access most of the necessities for daily living, including an appropriate mix of jobs, local stores and services, a full range of housing, transportation options, and public service facilities. Complete communities:

i. are age-friendly and may take different shapes and forms appropriate to their contexts;

ii. meet the needs for daily living without compromising the ability of future generations to meet their needs;

iii. have an appropriate ratio of population to jobs; and

iv. are based on decisions that integrate social, economic and environmental considerations.

Complete Streets: means streets planned to balance the needs of all road users, including pedestrian, cyclists, transit-users, goods movement and motorists as appropriate and feasible within the context of each project.

Comprehensive Review: means an official plan review which is undertaken by the Region, or an official plan amendment which is undertaken by the Region, in consultation with the respective area municipalities. A comprehensive review also includes an official plan review or an official plan amendment initiated by an area municipality that is in conformity with this Plan. For the purpose of this Plan, comprehensive review shall also mean a municipal comprehensive review, in accordance with the Growth Plan, where applicable.

Conserved: means the identification, protection, management and use of built heritage resources, cultural heritage landscapes and archaeological resources in a manner that ensures their cultural heritage value or interest is retained. This may be achieved by the implementation of recommendations set out in a conservation plan, archaeological assessment, and/or heritage impact assessment that has been approved, accepted or adopted by the relevant planning authority and/or decision-maker. Mitigative measures and/or alternative development approaches can be included in these plans and assessments.

Cultural Heritage Landscape: means a defined geographical area that may have been modified by human activity and is identified as having cultural heritage value or interest by a community, including an Indigenous community. The area may include features such as buildings, structures, spaces, views, archaeological sites or natural elements that are valued together for their interrelationship, meaning or association. Cultural heritage landscapes may be properties that have been determined to have cultural heritage value or interest under the Ontario Heritage Act or have been included on federal and/or international registers, and/or protected through official plan, zoning by-law, or other land use planning mechanisms.

Cultural Heritage Resources: means built heritage resources, cultural heritage landscapes and archaeological resources that have been determined to have cultural heritage value or interest for the important contribution they make to our understanding of the history of a place, an event, or a people. While some cultural heritage resources may already be identified and inventoried by official sources, the significance of others can only be determined after evaluation.

Delineated Built-up Area: means all land within the delineated built boundary. The delineated built boundary, in this context, refers to the limits of the developed urban area as defined by the Minister in consultation with affected municipalities for the purpose of measuring the minimum intensification target in this Plan.

Designated Greenfield Area: means lands within Settlement Areas (not including Rural Settlements) but outside of delineated built-up areas that have been designated in an official plan for development and are required to accommodate forecasted growth to the horizon of this Plan.

Development: means the creation of a new lot, a change in land use, or the construction of buildings and structures, any of which require approval under the Planning Act, or that are subject to the Environmental Assessment Act, but does not include:

a) activities that create or maintain infrastructure authorized under an environmental assessment process;

b) works that are subject to the Drainage Act; and

c) the carrying out of agricultural practices on land that continues to be used for agriculture uses.

District Energy System: means a system that distributes thermal energy to multiple buildings in an area or neighbourhood. These systems typically consist of a heating and cooling centre and a thermal network of pipes connected to a group of buildings.

Ecological Function: means the natural processes, products or services that living and non-living environments provide or perform within or between species, ecosystems and landscapes, including hydrologic functions and biological, physical, chemical and socio-economic interactions.

Ecological and/or Hydrological Integrity: means the condition of ecosystems in which:

a) the structure, composition and function of the ecosystems are unimpaired by the stresses from human activity;

b) natural ecological processes are intact and self-sustaining; and

c) the ecosystems evolve naturally.

Fish Habitat: means**,** as defined in the Fisheries Act, spawning grounds and any other areas, including nursery, rearing, food supply, and migration areas on which fish depend directly or indirectly in order to carry out their life processes.

Green Infrastructure: means natural and human-made elements that provide ecological and hydrologic functions and processes. Green infrastructure may include components such as natural heritage features and systems, parkland, stormwater management systems, trees, natural channels, permeable surfaces and green roofs.

Habitat of Endangered and/or Threatened Species: means habitat within the meaning of Section 2 of the Endangered Species Act. 2007:

a) with respect to a species listed on the Species at Risk in Ontario List as an endangered or threatened species for which a regulation made under clause 55(1)(a) of the Endangered Species Act, 2007 is in force, the area prescribed by that regulation as the habitat of the species; or

b) with respect to any other species listed on the Species at Risk in Ontario List as an endangered or threatened species, an area on which the species depends, directly or indirectly, to carry on its life processes, including life processes such as reproduction, rearing, hibernation, migration or feeding, as approved by the Ministry of Northern Development, Mines, Natural Resources and Forestry; and

c) places in the areas described in clause a) or b), whichever is applicable, that are used by members of the species as dens, nests, hibernacula or other residences.

Hazardous Forest Types for Wildland Fire: means forest types assessed as being associated with the risk of high to extreme wildland fire using assessment tools provided by the province.

Higher Order Transit: means transit that generally operates in partially or completely dedicated rights -of-way, outside of mixed traffic, and therefore can achieve levels of speed and reliability greater than mixed-traffic transit. Higher order transit can include heavy rail (such as subways and inter-city rail), light rail and buses in dedicated rights-of-way.

Highly Vulnerable Aquifers: means an aquifer that is particularly susceptible to contamination because of its location near the ground's surface or where the types of materials in the ground around it are highly permeable.

Housing Options: means a range of housing types such as, but not limited to single-detached, semi-detached, rowhouses, townhouses, stacked townhouses, multiplexes, additional residential units, microhomes, mid-rise and high-rise multi-residential buildings. The term can also refer to a variety of housing arrangements and forms such as, but not limited to rental and ownership housing, affordable housing, accessible housing, housing for people with special needs, seniors' housing, community housing, supportive housing, transitional housing, shared living, co-ownership housing, co-operative housing, community land trusts, life lease housing, land lease community homes, and housing related to employment, institutional or educational uses.

Hydrologic(al) Features: means:

a) permanent and intermittent streams;

b) wetlands;

c) kettle lakes and their surface catchment areas, referring to the area including and surrounding a kettle lake or wetland, from which surface runoff drains directly into the kettle lake or wetland.

d) seepage areas and springs; and

e) aquifers and recharge areas.

Hydrologic Functions: means the functions of the hydrological cycle that include the occurrence, circulation, distribution, and chemical and physical properties of water on the surface of the land, in the soil and underlying rocks, and in the atmosphere, and water's interaction with the environment including its relation to living things.

Impacts of a Changing Climate: means the present and future consequences from changes in weather patterns at local and regional levels including extreme weather events and increased climate variability.

Impervious Surface: means a surface that does not permit the infiltration of water, such as a rooftop, sidewalk, paved roadway, driveway or parking lot.

Infrastructure: means physical structures (facilities and corridors) that form the foundation for development. Infrastructure includes: sewage and water systems, septage treatment systems, stormwater management systems, waste management systems, electricity generation facilities and transmission and distribution systems, communications/telecommunications, transit and transportation corridors and facilities, oil and gas pipelines and associated facilities.

Intake Protection Zones: means the area on the water and land immediately surrounding a municipal water intake in a lake, river or stream that may be vulnerable to significant threats. The delineation of intake protection zones is based on the amount of time it takes for water to reach the intake, as outlined below:

a) Intake Protection Zone – 1: The one kilometre circle around the drinking water intake;

b) Intake Protection Zone – 2: The area within a 2-hour time travel to the drinking water intake; and

c) Intake Protection Zone – 3: The area that may contribute contaminants to an intake during an extreme event and is based on modeling contaminants released during the extreme event.

Intensification: means the development of a property, site or area at a higher density than currently exists through:

a) redevelopment, including the reuse of brownfield sites;

b) the development of vacant and/or underutilized lots within previously developed areas;

c) infill development;

d) additional residential units; and

e) the expansion or conversion, including adaptive reuse, of existing buildings.

Kettle Lake: means a depression formed by glacial action and permanently filled with water.

Key Hydrologic Areas: means significant groundwater recharge areas, highly vulnerable aquifers and significant surface water contribution areas that are necessary for the ecological and hydrological integrity of a watershed.

Key Hydrologic Features: means:

a) permanent and intermittent streams;

b) wetlands;

c) lakes and their littoral zones; and

d) seepage areas and springs.

Key Natural Heritage Features: means:

a) habitat of endangered and threatened species;

b) fish habitat;

c) wetlands;

d) areas of natural and scientific interest, life science;

e) significant valleylands;

f) significant woodlands;

g) significant wildlife habitat (including habitat of special concern species, as classified in Ontario Regulation 230/08, Species at Risk in Ontario List, made under the Endangered Species Act, 2007);

h) sand barrens, savannahs and tallgrass prairies; and

i) alvars.

Low and Moderate Income Households: means:

a) in the case of ownership housing, households with incomes in the lowest 60% of the income distribution for the Region; or

b) in the case of rental housing, households with incomes in the lowest 60% of the income distribution for renter households for the Region.

Low Impact Development: means an approach to stormwater management that seeks to manage rain and other precipitation as close as possible to where it falls to mitigate the impacts of increased runoff and stormwater pollution. It typically includes a set of site design strategies and distributed, small-scale structural practices to mimic the natural hydrology to the greatest extent possible through infiltration, evapotranspiration, harvesting, filtration and detention of stormwater. Low impact development can include, for example: bio-swales, vegetated areas at the edge of paved surfaces, permeable pavement, rain gardens, green roofs and exfiltration systems. Low impact development often employs vegetation and soil in its design, however, that does not always have to be the case and the specific form may vary considering local conditions and community character.

Major Development: means development consisting of:

a) the creation of four or more lots;

b) the construction of a building or buildings with a ground floor area of 500 square metres or more; or

c) the establishment of a major recreational use as described in Section 38 of the Oak Ridges Moraine Conservation Plan.

Major Facilities: means facilities which may require separation from sensitive land uses, including but not limited to airports, manufacturing uses, transportation infrastructure and corridors, rail facilities, marine facilities, sewage treatment facilities, waste management systems, oil and gas pipelines, industries, electricity generation facilities and transmission and distribution systems, and resources extraction activities.

Major Office: means freestanding office buildings of approximately 4,000 square metres of floor space or greater, or with 200 or more jobs.

Major Recreational Uses: means a recreational use that requires large-scale modification of terrain, vegetation or both and usually also requires large-scale buildings or structures, including but not limited to golf courses; serviced playing fields; serviced campgrounds; and ski hills.

Major Retail: means large-scale or large format stand-alone retail stores or retail centres that have a gross leasable area of 2,000 square metres or greater.

Major Transit Station Area: means the area including and around any existing or planned higher order transit station or stop within a settlement area; or the area including and around a major bus depot in an urban core. Major transit station areas generally are defined as the area within an approximate 500 to 800 metre radius of a transit station, representing about a 10-minute walk. “Protected” Major Transit Station Areas are MTSAs that have been delineated by a municipality and subsequently approved by the Minister of Municipal Affairs and Housing, as “protected” to allow for inclusionary zoning to be utilized.

Microhomes: also referred to as tiny homes, means a small, self-contained dwelling unit intended for year-round use, which cannot move and is not designed to be moved under its own power.

Mineral Aggregate Operation: means:

a) lands under license or permit, other than for wayside pits and quarries, issued in accordance with the Aggregate Resources Act;

b) or lands not designated under the Aggregate Resources Act, established pits and quarries that are not in contravention of municipal zoning by-laws and including adjacent land under agreement with or owned by the operator, to permit continuation of the operation; and

c) associated facilities used in the extraction, transport, beneficiation, processing or recycling of mineral aggregate resources and derived products, such as asphalt and concrete, or the production of secondary related products.

Mineral Aggregate Resources: means gravel, sand, clay, earth, shale, stone, limestone, dolostone, sandstone, marble, granite, rock or other material prescribed under the Aggregate Resources Act suitable for construction, industrial, manufacturing and maintenance purposes but does not include metallic ores, asbestos, graphite, kyanite, mica, nepheline syenite, salt, talc, wollastonite, mine tailings or other material prescribed under the Mining Act.

Minimum Distance Separation Formulae: means formulae and guidelines developed by the province, as amended from time to time, to separate uses so as to reduce incompatibility concerns about odour from livestock facilities.

Multi-modal: means relating to the availability or use of more than one form of transportation, such as automobiles, walking, cycling, buses, rapid transit, rail (such as commuter and freight), trucks, air and marine.

Natural Hazard Lands: means areas characterized by lands that exhibit unstable or organic soils, poor drainage, steep slopes, flood, erosion or landslide susceptibility or any other physical conditions that would create risk of life and property or damage to the environment.

Natural Heritage Features and/or Areas: means features and/or areas, including significant wetlands, significant coastal wetlands, other coastal wetlands in Ecoregions 5E, 6E and 7E, fish habitat, significant woodlands and significant valleylands in Ecoregions 6E and 7E (excluding islands in Lake Huron and the St. Marys River), habitat of endangered and/or threatened species, significant wildlife habitat and significant areas of natural and scientific interest, which are important for their environmental and social values as a legacy of the natural landscapes of an area.

Natural Heritage System: means a system made up of natural heritage features and areas, and linkages intended to provide connectivity (at the regional or site level) and support natural processes which are necessary to maintain biological and geological diversity, natural functions, viable populations of indigenous species and ecosystems. These systems can include natural heritage features and areas, federal and provincial parks and conservation reserves, other natural heritage features, lands that have been restored or have the potential to be restored to a natural state, areas that support hydrologic functions, and working landscapes that enable ecological functions to continue. The province has a recommended approach for identifying natural heritage systems, but municipal approaches that achieve or exceed the same objective may also be used.

Natural Self-sustaining Vegetation: means vegetation dominated by native plant species that can grow and persist without direct human management, protection, or tending.

Net-zero: means a building or community that is highly energy efficient and fully powered from on-site and/or off-site renewable energy sources. Net-zero buildings are designed and constructed to produce at least as much energy as they consume on an annual basis.

Net-zero Ready: means a building that has been designed and built to a level of performance such that it could, with the addition of solar panels or other renewable energy technologies, achieve net-zero energy performance.

Noise Sensitive Land Use: means land uses that may include, but are not limited to, noise sensitive spaces such as residential uses, day cares, hotels, institutional uses and retirement homes.

Normal Farm Practices: means a practice, as defined in the Farming and Food Production Protection Act, 1998, that is conducted in a manner consistent with proper and acceptable customs and standards as established and followed by similar agricultural operations under similar circumstances; or makes use of innovative technology in a manner consistent with proper advanced farm management practices. Normal farm practices shall be consistent with the Nutrient Management Act, 2002 and regulations made under that Act.

On-farm Diversified Uses: means uses that are secondary to the principal agricultural use of the property and are limited in area. On-farm diversified uses include, but are not limited to, home occupations, home industries, agri-tourism uses, and uses that produce value added agricultural products. Ground-mounted solar facilities are permitted in Prime Agricultural Areas, including specialty crop areas, only as on-farm diversified uses.

Permanent and/or Intermittent Streams: means a stream that continually flows in an average year, as in the case of a permanent stream; or, a stream-related watercourses that contain water or are dry at times of the year that are more or less predictable, generally flowing during wet seasons of the year but not the entire year, and where the water table is above the stream bottom during parts of the year, as in the case of an intermittent stream.

Prime Agricultural Area: means areas where prime agricultural lands predominate. This includes areas of prime agricultural lands and associated Canada Land Inventory Class 4 through 7 lands, and additional areas where there is a local concentration of farms which exhibit characteristics of ongoing agriculture. Prime agricultural areas are to be identified by the Ontario Ministry of Agriculture and Food and Rural Affairs using guidelines developed by the province as amended from time to time. A prime agricultural area may also be identified through an alternative agricultural land evaluation system approved by the province.

Prime Agricultural Land: means specialty crop areas and/or Canada Land Inventory Classes 1, 2 and 3 lands, as amended from time to time, in this order of priority for protection.

Protected Heritage Property: means property designated under Parts IV, V or VI of the Ontario Heritage Act; property subject to a heritage conservation easement under Parts II or IV of the Ontario Heritage Act; property identified by the Province and prescribed public bodies as provincial heritage property under the Standards and Guidelines for Conservation of Provincial Heritage Properties; property protected under federal legislation, and UNESCO World Heritage Sites.

Public Realm: means publicly accessible external space between private buildings including such areas as parking lots, streets, sidewalks, squares, lanes, parks and the municipal boulevard.

Public Service Facilities: means land, buildings and structures for the provision of programs and services provided or subsidized by a government or other body, such as social assistance, recreation, police and fire protection, health and educational programs, long-term care services and cultural services. Public service facilities do not include infrastructure.

Redevelopment: means the creation of new units, uses or lots on previously developed land in existing communities, including brownfield sites.

Renewable Energy [Systems]: means a system and/or facility that generates electricity, heat and/or cooling from a renewable energy source that is renewed by natural processes and includes wind, water, biomass, biogas, biofuel, solar energy, geothermal energy and tidal forces.

Rental Housing: means a building or related group of buildings on a rental property that containing one or more rented residential units, including vacant units that have been used for rented residential purposes.

Rental Property: meaning land where rental housing is located.

Rural Settlements: means existing Hamlets or similar existing small settlement areas that are long-established and identified in the official plan. These communities are serviced by individual private on-site water and wastewater systems containing a limited amount of undeveloped lands that are designated for development. All settlement areas that are identified as Hamlets in the Greenbelt Plan or as rural settlements in the Oak Ridges Moraine Conservation Plan are considered rural settlements for the purposes of this Plan, including those that would not otherwise meet this definition.

Sand Barrens: means land, not including land that is being used for agricultural purposes or no longer exhibits sand barrens characteristics, that:

a) has sparse or patchy vegetation that is dominated by plants that are:

   i) adapted to severe drought and low nutrient levels;

   ii) maintained by severe environmental limitations such as drought, low nutrient levels and periodic disturbances such as fire;

b) has less than 25% tree cover;

c) has sandy soils, other than shorelines, exposed by natural erosion or depositional process, or both; and

d) has been further identified, by the Ministry of Northern Development, Mines, Natural Resources and Forestry or by any other person, according to evaluation procedures established by the Ministry of Northern Development, Mines, Natural Resources and Forestry, as amended from time to time.

Savannah: means land (not including land that is being used for agricultural purposes and no longer exhibits savannah characteristics) that:

a) has vegetation with a significant component of non-woody plants, including tallgrass prairie species that are maintained by seasonal drought, periodic disturbances such as fire, or both;

b) has from 25% to 60% tree cover;

c) has mineral soils; and

d) has been further identified by the Ministry of Northern Development, Mines, Natural Resources and Forestry or by any other person, according to evaluation procedures established by the Ministry of Northern Development, Mines, Natural Resources and Forestry, as amended from time to time.

Seepage Areas and Springs: means sites of emergence of groundwater where the water table is present at the ground surface.

Sensitive Land Uses: means buildings, amenity areas, or outdoor spaces where routine or normal activities occurring at reasonably expected times would experience one or more adverse effects from contaminant discharges generated by nearby major facilities. Sensitive land uses may be a part of the natural or built environment. Examples may include, but are not limited to: residences, day care centres, and educational and health facilities.

Significant: means:

a) in regard to **groundwater recharge area**: means an area identified:

   i) as a significant groundwater recharge area by any public body for the purposes of implementing the Provincial Policy Statement;

   ii) as a significant groundwater recharge area in the assessment report required under the Clean Water Act, 2006; or

   iii) as an ecologically significant groundwater recharge area delineated in a subwatershed plan or equivalent in accordance with provincial guidelines.

   For the purposes of this definition, ecologically significant groundwater recharge areas are areas of land that are responsible for replenishing groundwater systems that directly support sensitive areas like cold water permanent and/or intermittent streams and wetlands.

b) in regard to **surface water contribution area**: means an area, generally associated with headwater catchments, that contributes to baseflow volumes which are significant to the overall surface water flow volumes within a watershed;

c) in regard to **valleyland**: means an area which is ecologically important in terms of features, functions, representation or amount, and contributing to the quality and diversity of an identifiable geographic area or natural heritage system. These are to be identified using criteria established by the province;

d) in regard to **wetlands, coastal wetlands and areas of natural and scientific interest**: means an area identified as provincially significant by the Ontario Ministry of Northern Development, Mines, Natural Resources and Forestry using evaluation procedures established by the province, as amended from time to time;

e) in regard to **wildlife habitat**: means an area that is ecologically important in terms of features, functions, representation or amount, and contributing to the quality and diversity of an identifiable geographic area or natural heritage system. These are to be identified using criteria established by the province; and

Criteria for determining significance for resources identified in c) to e) above are recommended by the province, but municipal approaches that achieve or exceed the same objective may also be used. While some significant resources may already be identified and inventoried by official sources, the significance of others can only be determined after evaluation.

Significant Woodlands: at the regional scale are identified as:

a) any woodland occurring within the Urban or Whitebelt Area which is two hectares in size or larger; or

b) any woodland occurring within the Rural Area which is 10 hectares in size or larger;

c) any woodland occurring within the Urban or Whitebelt Area which is one hectare in size or larger or any woodland occurring within the Rural Area which is four hectares in size or larger; and

   i) occurs within 30 metres of a significant natural heritage feature, any wetland greater than 0.5 hectares in size, or fish habitat; or

   ii) occurs wholly within an identified linkage area;

d) any woodland occurring within the Urban or Whitebelt Area which is one hectare in size or larger or any woodland occurring with the Rural Area which is four hectares in size or larger; and includes:

   i) a vegetation community with a provincial ranking of S1, S2, or S3 as designated by the Natural Heritage Information Centre;

   ii) rare, uncommon species or species with a restricted habitat preference; or

   iii) characteristics of older woodlands, including:

i. woodlands having 10 or more trees per hectare greater than 100 years old; or

ii. woodlands having 10 or more trees per hectare at least 50 centimetres in diameter, or a basal area of eight or more square metres in trees that are at least 40 centimetres in diameter.

e) notwithstanding, for woodlands occurring within the Oak Ridges Moraine or the Greenbelt Natural Heritage System, significant woodlands are based on the provincial criteria developed for the Oak Ridges Moraine Conservation Plan and the Greenbelt Plan.

Site Alteration: means activities such as the placement of fill, grading and excavation that would change the landform and natural vegetative characteristics of a site.

Special Needs: means any housing, including dedicated facilities, in whole or in part, that is used by people who have specific needs beyond economic needs, including but not limited to, needs such as mobility requirements or support functions required for daily living. Examples of special needs housing may include, but are not limited to long-term care homes, adaptable and accessible housing, and housing for persons with disabilities such as physical, sensory or mental health disabilities, and housing for older persons.

Strategic Growth Areas: means within the Urban Area, certain areas that have been identified at the Regional scale to be the focus for accommodating intensification and higher-density mixed uses in a compact urban built form. Strategic Growth Areas include Urban Growth Centres, Protected Major Transit Station Areas, Regional Centres and Rapid Transit Corridors (where applicable). Lands within these areas may include major opportunities for infill and/or redevelopment, brownfield sites and/or greyfield, or opportunities for the expansion or conversion of existing buildings. The other nodes and corridors described in Section 5.3 are not designated as Strategic Growth Areas in this Plan, but may be identified as appropriate locations for intensification and higher density development, as determined by area municipal official plans.

Tallgrass Prairies: means land, not including land that is being used for agricultural purposes or no longer exhibits tallgrass prairie characteristics, that:

a) has vegetation dominated by non-woody plants, including tall grass prairie species that are maintained by seasonal drought or periodic disturbances such as fire, or both;

b) has less than 25% tree cover;

c) has mineral soils; and

d) has been further identified, by the Ministry of Northern Development, Mines, Natural Resources and Forestry or by any other person, according to evaluation procedures established by the Ministry of Northern Development, Mines, Natural Resources and Forestry, as amended from time to time.

Traditional Ecological Knowledge: means Indigenous knowledge and values which have been acquired through experience, observation, from the land or from spiritual teachings through direct contact with the environment, and handed down from one generation to another. It includes the relationships between plants, animals, natural phenomena, landscapes and timing of events. This knowledge should be given equal consideration alongside western scientific knowledge.

Transit Supportive Density: means the minimum density target required to support a certain level of transit service. Transit supportive density of an area may evolve over time with changes in planned transit service and frequency of service. Unless a specific density target is established elsewhere in this Plan, the following guideline, adapted from the Province of Ontario's Transit Supportive Guidelines (2012) with reference to the Transit Priority Network (Map 3a) for comparison, should be considered when establishing transit supportive density targets:

a) Basic Transit Service (One bus every 20-30 minutes): 50 people and jobs per hectare (22 units per hectare); consistent with conventional bus routes and Other Transit Connection designated on Map 3a;

b) Frequent Transit Service (One bus every 10-15 minutes): 80 people and jobs per hectare (37 units per hectare); consistent with High Frequency Transit Network designated on Map 3a;

c) Very Frequent Bus Service (One busy every 5 minutes with potential for Bus Rapid Transit (BRT)): 100 people and jobs per hectare (45 units per hectare); consistent with certain components of the High Frequency Transit Network designated on Map 3a and Durham Transportation Master Plan (e.g., Whites Road, Brock Road, Westney Road, Taunton Road, Bayly Street);

d) Dedicated Rapid Transit (LRT/BRT): 160 people and jobs per hectare (72 units per hectare); consistent with Rapid Transit Network designated on Map 3a; and

e) Subway: 200 residents and jobs per hectare (90 units per hectare).

Transit-oriented Development: is the clustering of high-density, compact development in proximity to transit infrastructure. The design of transit-oriented development places includes a mix of residential, community use, retail and other pedestrian amenities that support transit ridership, along with good quality active transportation connections.

Universal Accessibility Design: means products, services and environments that can be used by people of all ages and abilities, to the greatest extent possible without the need for adaptation or specialized design. Seven principles for consideration include: equitable design, flexibility in use, simple and intuitive use, perceptible information, tolerance for error, low physical effort, and size and space for approach and use.

Urban Agriculture: means the practice of growing, processing and distribution of food within urban centres in accordance with local policies, by-laws and regulations.

Vegetation Protection Zone: means a vegetated buffer area surrounding a key natural heritage feature or key hydrologic feature.

Vulnerability Score: means the scoring of a designated vulnerable area, such as a wellhead protection area, intake protection zone, significant groundwater recharge area and/or area of high aquifer vulnerability, that reflects its vulnerability to contamination. The detailed delineation of vulnerability scoring is found in source protection plans and their associated assessment reports.

Waste Disposal Site: means:

a) any land upon, into, in or through which, or building or structure in which, waste is deposited, disposed of, handled, stored, transferred, treated or processed; and

b) any operation carried out or machinery or equipment used in connection with the depositing, disposal, handling, storage, transfer, treatment or processing referred to in clause a).

Water and/or Sewage Services: includes municipal sewage services and municipal water services, private communal sewage services and private communal water services, individual on-site sewage services and individual on-site water services and partial services, consistent with the definitions provided in the Provincial Policy Statement.

Water Quality and Quantity: is measured by indicators associated with hydrologic function such as minimum base flow, depth to water table, aquifer pressure, oxygen levels, suspended solids, temperature, bacteria, nutrients and hazardous contaminants and hydrologic regime.

Water Resources System: means a system consisting of ground water features and areas and surface water features (including shoreline areas), and hydrologic functions, which provide the water resources necessary to sustain healthy aquatic and terrestrial ecosystems and human water consumption. Ground water features refers to water-related features in the earth's subsurface, including recharge/discharge areas, water tables, aquifers and unsaturated zones that can be defined by surface and subsurface hydrogeologic investigations. The water resources system will comprise key hydrologic features and key hydrologic areas.

Wayside Pits and Quarries: means a temporary pit or quarry opened and used by or for a public authority solely for the purpose of a particular project or contract or road construction and not located on the road right-of-way.

Wellhead Protection Areas: means the area around a municipal drinking water well that may be vulnerable to threats in accordance with the following:

a) For water quality threats, the size and delineation of the wellhead protection areas are determined by how quickly water travels underground to the well, measured in years, as outlined below:

   i) Wellhead Protection Area – A: The area within a 100 metre radius of the wellhead;

   ii) Wellhead Protection Area – B: The area subject to a 2-year travel period to the well;

   iii) Wellhead Protection Area – C: The area subject to a 5-year travel period to the well;

   iv) Wellhead Protection Area – D: The area subject to a 25-year travel period to the well;

   v) Wellhead Protection Area – E: The area where a well is influenced by surface water;

b) For water quantity threats, the delineation of the wellhead protection area is based on a tiered water budget analysis that determined locations where there was a moderate or significant threat to water quantity. These are classified as:

   i) Wellhead Protection Area – Quantity 1: The area where activities that take water without returning it to the same aquifer may be a threat; and

   ii) Wellhead Protection Area – Quantity 2: The area where activities that reduce recharge may be a threat.

Wetlands: means lands that are seasonally or permanently covered by shallow water, as well as lands where the water table is close to or at the surface. In either case the presence of abundant water has caused the formation of hydric soils and has favoured the dominance of either hydrophytic plants or water-tolerant plants. The four major types of wetlands are swamps, marshes, bogs and fens.

Periodically soaked or wetlands being used for agricultural purposes which no longer exhibit wetland characteristics are not considered to be wetlands for the purposes of this definition.

Wetlands are further identified, by the province or by any other person, according to evaluation procedures established by the province, as amended from time to time.

Wildlife Habitat: means areas where plants, animals and other organisms live, and find adequate amounts of food, water, shelter and space needed to sustain their populations. Specific wildlife habitats of concern may include areas where species concentrate at a vulnerable point in their annual or life cycle; and areas which are important to migratory or non-migratory species.

Woodlands: means treed areas that provide environmental and economic benefits to both the private landowner and the general public, such as erosion prevention, hydrological and nutrient cycling, provision of clean air and the long-term storage of carbon, provision of wildlife habitat, outdoor recreational opportunities, and the sustainable harvest of a wide range of woodland products. Woodlands include treed areas, woodlots or forested areas, and vary in their level of significance at the local, regional and provincial levels. Woodlands may be delineated according to the Forestry Act definition of the province's Ecological Land Classification system definition for "forest".

Tables

Tables

Table 1. Complete Application Requirements

Information Requirement	Application/Development Scenario
Agricultural Assessment and/or a Statement of Conformity with Minimum Distance Separation Formulae	An Agricultural Assessment and/or a Statement of Conformity with Minimum Distance Separation formulae are required for any proposal for development or site alteration outside of Urban Areas and/or within proximity of a livestock facility as determined by Provincial Guidelines. This study requirement also applies to lands within and abutting the 2051 Settlement Area Boundary Expansion Areas, as described in Policy 5.7.3 g).
Air Quality Study	Where air quality is a potential concern between facilities and sensitive uses.
Archaeology and Cultural Heritage Assessment	An Archaeology and Cultural Heritage Assessment is required for any proposal for development or site alteration in proximity to lands that contain known archaeological resources or areas of archaeological potential, which refers to areas with the likelihood to contain archaeological resources. Methods to identify archaeological potential are established by the province, but municipal approaches which achieve the same objectives may also be used. The Ontario Heritage Act requires archaeological potential to be confirmed through archaeological fieldwork.
Climate Change Mitigation and Adaptation Plan	Evaluates and identifies recommendations to manage the vulnerability of natural systems and new development with the goal of reducing risks associated with the harmful impacts of a changing climate.

Information Requirement	Application/Development Scenario
Contaminant Management Plan	A Contaminant Management Plan is required for any proposal for development or site alteration on lands in proximity to a Wellhead Protection Area in accordance with Table 4.
Contamination Management Plan	A Contamination Management Plan is required within an area of high aquifer vulnerability within Urban Areas, for any proposal for development or site alteration to permit any high risk land uses as outlined in Table 3. The Contamination Management Plan must define the approach to protect water resources within the high aquifer vulnerable area.
Environmental Impact Study	An Environmental Impact Study is required for any proposal for development or site alteration in proximity to natural heritage or hydrological features, natural hazard lands, or which may have major environmental impacts. Components of the study may include an analysis of hydrogeological and geo-technical conditions, servicing options, groundwater and surface water analysis and an examination of terrestrial, wildlife, and aquatic species and enhancement opportunity areas, key linkages, and natural cover targets identified in applicable watershed plans. For lands within the limits of the Oak Ridges Moraine Conservation Plan and the Greenbelt Plan, the Environmental Impact Study shall be in accordance with the policies of the respective provincial plan. Prior to the submission of any application, applicants shall confirm the scope of any potential environmental study requirements with the Region, and area municipality to determine whether the study will be prepared by a consultant retained by the Region, or by the applicant. In those instances where the study is prepared by the Region, an application shall not be deemed to be a 'complete application' until such a time the study has been completed.

Information Requirement	Application/Development Scenario
Fiscal Impact Study	A Fiscal Impact Study is required for any proposal for development or site alteration in which the provision of any municipal services and utilities would cause financial, environmental or other hardship to the Region.
Heritage Impact Assessment	A Heritage Impact Assessment will be required for development on properties adjacent to protected heritage properties and for development on properties included in an area municipality's Heritage Register.
Hydrogeological and Servicing Options Report	A Hydrogeological and Servicing Options Report is required in accordance with Provincial Regulations, and for any proposal that would permit the development of five or more lots or units on privately owned and operated individual septic systems; or a proposal for fewer than five lots on privately owned and operated individual septic systems, and where more than 4500 litres of effluent would be produced per day. In the case of development on a lot with an abandoned well or borehole, an applicant must demonstrate the well or borehole has been decommissioned. Development or site alteration applications that require a Permit to Take Water under the Water Resources Act, or that have the potential to impact water quantity shall also be accompanied by a Hydrogeological and Servicing Options Report.
Land Use Compatibility Study	A Land Use Compatibility study is required where development may result in sensitive land uses (e.g. residential, schools, day care facilities, etc.) and Employment Area uses/Major Facilities locating within proximity to each other. The study shall address adequate separation distances in accordance with Provincial Guidelines. The study may be required in addition to other specific studies that assess noise, air quality/odour, dust and light emissions.

Information Requirement	Application/Development Scenario
Natural Hazard Study and/or Coastal Engineering Study	A Natural Hazard Study and/or Coastal Engineering Study are required for any proposal for development or site alteration in proximity to or within natural hazard lands or within hazardous lands along the shoreline of Lake Ontario and Lake Simcoe. The study must demonstrate that the proposal can occur in accordance with established standards and procedures. Prior to the submission of any application, an applicant shall confirm the scope of any potential natural hazards and study requirements with the Region and the local conservation authority.
Odour, Dust and Light Assessment	An Odour, Dust and Light Assessment is required for any proposal for development or site alteration in proximity to sources of noxious or hazardous substances or where sensitive land uses may experience adverse impacts from development.
Phase 1 and 2 Environmental Site Assessments and Records of Site Condition	A Phase 1, and if necessary, a Phase 2 Environmental Site Assessment Report is required for any proposal for development or site alteration on lands or adjacent lands that were previously used for industrial or noxious uses or in proximity to areas where soil or groundwater contamination is known or suspected. Environmental Site Assessment reports must be submitted in accordance with Regional requirements and Provincial guidelines and laws. In accordance with Regional requirements and Provincial guidelines and laws, a Record of Site Condition (RSC) may also be required. The RSC should be submitted prior to the consideration and approval of the development application. For a plan of subdivision or condominium application it may be included as a condition of draft approval. For an official plan amendment, it may be included as a requirement to be fulfilled prior to the adoption of a site specific official plan amendment or as a condition for the removal of a “H” holding symbol in the area municipal zoning by-law to the satisfaction of the Region and the area municipality.

Information Requirement	Application/Development Scenario
Planning Rationale/Justification Report	A Planning Rationale/Justification Report prepared by a Registered Professional Planner is required for any proposal for development or site alteration. The report shall demonstrate that the proposal meets the goals, objectives and policies of this Plan; and provide an indication of whether it conforms to applicable provincial plans and policies.
Rental Housing Conversion Study	A Rental Housing Conversion Study is required for any proposal for development or site alteration on a rental property that will facilitate the conversion of rental units to condominium tenure.
Salt Management Plan	Within the Credit Valley, Toronto and Region and Central Lake Ontario Source Protection Plan Area, development within a wellhead protection area – B with a vulnerability score of 10 requires the submission of a Salt Management Plan as part of a complete application. A Salt Management Plan may be required for development within a highly vulnerable aquifer or area of high aquifer vulnerability, in accordance with the applicable area municipal official plan.
Section 59 Notice	Development applications within a wellhead protection area or intake protection zone require a Section 59 notice, made under the authority of the Clean Water Act, 2006 and issued by the Risk Management Official, as part of a complete application.
Servicing and Infrastructure Study	A Servicing and Infrastructure Study is required for any proposal for development or site alteration which may have an impact on Regional servicing and infrastructure. The Study must ensure that the development application and/or change in land use can be supported by adequate municipal water, sanitary sewer, and stormwater management services. The requirement for the report shall be determined on a case-by-case basis, in consultation with the appropriate conservation authority and area municipality.

Information Requirement	Application/Development Scenario
Storm Water Management and/ or Functional Servicing Plan	A Storm Water Management and/or Functional Servicing Plan are required for any proposal for development or site alteration that will facilitate an application for a non-delegated subdivision or condominium application. The requirement for the report shall be determined on a case-by-case basis, in consultation with the appropriate conservation authority and area municipality.
Transportation Impact Study	A Transportation Impact Study (TIS) is required for any proposal for development or site alteration in proximity to a Regional Road. A TIS may be required by the Ministry of Transportation (MTO) as part of the permit application process to determine the extent to which highway improvements are required as a direct result of proposed construction or development within the MTO permit control area and adjacent to a provincial highway. In such cases, the requirement for the study shall be determined on a case-by-case basis, in consultation with the MTO.

Information Requirement	Application/Development Scenario
Stationary and/or Transportation Impact Noise Study	A Stationary and/or Transportation Impact Noise Study will be required as part of a complete application in the following circumstances: 1. Where a noise sensitive use is proposed: • Within a mixed-use area as designated by the area municipal official plan; • Up to 300 metres of an existing or future Arterial Road, depending on site conditions, road classification, and intervening land uses; • Within proximity of lands designated and/or zoned for Employment Areas as determined through the area municipal official plan; or in the vicinity of an existing stationary noise source; • Within 400 metres of an existing or proposed Freeway; • Within proximity of a pit licensed under the Aggregate Resources Act; • Within 300 metres of a railway corridor; • Within 1,000 metres of a railway yard; • Located at or above the 25 Noise Exposure Forecast (NEF) contours of an existing or planned airport. 2. Where a noise generating use is proposed in proximity to an existing or proposed noise sensitive use: • Within proximity of a proposed new stationary noise source in relation to an existing or designated noise sensitive land use; • Where a new or expanded pit licensed under the Aggregate Resources Act is proposed proximity of an existing or designated noise sensitive land use; • Where a new employment use is proposed within proximity of an existing or designated noise sensitive use; • Where a new or expanding rail yard is located within 1,000 metres of an existing or designated noise sensitive land use.

Information Requirement	Application/Development Scenario
Watershed/Sub-Watershed Study	A Watershed/Sub-Watershed Study may be required for any development or site alteration, and shall be determined on a case by case basis, in consultation with the appropriate conservation authority and area municipality.

Table 2. Country Residential Subdivisions

Area Identified on Map 1	Area Municipality	Location/Description	Maximum # of Residential Units Permitted
1	Uxbridge	Part of Lot 23, 24 & 25, Concession 2, former Township of Uxbridge, Subdivision Plan 18T-23023 (40M-1034)	36
2	Uxbridge	Part Lots 22, 23 & 24, Concession 6, former Township of Uxbridge, Subdivision Plan 18T-76009 (40M-1183) and S-U-2001-01 (40M-2219)	53
3	Uxbridge	Lots 12 & 13, Concession 8, former Township of Scott, Subdivision Plan 18T-78070 (40M-1195)	17
4	Clarington	Part Lot 25, Broken Front Concession, former Township of Clarke, Subdivision Plan 18T-78006 (10M-0758)	7
5	Uxbridge	Part Lots 21 & 22, Concession 7, former Township of Uxbridge, Subdivision Plan 18T-80058 (40M-1639)	60
6	Scugog	Part Lot 24, Concession 12, former Township of Reach, Subdivision Plan 18T-81036 (40M-1314)	17
7	Whitby	Part Lot 25, Concession 7, Subdivision Plan 18T-81006 (40M-1269)	15
8	Scugog	Part Lots 3 & 4, Concession 2, former Township of Reach, Subdivision Plan 18T-80501 (40M-1430)	76
9	Clarington	Part of Lots 32 & 33, Concession 3, former Township of Darlington, Subdivision Plans 18T-82030 (10M-0751), 18T-84048 (Block 12, Plan 10M-0774) & 18T-87023 (40M-1785)	48

Area Identified on Map 1	Area Municipality	Location/Description	Maximum # of Residential Units Permitted
10	Clarington	Part Lot 15, Concession 3, former Township of Darlington, Subdivision Plans 18T-82034 (10M-0755), 18T-84021 (10M-0763), 18T-85020 (10M-0780) & 18T-87036 (10M-0836)	40
11	Oshawa	Part Lot 12, Concession 9, former Township of East Whitby, Subdivision Plan 18T-83023 (40M-1374)	13
12	Ajax	Part Lot 10, Concession 4, former Township of Pickering, Subdivision Plan 18T-84025 (40M-1376)	15
13	Ajax	Part Lot 10, Concession 4, former Township of Pickering, Subdivision Plan 18T-84037 (40M-1372)	6
14	Pickering	Part Lots 7 & 8, Concession 5, former Township of Pickering, Subdivision Plan 18T-84043 (40M-1383)	30
15	Clarington	Part Lot 15, Concession 3, former Township of Darlington, Subdivision Plan 18T-85002 (10M-0768)	17
16	Clarington	Part Lot 15, Concession 3, former Township of Darlington, Subdivision Plan 18T-86047 (10M-0793)	12
17	Oshawa	Part Lot 11, Concession 9, former Township of East Whitby, Subdivision Plan 18T-87046 (40M-1775)	14
18	Ajax	Part Lots 4, 5 & 6, Concession 4, Subdivision Plan 18T-86027 (40M-1577)	68
19	Whitby	Part Lot 31, Concession 9, former Township of Whitby, Subdivision Plan 18T-87025 (40M-1673)	9
20	Clarington	Part Lots 31 & 32, Concession 4, former Township of Darlington, Subdivision Plan 18T-85018 (10M-0808)	52

Area Identified on Map 1	Area Municipality	Location/Description	Maximum # of Residential Units Permitted
21	Clarington	Part Lots 1 & 2, Concession 1, former Township of Clarke, Subdivision Plan 18T-89007	19
22	Whitby	Part Lot 24, Concession 8, former Township of Whitby, Subdivision Plan 18T-87045 (40M-2398)	30
23	Clarington	Part Lot 15, Concession 3, former Township of Darlington, Subdivision Plan 18T-87076, Part 1 of Reference Plan 10R-1274 (40M-2279)	6
24	Clarington	Part Lot 15, Concession 7, former Township of Clarke, Subdivision Plan 18T-90001 (40M-2480)	14
26	Whitby	Part of Lots 32 & 33, Concession 7, Town of Whitby, Subdivision Plan 18T-98003. Furthermore, a golf course and ancillary use shall be permitted on this site.	31
27	Ajax	Part Lot 6, Concession 4, former Township of Pickering, Subdivision Plan 18T-89058 (40M-2460)	7
28	Clarington	Part Lot 19, Concession 2, former Township of Clarke (40M-2255)	21
29	Pickering	Part Lot 4, Concession 5, former Township of Pickering, Subdivision Plan 18T-88059 (40M-2302) and being identified in the 1989 Assessment Roll Book as Parcel #18-01-030-008-21200. This plan of subdivision will not be serviced by municipal water or a sanitary sewer system.	35

Area Identified on Map 1	Area Municipality	Location/Description	Maximum # of Residential Units Permitted
30	Ajax	Part Lot 4, Concession 4, former Township of Pickering, Subdivision Plan 18T-90024 (S-A-2007-01) and being identified in the 1989 Assessment Roll Book as Parcel #18-05-010-010-07700. This development may be serviced with piped municipal sewerage and water supply systems.	27
31	Pickering	Part of Lot 11, Concession 8, City of Pickering, Subdivision Plan 18T-95035 (40M-2167)	8
32	Pickering	Part of Lot 2, Concession 5, City of Pickering, Subdivision Plan 18T-86013	14
33	Pickering	Part of Lots 3 & 4, Concession 5, City of Pickering, Subdivision Plan 18T-87096	23
34	Pickering	Part of Lot 7, Concession 5, City of Pickering, Subdivision Plan (S-P-2002-05) (40M-2382)	10
35	Uxbridge	Part of Lots 8 and 9, Concession 4, Township of Uxbridge, Subdivision Plan 18T-97020	36
36	Oshawa	Part Lot 9, Concession 6, Former East Whitby Township, Subdivision Plan 18T-84002 (S-O-2007-01)	15

Table 3. Land Use Groups by Risk to Drinking Water

Group 1 – High Risk Land Uses

- Waste disposal sites (Environmental Protection Act, Part V):
  - untreated septage
  - tailings from mines
- Landfilling of hazardous, municipal, or solid non-hazardous industrial or commercial waste:
  - liquid industrial waste injected into a well
  - PCB waste storage
- Organic soil conditioning sites
- Auto wrecking & salvage yards
- Commercial or industrial dry cleaning of textiles & textile products
- Foundries, non-ferrous metal smelting & refining & casting operations
- Metal finishing operations:
  - electroplating
  - electrocoating
  - galvanizing
  - painting
  - application of based enamel
- Vehicle stampings
- Wood & wood product preservation & treatment
- Bulk liquid trucking
- Local inter-municipal passenger service terminals
- Warehousing, bulk storage or retail sale of:
  - oil, natural gas & petroleum products
  - household or industrial cleaning production
  - herbicides & fungicides
  - construction equipment
  - underground and above-ground storage tanks that are not equipped with an approved secondary containment device
- Manufacturing of:
  - petroleum products or asphalt batching (including processing)
  - motor vehicles, trucks & bus bodies, aircraft & aircraft parts
  - trailers
  - rail cars
  - mobile homes
  - ships & boats
  - industrial chemicals
  - printing inks
  - adhesives
  - small electrical appliances
  - electric lamps
  - wet batteries
  - dry electrical industrial equipment
  - vehicle engines
  - cable & wire
  - pharmaceuticals & medicines
  - paints & varnishes
  - major electric appliances
  - plastics & synthetic resins
  - lighting fixtures
  - wet electrical equipment
  - steering & suspension parts
  - engine parts
  - motor vehicle wiring
  - jewelry & precious metals
  - reinforced fibreglass plastic

- electronic components (semi-conductors, printed circuit board, cathode ray tubes)
- unfinished fabricated metal products
- wheels & brakes
- leather products
- soaps & toilet preparations

- Generation and storage of hazardous waste or liquid industrial waste
- Airports
- Schedule 3 contaminants of Ontario Regulation 347 of the Environmental Protection Act

Group 2 – Moderate Risk Land Uses

- Golf courses
- Photo developing facilities
- Printing of newspapers, packing & books
- Repair of industrial machinery
- Repair of:
  - motor vehicles
  - aircraft
  - watercraft
  - rail vehicles
  - trucks
- Storage of:
  - plastic parts for vehicles
  - telephones
  - business machines
  - plastic products
  - paper & newsprint
  - stereo equipment
  - fax machines
  - dry batteries
  - glass & glass products
  - furniture, caskets, cabinets & other wood products
  - radios & televisions
  - computing equipment
  - rubber products
  - photographic equipment
  - Agricultural equipment

Group 3 – Low Risk Land Uses

- Funeral homes & cemeteries
- Medical, health & other laboratories
- Storage, repair yards & facilities for contractors
- Asphalt paving & roofing contractor yards
- Lawn care contractors
- Machinery, equipment rental yards
- Retail sale of agricultural pesticides & herbicides
- Repair (including welding) of:
  - photographic equipment
  - watches
  - electronic equipment
  - appliances
  - furniture
  - jewelry
  - electronic motors
  - small motors
  - vending machines
  - computer equipment
- Manufacturing of:
  - textiles (including dyeing)
  - vehicle fabric accessories
  - dairy
  - processed foods & meats
  - soft drinks & alcohol
  - baked goods
  - canned goods
  - frozen foods
- Pathogenic land uses or storage of pathogenic contaminants in excess of specified quantities

Group 4 – Restricted Land Uses

- Application, handling or storage of agricultural source material[1]
- Application, handling or storage of non-agricultural source material[1]
- Application, handing or storage of commercial fertilizer
- Application, handling or storage of pesticides
- Application or Storage of road salt
- Storage of snow
- Handling or storage of fuel
- Handling or storage of dense non-aqueous phase liquid
- Handling or storage of an organic solvent
- Livestock grazing, pasturing, outdoor confinement area or farm yard
- The management of runoff that contains chemicals used in the de-icing of aircraft
- Waste disposal sites that do not require Environmental Protection Act approval or Ontario Water Resources Act Approval

Note: This Table should be read in conjunction with Table 4 (Wellhead Protection Area & Intake Protection Zone Restrictions).

[1] **Agricultural Source Material** refers to treated or untreated material that is capable of being applied to land as a nutrient, but does not include compost that meets the Compost Guidelines, or a commercial fertilizer. Some examples of ASM are manure produced by farm animals, runoff from farm-animal yards and manure storages and milking center wash water.

Table 4. Wellhead Protection Area & Intake Protection Zone Restrictions

Land Use Type	WHPA-A	WHPA-B	WHPA-C	WHPA-D	Beaverton IPZ-1
High risk land uses	P	P	P	R*	P
Moderate risk land uses	P	P	R*	R*	
Low risk land uses	P	R*	R*		
Restricted land uses	RLU*	RLU*	RLU*	RLU*	RLU*
New lot creation	P				
Site alteration/ponds	P				
Expansion of existing uses, buildings, and structures, as permitted by the official plan	R*	R*	R*	R*	
A change of use to a similar use, as permitted by the official plan	R*	R*	R*	R*	
New public or private roads that are not infrastructure	P				
Conservation and flood or erosion control projects	P**				
Aggregate extraction below the water table	R*	R*			

Notes: This Table should be read in conjunction with Table 3 (Land Use Groups by Risk to Drinking Water).

* = Land uses may only be permitted if an appropriate study demonstrates that any impacts on the municipal well(s) will be within acceptable limits and the proposal is also in accordance with the applicable source protection plan.

** = Land uses are only permitted if demonstrated to be necessary in the public interest after all other alternatives have been considered, and the proposal is in accordance with the applicable source protection plan.

IPZ = Intake Protection Zone

WHPA = Wellhead Protection Area

P = Land uses that are prohibited.

R = Land uses that are subject to restrictions.

RLU = Restricted land uses – may only be permitted if a Section 59 Notice is issued by the Risk Management Official.

Table 5. Arterial Road Criteria

Classification Criteria

Criteria	Definition
Continuity	Roads of higher classification have longer continuous road sections, serve inter-municipal or inter-regional traffic and are characterized by higher volumes of through traffic. On the other hand, lower order roads have shorter, discontinuous road sections, serving shorter local trips and playing a key role in providing access to adjacent properties.
Cross-Section Features	Roads of higher classification tend to be higher capacity routes with relatively higher operating speeds and traffic volumes, with enhanced features such as auxiliary lanes, climbing and passing lanes, and intersection turn bays to improve traffic flow. Lower classes tend to have lower capacities with lower operating speeds and traffic volumes.
Cycling and Pedestrian Provisions	On roads of higher classification, cycling and pedestrian activity should be provided for in separated facilities from vehicular traffic such as multi-use paths, sidewalks and cycle tracks, or sidewalks and buffered bike lanes. On lower classes of roads, cycling and pedestrian activity should be encouraged, requiring sidewalks, but would not necessarily require separated cycling facilities from vehicular traffic.
Minimum Intersection Spacing	Roads of higher classification should have limited, appropriately spaced side road connections and a minimum of lower class road intersections. They may be grade separated or controlled at grade by well co-coordinated traffic control signals or roundabouts. More frequent intersection spacing is acceptable on lower classes of road. These intersections may be controlled at grade using regulatory signs and other traffic control mechanisms, including traffic calming measures.

Criteria	Definition
Network Spacing	The spacing of roads in the hierarchy normally relates to the density of activity occurring in the area. Roads of higher classification will be spaced more widely apart than the lower road classes, which provide for a completed grid to enable efficient traffic circulation.
On-Street Parking	Parking should be prohibited or restricted on roads of higher classification to provide for clearway conditions, while curbside parking may be accommodated on lower road classes and historic or emerging downtowns.
Right-of-Way Width	The cross-section of roads can range from divided, multi-lane facilities for higher classifications, through to two-lane undivided facilities for lower classes of road. This criterion is related to route capacity as well as maneuverability of heavy vehicles. The ultimate cross-section for a road generally evolves over time as traffic volumes increase. As such, rights-of-way should be of sufficient width to accommodate the ultimate cross-section.
Transit	Roads of higher classification should be the focus of more frequent and higher-order transit service, and can include dedicated transit lanes and/or express bus operations. Lower classes of road should accommodate bus operations of a more local nature.
Vehicle Priority	Roads of higher classification are likely to provide priority capacity for particular modes/ uses by way of bus, High Occupancy Vehicle (HOV), truck or transit lanes. Lower road classes generally provide for mixed traffic.

Arterial Road Class Criteria

Criteria	Type A Arterial	Type B Arterial	Type C Arterial
Connectivity	Connects with freeways, arterials and collectors	Connects with freeways, arterials, collectors and minimal local road access	Connects with arterials, collectors and limited local road access
Continuity	Continuous across regional areas or larger municipal areas	Typically continuous across several municipalities	Typically continuous within a single municipality with few spanning two or more; may be shorter and discontinuous sections when serving major traffic generators
Cross-Section Features	Enhanced through development of supporting circulation system, roadway widening, transit or HOV lanes, raised medians, coordination of traffic signals, consolidation of private accesses, reducing and controlling local residential street intersections, adding auxiliary lanes at intersections, improved curb radii, provision of right turn lanes, bus stops including shelters, far-side bus lanes or bus bays	Enhanced through development of supporting circulation system, roadway widening, transit or HOV lanes, raised medians, coordination of traffic signals, consolidation of private accesses, reducing and controlling local residential street intersections, adding auxiliary lanes at intersections, improved curb radii, provision of right turn lanes, bus stops including shelters, far-side bus lanes or bus bays	Enhanced through development of supporting circulation system, roadway widening, raised medians, coordination of traffic signals, consolidation of private accesses, reducing and controlling local residential street intersections, adding auxiliary lanes at intersections, channelized non-traversable medians, improved curb radii, provision of right turn lanes and bus stops including shelters

Criteria	Type A Arterial	Type B Arterial	Type C Arterial
Cycling and Pedestrian Provisions	Cycling provisions identified in the Regional Cycling Plan and corridor specific Environmental Assessment studies Sidewalk on both sides for pedestrians; a multi-use path may be provided as an alternative to a sidewalk Separation from traffic lane preferred for cyclists	Cycling provisions identified in the Regional Cycling Plan and corridor specific Environmental Assessment studies Sidewalk on both sides for pedestrians; a multi-use path may be provided as an alternative to a sidewalk	Cycling provisions identified in the Regional Cycling Plan and corridor specific Environmental Assessment studies Sidewalk on both sides for pedestrians; a multi-use path may be provided as an alternative to a sidewalk
Flow Characteristics	Uninterrupted flow except at traffic control signals and roundabouts	Uninterrupted flow except at traffic control signals, roundabouts and pedestrian crossings	Uninterrupted flow except at traffic control signals, roundabouts and pedestrian crossings
Goods Movement	Generally no restrictions[1]	Generally no restrictions[1]	Generally no restrictions[1]
Land Service/ Access	Rigid/Progressive access control Permit private access generally located a minimum of 200 metres apart in Urban Areas Permit large scale commercial and industrial developments, mixed-use developments and higher density developments with shared or combined access	Incremental/ Progressive access control Permit private access generally located a minimum of 80 metres apart in Urban Areas Promote higher densities with shared or combined access	Limited access control Promote higher densities with shared or combined access, or limit to single detached dwelling unit frontage

Criteria	Type A Arterial	Type B Arterial	Type C Arterial
Minimum Intersection Spacing	700 m intersection spacing in north-south direction 300 m /500 m intersection spacing in east-west direction[2] Signalized intersections or roundabouts where required	525 m major intersection spacing in north-south direction 300 m /500 m intersection spacing in east-west direction[2] Some minor intersections (T-type) mid-block subject to possible future control, if necessary to maintain corridor protection Signalized intersections, roundabouts or pedestrian crossovers where required	300 m intersection spacing Some minor intersections with future control provisions, if necessary due to capacity and queuing considerations Signalized intersections, roundabouts or pedestrian crossovers where required but not at consecutive intersections
Network Spacing	Generally 6.5 km between north/ south and east/west arterials	Generally 1.6 km between north/south arterials and 2.0 km between east/west arterials	Generally, no less than 0.8 km between north/south and east/ west arterials
On-Street Parking	Prohibited or peak hour restrictions	Prohibited or peak hour restrictions	Not recommended where traffic movement is impacted or it becomes a safety issue

Criteria	Type A Arterial	Type B Arterial	Type C Arterial
Right-of-Way Width[3]	For all existing and future Regional roads, refer to Table 6 For other Type A Arterials: • 36-45 m right-of-way • 36 m for ultimate 2-4 lane cross section • 40 m for ultimate 4-lane cross-section with left and right-turn lanes at intersections	For all existing and future Regional roads and sections of Dundas Street in Whitby and King/Bond Streets in Oshawa under area municipal jurisdiction, refer to Table 6 For other Type B Arterials: • 30-36 m right-of-way • 36 m for ultimate 4-lane cross-section	For all existing and future Regional roads, refer to Table 6 For other Type C Arterials: • 26-30 m right-of-way, dependent on transit facilities, on street parking and established development • 2-4 lane cross-section within the Urban Area
Traffic Service Objective	Traffic movement primary consideration Predominantly serves inter-regional and inter-municipal trips	Traffic movement major consideration Predominantly serves inter- and intra-municipal trips	Traffic movement slightly more important than land access Predominantly serves intra-municipal trips
Transit	May serve as Rapid Transit Spines, High Frequency Transit Network and Other Transit Connections	May serve as Rapid Transit Spines, High Frequency Transit Network and Other Transit Connections	May serve as High Frequency Transit Network
Travel Speed[4]	60-70 km/h Urban Area 80 km/h outside Urban Areas	50-60 km/h Urban Area 80 km/h outside Urban Areas	50-60 km/h
Typical Daily Traffic Volume	>10,000 AADT	5,000-40,000 AADT	4,000-20,000 AADT

Criteria	Type A Arterial	Type B Arterial	Type C Arterial
Vehicle Priority	To be considered as part of Strategic Goods Movement Network Consideration may be given for transit priority measures including dedicated transit lanes, queue jump lanes, and priority signals	To be considered for goods movement Consideration may be given for transit priority measures including queue jump lanes, and priority signals	Predominantly passenger and service vehicles, low to moderate truck traffic (except in Centres and Employment Areas)

Exceptions:

[1] Load restrictions due to seasonal conditions may apply.

[2] In some cases, spacing for east-west arterials can be reduced to 300 m if signals are "coupled" provided adjacent intersections are a minimum of 500 m away.

[3] Reduced right-of-way widths will only be considered in locations identified as exceptions in the area municipal Official Plans in accordance with regional policy. Wider rights-of-way may be required to accommodate features such as grading, utilities, active transportation facilities, transit facilities, landscaping, stormwater management infrastructure, noise attenuation installations, medians, traffic signals or other traffic control devices, roundabouts, auxiliary lanes, bridges, interchanges, and intersection sight triangles including at intersections of an arterial road and a railway. The required right-of-way shall be based on the specific characteristics of the location and shall be determined in accordance with accepted engineering design criteria. For new roads, the immediate provision of wider rights-of-way may be considered to accommodate such features. Unless otherwise identified by another appropriate comprehensive planning process or Official Plan, a corridor study or Environmental Assessment shall be undertaken to identify any exceptions to the right-of-way widths identified in this Table.

[4] Posted speed limits may be lower in school or community safety zones.

Outside of Urban Growth Centres, Regional Centres, Rural Regional Centres and Hamlets, the right-of-way widths, speeds and access spacing requirements shall generally apply to the arterial roads shown on Map 3b – Road Network. However, if the intent of this Plan is adhered to, and following adequate study to the effect that such provisions are impractical and cannot be implemented precisely, the authority having jurisdiction on such roads may deviate from these provisions without the need for an amendment to this Plan. Within Urban Growth Centres, Regional Centres, Rural Regional Centres and Hamlets, speed and access spacing requirements shall not apply to arterial roads. The above right-of-way width requirements shall apply unless it can be demonstrated, in consultation with the Region, that exceptions to the right-of-way widths are appropriate for specific sections of arterial roads. The exceptions shall be incorporated into the respective area municipal Official Plan.

Table 6. Regional Road Right-of-Way Requirements

Rd. #	Regional Road Name	From	To	Road Designation	Right-of-Way Width (m)[1]
1	Brock Rd.	Montgomery Park Rd.	Clements Rd.	Collector (Pickering)	36
1	Brock Rd.	Clements Rd.	Bayly St.	Type C Arterial	36
1	Brock Rd.	Bayly St.	Mowbray St.	Type A Arterial	45
1	Brock Rd.	Mowbray St.	Goodwood Rd.	Type A Arterial	36
1	Brock Rd.	Goodwood Rd.	Regional Hwy. 47	Type B Arterial	30
1	Main St.	Reach St.	Brock St.	Type B Arterial	20
1	Main St.	Brock St.	Toronto St.	Type B Arterial	20
1	Main St.	Toronto St.	Ball Rd.	Type B Arterial	30
1	Regional Rd. 1	Ball Rd.	Ravenshoe Rd.	Type B Arterial	30
2	Simcoe St.	Harbour Rd.	Wentworth St.	Type C Arterial	26[2]
2	Simcoe St.	Wentworth St.	Bloor St.	Type C Arterial	30[2]
2	Simcoe St.	Bloor St.	Olive Ave.	Type B Arterial	36[2]
2	Simcoe St.	Olive Ave.	Brock St.	Type B Arterial	26-30[2]
2	Simcoe St.	Brock St.	Conlin Rd.	Type B Arterial	38[2]

Rd. #	Regional Road Name	From	To	Road Designation	Right-of-Way Width (m)[1]
2	Simcoe St.	Conlin Rd.	Winchester Rd.	Type B Arterial	45[2]
2	Simcoe St.	Winchester Rd.	Westview Dr./ Steepleview Court	Type B Arterial	36
2	Simcoe St.	Westview Dr./ Steepleview Court	250 m north of Ridge Top Court	Type B Arterial	30
2	Simcoe St.	250 m north of Ridge Top Court	Howden Rd.	Type B Arterial	36
2	Simcoe St.	Howden Rd.	Scugog St. (Hwy. 7A)	Type A Arterial	36
2	Simcoe St.	Scugog St. (Hwy. 7A)	Beech St.	Type A Arterial	20-26
2	Simcoe St.	Beech St.	Regional Rd. 6	Type A Arterial	36
2	Simcoe St.	Regional Rd. 6	Hwy. 7	Type A Arterial (Kawartha Lakes Rd. 2)	N/A
2	Simcoe St.	Hwy. 7	Brock Conc. Rd. 14	Type A Arterial	36
2	Simcoe St.	Brock Conc. Rd. 14	980 m north of Brock Conc. Rd. 14	Type A Arterial (Kawartha Lakes Rd. 2)	N/A
2A	Brock St.	Simcoe St.	Centre St.	Type B Arterial	20-22
2A	Centre St.	Brock St.	Fairbanks St.	Type B Arterial	20-22
2A	Fairbanks St.	Centre St.	Simcoe St.	Type B Arterial	20-22
3	Winchester Rd.	Baldwin St.	Anderson St./ Watford St.	Type B Arterial	30
3	Winchester Rd.	Anderson St./ Watford St.	Ritson Rd.	Type B Arterial	36

Rd. #	Regional Road Name	From	To	Road Designation	Right-of-Way Width (m)[1]
3	Winchester Rd.	Ritson Rd.	Grandview St.	Type B Arterial	30
3	Grandview St.	Winchester Rd.	Columbus Rd.	Type C Arterial	30
3	Columbus Rd.	Grandview St.	Townline Rd.	Type B Arterial	30
3	Regional Rd. 3	Townline Rd.	Holt Rd.	Type B Arterial	30
3	Regional Rd. 3	Holt Rd.	175 m east of Lionel Byam Dr./Potters Ln.	Type B Arterial	26-30
3	Regional Rd. 3	175 m east of Lionel Byam Dr./ Potters Ln.	Bowmanville Ave.	Type B Arterial	30
4	Taunton Rd.	York Durham Line	Townline Rd.	Type A Arterial	45
4	Taunton Rd.	Townline Rd.	Hwy. 35/115	Type A Arterial	36
5	Ninth Conc. Rd.	York Durham Line	Sideline 20	Type B Arterial	30
5	Central St.	Sideline 20	190 m west of William St./ Canso Dr.	Type B Arterial	30
5	Central St.	190 m west of William St./ Canso Dr.	Brock Rd.	Type B Arterial	26-30
5	Ninth Conc. Rd.	Brock Rd.	Lake Ridge Rd.	Type B Arterial	30
5	Myrtle Rd.	Lake Ridge Rd.	440 m west of Ashburn Rd.	Type B Arterial	30
5	Myrtle Rd.	440 m west of Ashburn Rd.	Wilson House Dr.	Type B Arterial	26-30
5	Myrtle Rd.	Wilson House Dr.	Whitby/Oshawa Boundary	Type B Arterial	30

Rd. #	Regional Road Name	From	To	Road Designation	Right-of-Way Width (m)[1]
5	Raglan Rd.	Whitby/Oshawa Boundary	190 m west of Old Simcoe St.	Type B Arterial	30
5	Raglan Rd.	190 m west of Old Simcoe St.	Simcoe St.	Type B Arterial	26-30
6	Regional Rd. 6	Hwy. 7/12	Simcoe St.	Type B Arterial	30
7	Island Rd.	Hwy. 7A	Hood Dr./ Carnegie Beach Rd.	Type B Arterial	30
8	Regional Rd. 8	York Durham Line	Concession 6	Type B Arterial	30
8	Brock Street	Concession 6	Quaker Village Dr.	Type B Arterial	36
8	Brock Street	Quaker Village Dr.	Centre Rd.	Type B Arterial	30
8	Brock Street	Centre Rd.	Victoria Dr./ Railway St.	Type B Arterial	26-30
8	Brock Street	Victoria Dr./ Railway St.	Toronto St.	Type B Arterial	26
8	Reach St.	Main St.	Testa Rd./Coral Creek Dr.	Type B Arterial	26-30
8	Reach St.	Testa Rd./Coral Creek Dr.	Simcoe St.	Type B Arterial	30
9	Ganaraska Rd.	Highway 35/115	Cold Springs Camp Rd.	Type B Arterial	30
10	Regional Rd. 10	Lake Ridge Rd.	Sunderland Meadows Dr.	Type B Arterial	30
10	River St.	Sunderland Meadows Dr.	Hwy. 7/12	Type B Arterial	26-30
11	Sandford Rd.	York Durham Line	Regional Rd. 1	Type B Arterial	30
12	Regional Rd. 12	Lake Ridge Rd.	Brock Rd.	Type B Arterial	26-30
12	Regional Rd. 12	Brock Rd.	Sideroad 18A	Type B Arterial	30

Rd. #	Regional Road Name	From	To	Road Designation	Right-of-Way Width (m)[1]
12	Cameron St.	Sideroad 18A	Albert St.	Type B Arterial	30
12	Cameron St.	Albert St.	150 m east of Mcrae St.	Type B Arterial	26-30
12	Cameron St.	150 m east of Mcrae St.	400 m east of Simcoe St.	Type B Arterial	30
12	Regional Rd. 12	400 m east of Simcoe St.	Simcoe St.	Type B Arterial	30
13	Zephyr Rd.	Regional Rd. 39	Regional Rd. 1	Type B Arterial	30
13	Regional Rd. 13	Regional Rd. 1	Simcoe St.	Type B Arterial	30
14	Liberty St.	Baseline Rd.	Taunton Rd.	Type B Arterial	30
15	Simcoe St.	Mara Rd.	350 m east of Madill St.	Type B Arterial	26-30
15	Regional Rd. 15	350 m east of Madill St.	Simcoe St.	Type B Arterial	30
16	Ritson Rd.	Wentworth St.	Bloor St.	Type C Arterial	26
16	Ritson Rd.	Bloor St.	Olive Ave.	Type B Arterial	30-36
16	Ritson Rd.	Olive Ave.	William St.	Type B Arterial	26-30
16	Ritson Rd.	William St.	260 m north of Adelaide Ave.	Type B Arterial	36
16	Ritson Rd.	260 m north of Adelaide Ave.	Beatrice St.	Type B Arterial	30
16	Ritson Rd.	Beatrice St.	Taunton Rd.	Type B Arterial	36
16	Ritson Rd.	Taunton Rd.	Conlin Rd.	Type B Arterial	32-36
16	Ritson Rd.	Conlin Rd.	Winchester Rd.	Type B Arterial	36

Rd. #	Regional Road Name	From	To	Road Designation	Right-of-Way Width (m)[1]
17	Mill St.	Hwy. 401 Westbound Ramps	Manvers Rd./ Wilmot St.	Type B Arterial	20-26
17	Manvers Rd.	Mill St./Wilmot St.	Grady Dr./ Monroe St.	Type B Arterial	26-30
17	North St.	Grady Dr./ Monroe St.	450 m south of Conc. Rd. 3	Type B Arterial	30
17	North St.	450 m south of Conc. Rd. 3	Conc. Rd. 3	Local (Clarington)	30
17	North St. Realignment	450 m south of Conc. Rd. 3	Conc. Rd. 3	Type B Arterial	30
17	Conc. Rd. 3	Hwy. 35/115	North St. Realignment	Type B Arterial	30
17	Main St.	Hwy. 35/115	Sommerville Dr.	Type B Arterial	30
17	Main St.	Sommerville Dr.	Mill St.	Type B Arterial	20-26
17	Main St.	Mill St.	Taunton Rd.	Type B Arterial	30
18	Newtonville Rd.	Hwy. 401 Westbound Ramps	260 m north of Church Ln.	Type B Arterial	26
18	Newtonville Rd.	260 m north of Church Ln.	Ganaraska Rd.	Type B Arterial	30
19	Shirley Rd.	Simcoe St.	Regional Rd. 57	Type B Arterial	30
20	Regional Rd. 20	Bowmanville Ave.	Hwy. 35	Type A Arterial	36
21	Goodwood Rd.	Regional Hwy. 47	Old Mill Ln.	Type A Arterial	36
21	Goodwood Rd.	Old Mill Ln.	Front St.	Type A Arterial	30-36
21	Goodwood Rd.	Front St.	Lake Ridge Rd.	Type A Arterial	36

Rd. #	Regional Road Name	From	To	Road Designation	Right-of-Way Width (m)[1]
21	Regional Rd. 21	Lake Ridge Rd.	200 m west of Christie Cr.	Type A Arterial	36
21	Regional Rd. 21	200 m west of Christie Cr.	170 m east of Marsh Hill Rd. (north leg)	Type A Arterial	30
21	Regional Rd. 21	170 m east of Marsh Hill Rd. (north leg)	Hwy. 7/12	Type A Arterial	36
22	Bayly St.	Whites Rd.	Liverpool Rd.	Type A Arterial	40
22	Bayly St.	Liverpool Rd.	MacKenzie Ave.	Type A Arterial	45
22	Bayly St.	MacKenzie Ave.	50 m west of Burcher Rd.	Type A Arterial	42
22	Bayly St.	50 m west of Burcher Rd.	Lake Ridge Rd.	Type A Arterial	45
22	Victoria St.	Lake Ridge Rd.	Brock St.	Type A Arterial	40
22	Victoria St.	Brock St.	450 m east of South Blair St.	Type A Arterial	36
22	Victoria St. Realignment	450 m east of South Blair St.	380 m west of Thickson Rd.	Type A Arterial	36
22	Victoria St.	450 m east of South Blair St. (planned cul-de-sac)	380 m west of Thickson Rd.	Local (Whitby)	26
22	Victoria St.	380 m west of Thickson Rd.	Whitby/ Oshawa Boundary	Type A Arterial	40
22	Bloor St.	Whitby/Oshawa Boundary	Stevenson Rd. Connector	Type A Arterial	32-36
22	Bloor St.	Stevenson Rd. Connector	Park Rd. (south leg)	Type A Arterial	36
22	Bloor St.	Park Rd. (south leg)	Farewell St.	Type A Arterial	32-36

Rd. #	Regional Road Name	From	To	Road Designation	Right-of-Way Width (m)[1]
22	Bloor St.	Farewell St.	Grandview St.	Type A Arterial	40
22	Bloor St.	Grandview St.	Prestonvale Rd.	Type A Arterial	36
22	Bloor St.	Prestonvale Rd.	Courtice Rd.	Type A Arterial	40
23	Lake Ridge Rd.	Bayly St.	500 m north of Bayly St.	Type A Arterial	36
23	Lake Ridge Rd.	500 m north of Bayly St.	Brawley Rd.	Type A Arterial	40
23	Lake Ridge Rd.	Brawley Rd.	Hwy. 48	Type A Arterial	36
23	Lake Ridge Rd.	Hwy. 48	Thorah Conc. Rd. 5	Type B Arterial	30
23	Osborne St.	Thorah Conc. Rd. 5	Simcoe St.	Type B Arterial	26-30
23	Mara Rd.	Simcoe St.	Butcher St.	Type B Arterial	26-30
23	Mara Rd.	Butcher St.	500 m south of Thorah Conc. Rd. 7	Type B Arterial	30
23	Regional Rd. 23	500 m south of Thorah Conc. Rd. 7	Hwy. 12	Type B Arterial	30
24	Church St.	Bayly St.	290 m north of Durham Live Ave.	Type B Arterial	36
25	Consumers Dr.	Brock St.	Thickson Rd.	Type C Arterial	30
25	Stellar Dr.	Thickson Rd.	Thornton Rd.	Type C Arterial	30
25	Stellar Dr./Laval Dr. Connection	Thornton Rd.	Stevenson Rd.	Type C Arterial	30
25A	Champlain Ave.	Stellar Dr.	Stevenson Rd.	Type C Arterial	26

Rd. #	Regional Road Name	From	To	Road Designation	Right-of-Way Width (m)[1]
26	Thickson Rd.	Wentworth St.	Victoria St.	Type C Arterial	36
26	Thickson Rd.	Victoria St.	Crawforth St.	Type A Arterial	45
26	Thickson Rd.	Crawforth St.	Brawley Rd.	Type A Arterial	40
27	Altona Rd.	Kingston Rd.	Sparrow Circle (north leg)	Type B Arterial	36
27	Altona Rd.	Sparrow Circle (north leg)	Finch Ave.	Type B Arterial	32
27	Altona Rd.	Finch Ave.	Alexander Knox Dr. extension	Type B Arterial	36
27	Altona Rd.	Alexander Knox Dr. extension	Whitevale Rd.	Local (Pickering)	36
27	Whitevale Rd.	Altona Rd.	York Durham Line	Local (Pickering)	30
28	Peter Matthews Dr.	Hwy. 7	Brock Rd.	Type B Arterial	36
28	Rossland Rd.	Lake Ridge Rd.	East of Townline Rd.	Type B Arterial	36
29	Liverpool Rd.	Bayly St.	Kingston Rd.	Type B Arterial	45
29	Liverpool Rd.	Kingston Rd.	Glenanna Rd.	Type B Arterial	36
29	Liverpool Rd.	Glenanna Rd.	Finch Ave.	Type B Arterial	30
30	York Durham Line	Taunton Rd.	Regional Hwy. 47	Type B Arterial (York Regional Rd. 30)	N/A
30	York Durham Line	Regional Hwy. 47	Regional Rd. 39	Type B Arterial	30
31	Westney Rd.	Harwood Ave.	Monarch Ave.	Type C Arterial	36

Rd. #	Regional Road Name	From	To	Road Designation	Right-of-Way Width (m)[1]
31	Westney Rd.	Monarch Ave.	Bayly St.	Type C Arterial	30
31	Westney Rd.	Bayly St.	Kingston Rd.	Type B Arterial	45
31	Westney Rd.	Kingston Rd.	Taunton Rd.	Type B Arterial	36
31	Westney Rd.	Taunton Rd.	530 m south of Greenridge Dr.	Type B Arterial	30
31	Westney Rd. (Greenwood By-Pass)	530 m south of Greenridge Dr.	Hwy. 407 Eastbound Off-Ramp	Type B Arterial	36
31	Old Westney Rd.	530 m south of Greenridge Dr.	Cul-de-sac (planned south of Hwy. 7)	Local (Pickering)	30
31	Westney Rd.	Hwy. 407 Eastbound Off-Ramp	Seventh Conc. Rd.	Type B Arterial	30
31	Seventh Conc. Rd.	Westney Rd.	Brock Rd.	Type B Arterial	30
33	Harmony Rd.	Bloor St.	Missom Gt.	Type A Arterial	36
33	Harmony Rd.	Missom Gt.	Greenhill Ave.	Type A Arterial	40
33	Harmony Rd.	Greenhill Ave.	Conlin Rd.	Type A Arterial	45
33	Harmony Rd.	Conlin Rd.	Winchester Rd.	Type A Arterial	36
34	Courtice Rd.	Hwy. 401 Westbound Ramps	Regional Hwy. 2	Type A Arterial	40
34	Courtice Rd.	Regional Hwy. 2	Taunton Rd.	Type A Arterial	36
34	Enfield Rd.	Taunton Rd.	Regional Rd. 3	Type A Arterial	36

Rd. #	Regional Road Name	From	To	Road Designation	Right-of-Way Width (m)[1]
35	Wilson Rd.	Bloor St.	Olive Ave.	Type C Arterial	30
35	Wilson Rd.	Olive Ave.	Colborne St.	Type C Arterial	20-26
35	Wilson Rd.	Colborne St.	Attersley Dr.	Type C Arterial	26
35	Wilson Rd.	Attersley Dr.	Taunton Rd.	Type C Arterial	30
36	Hopkins St. Flyover	Victoria St. Realignment	Consumers Dr.	Type B Arterial	36
36	Hopkins St.	Consumers Dr.	Dundas St.	Type B Arterial	36
36	Anderson St.	Dundas St.	Rossland Rd.	Type B Arterial	36
37	Finch Ave.	Altona Rd.	Rosebank Rd.	Type B Arterial	30
37	Finch Ave.	Rosebank Rd.	Spruce Hill Rd.	Type B Arterial	36
37	Finch Ave.	Spruce Hill Rd.	Huntsmill Dr.	Type B Arterial	30
37	Finch Ave.	Huntsmill Dr.	Brock Rd.	Type B Arterial	36
38	Whites Rd.	Broadgreen St.	Downland Dr.	Local (Pickering)	23
38	Whites Rd.	Downland Dr.	Oklahoma Dr.	Collector (Pickering)	23
38	Whites Rd.	Oklahoma Dr.	Bayly St.	Collector (Pickering)	33
38	Whites Rd.	Bayly St.	280 m north of Sheppard Ave.	Type A Arterial	45
38	Whites Rd.	280 m north of Sheppard Ave.	Finch Ave.	Type A Arterial	45
38	Whites Rd. (including realignment)	Finch Ave.	Hwy. 7	Type A Arterial	45

Rd. #	Regional Road Name	From	To	Road Designation	Right-of-Way Width (m)[1]
38	Whites Rd. (west leg)	Whites Rd. Realignment	Taunton Rd.	Type A Arterial	36
39	Regional Rd. 39	York Durham Line	Concession 3	Type B Arterial	30
39	Concession 3	Regional Rd. 39	440 m south of Zephyr Rd.	Type B Arterial	30
39	Concession 3	440 m south of Zephyr Rd.	70 m south of Kester Ln.	Type B Arterial	26-30
39	Concession 3	70 m south of Kester Ln.	Ravenshoe Rd.	Type B Arterial	30
40	Alexander Knox Rd.	York Durham Line	370 m west of Whites Rd.	Type B Arterial	36
40	Alexander Knox Rd.	370 m west of Whites Rd.	Peter Matthews Dr.	Type B Arterial	37
40	Alexander Knox Rd.	Peter Matthews Dr.	Brock Rd.	Type B Arterial	36
41	Salem Rd.	Bayly St.	Kingston Rd.	Type B Arterial	45
41	Salem Rd.	Kingston Rd.	Ringer Rd.	Type B Arterial	40
41	Salem Rd.	Ringer Rd.	200 m south of Pugsley Ct.	Type B Arterial	36
41	Salem Rd.	200 m south of Pugsley Ct.	Rossland Rd.	Type B Arterial	45
41	Salem Rd.	Rossland Rd.	Taunton Rd.	Type B Arterial	36
42	Darlington-Clarke Townline Rd.	Regional Hwy. 2	Taunton Rd.	Type B Arterial	30
46	Brock St.	430 m south of Front St.	Victoria St.	Type C Arterial	26
46	Brock St.	Victoria St.	Hwy. 401 Eastbound Ramps	Type B Arterial	36

Rd. #	Regional Road Name	From	To	Road Designation	Right-of-Way Width (m)[1]
47	Shoreline Rd.	Regional Rd. 23	Simcoe/ Durham Boundary	Type B Arterial	30
50	Regional Rd. 50	Hwy. 12	190 m south of Talbot Rd.	Local (Brock)	30
50	Regional Rd. 50	190 m south of Talbot Rd.	Talbot Rd.	Local (Brock)	20
50	Regional Rd. 50	Talbot Rd.	Simcoe/ Durham Boundary	Local (Brock)	20
50	Regional Rd. 50	Regional Hwy. 48	Simcoe/ Durham Boundary	Type B Arterial	30
51	Talbot Rd.	Regional Rd. 50	Simcoe/ Durham Boundary	Local (Brock)	20
52	Boundary Rd.	Wentworth St.	Thornton Rd.	Type C Arterial	30
52	Phillip Murray Ave.	Stevenson Rd.	Park Rd.	Type C Arterial	26
52	Thornton Rd.	Champlain Ave.	Stellar Dr.	Type C Arterial	30
52	Thornton Rd.	Stellar Dr.	King St.	Type C Arterial	36
52	Thornton Rd.	King St.	Rossland Rd.	Type C Arterial	30
52	Thornton Rd.	Rossland Rd.	Taunton Rd.	Type B Arterial	30-36
53	Stevenson Rd.	Phillip Murray Ave.	Bloor St. Connector	Type C Arterial	26
53	Stevenson Rd.	Bloor St. Connector	Bond St.	Type B Arterial	36
53	Stevenson Rd.	Bond St.	Rossland Rd.	Type B Arterial	32

Rd. #	Regional Road Name	From	To	Road Designation	Right-of-Way Width (m)[1]
54	Park Rd.	Phillip Murray Ave.	Fenelon Cr. (north leg)	Type C Arterial	30
54	Park Rd.	Fenelon Cr. (north leg)	Bloor St.	Type C Arterial	40
54	Park Rd.	Bloor St.	Buena Vista Ave.	Type C Arterial	30
54	Park Rd.	Buena Vista Ave.	Rossland Rd.	Type C Arterial	26
55	Townline Rd.	Olive Ave.	King St.	Type B Arterial	30
55	Townline Rd.	King St.	Taunton Rd.	Type B Arterial	36
56	Farewell St.	200 m south of Harbour Rd.	Bloor St.	Type C Arterial	30
57	Bowmanville Ave.	Hwy. 401 Westbound On/ Off Ramps	280 m north of William Fair Dr.	Type A Arterial	40
57	Bowmanville Ave.	280 m north of William Fair Dr.	Boundary Rd.	Type A Arterial	36
57	Regional Rd. 57	Boundary Rd.	Hwy. 7A	Type A Arterial	36
57	Regional Rd. 57	Hwy. 7A	360 m south of Heron St.	Type B Arterial	30
57	Regional Rd. 57	360 m south of Heron St.	Cedar Grove Dr.	Type B Arterial	26-30
57	Regional Rd. 57	Cedar Grove Dr.	Pleasant View Ave.	Type B Arterial	26-30
57	Regional Rd. 57	Pleasant View Ave.	Cartwright Manvers Boundary Rd.	Type B Arterial	30
58	Manning Rd.	Brock St.	Hazelwood Dr.	Type C Arterial	36
58	Manning Rd.	Hazelwood Dr.	Garrard Rd.	Type C Arterial	30

Rd. #	Regional Road Name	From	To	Road Designation	Right-of-Way Width (m)[1]
58	Manning/ Adelaide Connection	Garrard Rd.	Sagebrush St.	Type C Arterial	36
58	Adelaide Ave.	Sagebrush St.	Thornton Rd.	Type C Arterial	36
58	Adelaide Ave.	Thornton Rd.	Kaiser Cr./ Grooms Ave.	Type C Arterial	26
58	Adelaide Ave.	Kaiser Cr./ Grooms Ave.	Simcoe St.	Type C Arterial	20-26
58	Adelaide Ave.	Simcoe St.	Mary St.	Type C Arterial	26
58	Adelaide Ave.	Mary St.	Division St.	Type C Arterial	20-26
58	Adelaide Ave.	Division St.	70 m west of Ritson Rd.	Type C Arterial	26
58	Adelaide Ave.	70 m west of Ritson Rd.	120 m east of Ritson Rd.	Type C Arterial	30
58	Adelaide Ave.	120 m east of Ritson Rd.	Townline Rd.	Type C Arterial	26
58	Adelaide Ave. Extension	Townline Rd.	Trulls Rd.	Type C Arterial	30
59	Gibb St.	Thornton Rd.	Simcoe St.	Type C Arterial	30
59	Gibb St./Olive Ave. Connection	Simcoe St.	Ritson Rd.	Type C Arterial	36
59	Olive Ave.	Simcoe St.	250 m east of Court St.	Local (Oshawa)	20
59	Olive Ave.	Ritson Rd.	Elmridge St.	Type C Arterial	20-26
59	Olive Ave.	Elmridge St.	Townline Rd.	Type C Arterial	26
60	Wentworth St.	Thickson Rd.	Thornton Rd.	Type C Arterial	36
60	Wentworth St.	Thornton Rd.	Stevenson Rd.	Type C Arterial	30

Rd. #	Regional Road Name	From	To	Road Designation	Right-of-Way Width (m)[1]
60	Wentworth St.	Park Rd.	60 m west of Ravine Rd.	Type C Arterial	30
60	Wentworth St.	60 m west of Ravine Rd.	Ritson Rd.	Type C Arterial	36
60	Wentworth St.	Ritson Rd.	Wilson Rd.	Type C Arterial	33
60	Wentworth St.	Wilson Rd.	Farewell St.	Type C Arterial	30
Hwy. 2	Kingston Rd.	Toronto-Durham Boundary	Elizabeth St.	Type B Arterial	45
Hwy. 2	Kingston Rd.	Elizabeth St.	Mill St.	Type B Arterial	30-34
Hwy. 2	Kingston Rd.	Mill St.	Rotherglen Rd.	Type B Arterial	34-42
Hwy. 2	Kingston Rd.	Rotherglen Rd.	Lake Ridge Rd.	Type B Arterial	45
Hwy. 2	Dundas St.	Lake Ridge Rd.	White Oaks Dr.	Type B Arterial	45
Hwy. 2	Dundas St.	White Oaks Dr.	200 m east of Cochrane St./ Annes St.	Type B Arterial	42-45
Hwy. 2	Dundas St.	200 m east of Cochrane St./ Annes St.	Henry St./Euclid St. to Byron St.	Type B Arterial	36
Hwy. 2	Dundas St.	Henry St./Euclid St. to Byron St.	Byron St.	Type B Arterial	26-30
Hwy. 2	Dundas St.	Byron St.	Athol St.	Type B Arterial	20-26
Hwy. 2	Dundas St.	Athol St.	Hickory St.	Type B Arterial	26-32
Hwy. 2	Dundas St.	Hickory St.	Garden St.	Type B Arterial	32-36
Hwy. 2	Dundas St.	Garden St.	Powell Rd.	Type B Arterial	42-45

Rd. #	Regional Road Name	From	To	Road Designation	Right-of-Way Width (m)[1]
Hwy. 2	Dundas St.	Powell Rd.	Whitby/ Oshawa Boundary	Type B Arterial	36
Hwy. 2	King St.	Whitby/Oshawa Boundary	Thornton Rd.	Type B Arterial	45
Hwy. 2	King St.	Thornton Rd.	Bond St.	Type B Arterial	40
Hwy. 2	King St.	Bond St.	Grenfell St.	Type B Arterial	28
Hwy. 2	King St.	Grenfell St.	Simcoe St.	Type B Arterial	20-22
Hwy. 2	King St.	Simcoe St.	Wilson Rd.	Type B Arterial	20-22
Hwy. 2	King St.	Wilson Rd.	Bond St./ Riverside Dr.	Type B Arterial	26
Hwy. 2	King St.	Bond St./ Riverside Dr.	Townline Rd.	Type B Arterial	45
Hwy. 2	King St.	Townline Rd.	Hwy. 418 Southbound Off-Ramp	Type B Arterial	45
Hwy. 2	Regional Hwy. 2	Hwy. 418 Southbound Off-Ramp	Bowmanville Ave.	Type B Arterial	36
Hwy. 2	King St.	Haines St.	Darlington-Clarke Townline Rd.	Type B Arterial	36
Hwy. 2	King St.	Darlington-Clarke Townline Rd.	North St./ Baldwin St.	Type A Arterial	36
Hwy. 2	King Ave.	190 m east of Beaver St.	Farrow Ave.	Type A Arterial	36
Hwy. 2	Regional Hwy. 2	Farrow Ave.	590 m east of Brownsville Rd. (north leg)	Type A Arterial	36

Rd. #	Regional Road Name	From	To	Road Designation	Right-of-Way Width (m)[1]
Hwy. 2	Regional Hwy. 2	590 m west of Brownsville Rd. (north leg)	330 m east of Brownsville Rd. (south leg)	Type A Arterial	30
Hwy. 2	Regional Hwy. 2	330 m east of Brownsville Rd. (south leg)	Reid Rd.	Type A Arterial	36
Hwy. 2	Regional Hwy. 2	Reid Rd.	Paynes Cr.	Type A Arterial	26
Hwy. 2	Regional Hwy. 2	Paynes Cr.	East Townline Rd.	Type A Arterial	36
Hwy. 2	Bond St.	King St.	King St./ Riverside Dr.	Type B Arterial	20-22
Hwy. 12	Brock St.	Rossland Rd.	Taunton Rd.	Type B Arterial	36
Hwy. 12	Baldwin St.	Taunton Rd.	Garden St. road allowance	Type B Arterial	36
Hwy. 47	Regional Hwy. 47	York Durham Line	Goodwood Rd.	Type A Arterial	40
Hwy. 47	Regional Hwy. 47	Goodwood Rd.	Tindall Ln.	Type B Arterial	26-30
Hwy. 47	Regional Hwy. 47	Tindall Ln.	Conc. 6	Type B Arterial	30
Hwy. 47	Toronto St.	Conc. 6	Elgin Dr.	Type B Arterial	36
Hwy. 47	Toronto St.	Elgin Dr.	Victoria Dr.	Type B Arterial	30
Hwy. 47	Toronto St.	Victoria Dr.	Brock St.	Type B Arterial	20
Hwy. 47	Brock St.	Toronto St.	First Ave./ Marietta St.	Type B Arterial	20
Hwy. 47	Brock St.	Fourth Ave.	Allinson Ln.	Type B Arterial	30
Hwy. 47	Regional Hwy. 47	Allinson Ln.	O'Neil Rd.	Type B Arterial	30

Rd. #	Regional Road Name	From	To	Road Designation	Right-of-Way Width (m)[1]
Hwy. 47	Regional Hwy. 47	O'Neil Rd.	Hwy. 7/12	Type B Arterial	36
Hwy. 48	Regional Hwy. 48	Hwy. 12	Simcoe St.	Type A Arterial	36

Notes:

[1] Wider rights-of-way on Regional roads may be required to accommodate features such as grading, utilities, active transportation facilities, transit facilities, landscaping, stormwater management infrastructure, noise attenuation installations, medians, traffic signals or other traffic control devices, roundabouts, auxiliary lanes, bridges, interchanges, and intersection sight triangles including at intersections of an arterial road and a railway. The required right-of-way shall be based on the specific characteristics of the location and shall be determined in accordance with accepted engineering design criteria. For new Regional roads, the immediate provision of wider rights-of-way may be considered to accommodate such features. A corridor study or Environmental Assessment shall be undertaken by the Region to identify any exceptions to the right-of-way widths identified in this table. If the intent of this Plan is adhered to, and following adequate study to the effect that the identified right-of-way provisions are impractical and cannot be implemented precisely, the Region may deviate from these provisions without the need for an amendment to this Plan. Within Urban Growth Centres, Regional Centres, Rural Regional Centres and Hamlets, the above right-of-way width requirements shall apply unless it can be demonstrated, in consultation with the Region, that exceptions to the right-of-way widths are appropriate for specific sections of Regional roads. The exceptions shall be incorporated into the respective area municipal Official Plan, and updated in this table and Map 3e through consolidation.

[2] Right-of-way widths to be confirmed upon completion of the Simcoe Street Rapid Transit Environmental Assessment Study.

Table 7. Key Natural Heritage & Key Hydrologic Features by Provincial Plan

Feature	Greenbelt Plan	Oak Ridges Moraine Conservation Plan	Lake Simcoe Protection Plan	Growth Plan	Provincial Policy Statement
Habitat of endangered and threatened species	●	●		●	●
Fish habitat	●	●		●	●
Areas of natural and scientific interest	● (life science)	● (life science)		● (life science)	●
Significant valleylands	●	●	●	●	●
Significant woodlands	●	●	●	●	●
Significant wildlife habitat	●	●		●	●
Sand barrens, savannahs, tallgrass prairies	●	●		●	
Alvars	●			●	
Wetlands	●	●	●	●	● (significant wetlands, significant coastal wetlands, coastal wetlands)

Feature	Greenbelt Plan	Oak Ridges Moraine Conservation Plan	Lake Simcoe Protection Plan	Growth Plan	Provincial Policy Statement
Permanent and intermittent streams	●	●	●	●	
Lakes and littoral zones	●		●	●	
Kettle lakes		●			
Seepage areas and springs	●	●		●	
Lake Simcoe Shoreline			●		
Natural areas abutting Lake Simcoe			●		

Maps

Maps

Map 1. Regional Structure – Urban & Rural Systems (online)

Map 2. Greenlands System (online)

Map 2a. Regional Natural Heritage System

Map 2b. Provincial Oak Ridges Moraine Conservation Plan and Greenbelt Plan Land Use Designations

Map 2c. Water Resources System – Key Hydrologic Features

Map 2d. Water Resources System – Significant Groundwater Recharge Areas

Map 2e. Water Resources System – Significant Surface Water Contribution Areas and Ecologically Significant Groundwater Recharge Areas

Map 2f. Source Water Protection

Map 2g. Highly Vulnerable Aquifers and Areas of High Aquifer Vulnerability

Map 2h. Landform Conservation Areas on the Oak Ridges Moraine

Map 3. Transportation System (online)

Map 3a. Transit Priority Network

Map 3b. Road Network

Map 3c. Strategic Goods Movement Network

Map 3d. Active Transportation Network

Map 3e. Regional Road Right-of-Way Requirements

Map 4. Aggregate Resources (online)



The Regional Municipality of Durham
605 Rossland Road East
Whitby, Ontario L1N 6A3
905-668-7711 or 1-800-372-1102
www.durham.ca

If this information is required in an accessible format, please contact us.
Within Durham: 311 • Toll-Free: 1-800-372-1102

City of Pickering



Seaton Community

Section Menu

The Seaton community, and the specific policies that direct growth in this urban area, were originally developed through the Central Pickering Development Plan. The plan was approved by the province in 2006 and was a product of years of work to create a sustainable urban community, with an extensive natural heritage system. The Seaton community is made up of over 7,000 acres of land, and over half will be preserved as open space lands. The Seaton community is planned to accommodate a population of approximately 61,000 residents, with a long-term intensification target of 70,000 residents.

Seaton Community Map **(/media/cdblqxe5/seaton-map-aug-2025.pdf)**

Seaton Elementary Schools **(#collapse_90224512-cfba-4ce0-b85e-e95decc2899f_1)**

Presently, two elementary school sites are approved in the south part of the Seaton community. The school sites are located on the south side of Taunton Road, east of Whites Road, and west of Peter Matthews Drive.

The **Durham District School Board** plans to open a new elementary school in fall 2025. The school will be located at the northwest corner of Burkholder Drive and Azalea Avenue.

The **Durham District Catholic School Board** plans to open a new elementary school in **September 2026**. The school will be located on the north side of Hibiscus Drive between Sapphire Drive and Burkholder Drive.

Several school sites are planned for the Seaton community. New school construction is dependent on provincial funding to school boards, and the school boards set their priority for new school locations. As a result, students may have to attend an existing school outside of their immediate neighbourhood.

Please contact the school boards directly to find the location of the school your child may attend. Links to the school boards are below:

Durham District School Board (DDSB) **(https://www.ddsb.ca/en/our-schools/find-a-school.aspx)**
Durham Catholic District School Board (DCDSB) **(https://www.dcdsb.ca/en/schools/Find-My-Local-Catholic-School.aspx)**

Recreation Complex, Community Centre and Libraries (#collapse_90224512-cfba-4ce0-b85e-e95decc2899f_2)

The Parks, Recreation & Culture (/parks-recreation-culture/) section provides links to information about City programs, services, activities, and events for the whole family.

Seaton Recreation Complex & Library

The Seaton Recreation Complex & Library (https://letstalkpickering.ca/seaton) will serve the growing community of Seaton and surrounding areas. The new facility will be located at the southeast corner of the re-aligned Whitevale Road (future Alexander Knox) & Sideline 24 (future Burkholder Drive).

This facility is envisioned to include various program amenities including a 25-metre indoor pool with a separate warm-water leisure tank, fitness centre with a group fitness studio, gymnasium, two indoor ice pads, walking track, multi-purpose program rooms, and library branch with a full suite of services.

Project Updates

April 22, 2025 - Council receives the findings of the public engagement process for the design of the Seaton Recreation Complex & Library for information and considered other staff recommendations outlined in the report. The project is on pause and staff will provide a project update to Council in September 2025. Read Report CAO 05-25 (https://corporate.pickering.ca/WebLink/DocView.aspx?id=259201&dbid=1&repo=PICKERING) for details.

December 2, 2024 - Council receives a project status update on the construction of the Seaton Recreation Complex & Library. Read Report CAO 06-24 (https://corporate.pickering.ca/WebLink/DocView.aspx?id=258145&dbid=1&repo=PICKERING) for details.

July 2, 2024 - Pickering selects Architect for highly anticipated Seaton Recreation Complex & Library. Read Report OPS 12-24 (https://corporate.pickering.ca/WebLink/DocView.aspx?id=255165&dbid=1&repo=PICKERING) for details.

Pickering Heritage & Community Centre

The Pickering Heritage & Community Centre (/parks-recreation-culture/dorsay-community-heritage-centre/) facility is located on the upper site of the Pickering Museum Village, located at Highway 7 and Greenwood Road. This facility will bring together a museum, library, and community centre under one roof. Construction has begun with opening anticipated in 2026.

Seaton Community Park (#collapse_90224512-cfba-4ce0-b85e-e95decc2899f_3)

Dave Ryan Community Park

The future Dave Ryan Community Park will be located at the southeast corner of Mulberry Lane and Alexander Knox Road. The community park will include a full-size lit soccer pitch, lit ball diamond, tennis/pickleball courts, half-court basketball, large junior and senior playground, water play area, on-site parking lot, and a washroom/fieldhouse.

Learn more about Parks and Trails (/parks-recreation-culture/parks-and-trails/) within Pickering

Seaton Commercial Plazas (#collapse_90224512-cfba-4ce0-b85e-e95decc2899f_4)

At this time, the City is reviewing a proposal for a commercial plaza located on the south side of Taunton Road between Burkholder Drive and Peter Matthews Drive. The applicant advises that the start of construction is anticipated Spring 2026. The exact tenants at this time are not known. However, it is anticipated that a variety of commercial uses will be provided, such as a grocery store, banks, and restaurants.

Another commercial plaza is planned at the southwest corner of Alexander Knox Road and Peter Matthews Drive. The proposed commercial plaza is planned to include a variety of commercial uses such as a grocery store, daycare centre, pharmacy, restaurants, and other commercial/service uses. The applicant anticipates the start of construction in 2026.

Several other commercial plazas are planned for the Seaton Community. The timing of commercial construction is dependent on retail market conditions, population growth and the demand for services.

Doing Business in Seaton **(#collapse_90224512-cfba-4ce0-b85e-e95decc2899f_5)**

Providing opportunities for residents to work close to home is a key component of ensuring the sustainability of both the Seaton Community, and the City of Pickering as a whole. Our goal is to attract investment in a wide variety of industrial, commercial and retailing businesses throughout Seaton.

Seaton supports a balance of residential and employment growth, with the objective of providing up to 35,000 jobs when fully built out. The majority of job creation will occur within a prestige employment area, the "Innovation Corridor", located along Highway 7/407. There will also be 'population-serving' jobs throughout the community, including personal service, office and retail employment.

Transportation infrastructure has been enhanced to support new business growth. Highway 407 spans the breadth of the City of Pickering and Durham Region, connecting directly through to Highway 412 & 418. Wherever your destination, full interchanges at Brock Road, Whites Road, and Peter Matthews Drive (planned) make the movement of goods and people quick and easy. The Province of Ontario has also announced the widening of Highway 7.

Contact our Economic Development Office **(https://www.investpickering.ca/)** to explore new business opportunities in Seaton.

Business, Building & Development **(/business-building-development/)**

Seaton Community **(/business-building-development/seaton-community/)**

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Canadian Environmental Law Association
EQUITY. JUSTICE. HEALTH.

Emergency Planning at the Pickering Nuclear Generating Station



Submission by Canadian Environmental Law Association

Theresa McClenaghan, Executive Director and Counsel

May 3, 2013

CELA Publication #899 / ISBN #978-1-926602-49-3

Canadian Environmental Law Association

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Submission to: The Canadian Nuclear Safety Commission c/o Louise Levert Secretariat Canadian Nuclear Safety Commission 280 Slater St., P.O. Box 1046 Ottawa, Ontario K1P 5S9

Sent by E-mail: interventions@cnsc-ccsn.gc.ca

Hearing Ref. 2013-H-03

Pickering Day Two Hearing to renew and merge the Pickering A and B operating licences

Canadian Environmental Law Association: Review and Submissions on Emergency Planning at the Pickering Nuclear Generating Station

May 3, 2013

Dear Ms. Levert:

The Canadian Environmental Law Association requests to Intervene at the Day Two Hearings in the above-referenced matter. Please find attached our submissions in respect of our review of emergency planning at the Pickering Nuclear Generating Station.

Theresa A. McClenaghan

Executive Director and Counsel

Canadian Environmental Law Association

Overview of Contents:

Summary of Recommendations

A. Introduction

B. Review of Emergency Planning Issues At Pickering

C. Safety

D. Sufficiency of the Information Base for Licensing

E. Siting

F. Community Engagement

G. Regulatory Oversight / Decision of the CNSC

H. Conclusion and Recommendations

I. Decision Requested

SUMMARY OF RECOMMENDATIONS:

- **RECOMMENDATION 1:** CELA submits that this licence should not be granted until all of the measures list by OPG in its application in Appendix 6, along with other recommendations made by the 2011 IRSS Report, the 2011 CNSC Fukushima Task Force and recommendations herein are actually in place and demonstrated to the regulator, with evidence, to be effective. CELA also submits that it is critical that this evidence be made public. Members of the surrounding communities must be able to understand what is in place; how effective it is; what has changed; and on what basis the regulator is judging the emergency plans to be in place.

- **RECOMMENDATION 2:** CNSC should require multi-unit severe accident planning to be demonstrated by OPG, along with the effectiveness of off-site emergency response in such a case. Similarly, CNSC should ensure, contrary to previous practice, that extreme natural hazard initiated events and "gross human error" are also examined in terms of presenting an emergency planning basis, and that the on-site and off-site emergency preparedness and planning are demonstrated to be sufficient and reliable to respond to all of these undesirable scenarios in the event that they lead to severe offsite releases.

- **RECOMMENDATION 3:** CELA recommends that this post-accident source term information be required by the CNSC as a condition of licensing and that the CNSC require OPG to upgrade their capacity to provide source term information and its basis, for multi-unit accidents, as a condition of the Pickering NGS licence. This should include reassessment of plume and dose modelling for multi-unit accidents at the Pickering NGS as recommended by the Fukushima Task Force.

- **RECOMMENDATION 4:** CELA recommends that the CNSC should require the licensees to demonstrate that there are, in place, properly resourced, sufficiently detailed emergency planning and preparedness plans that would address Chernobyl–size accidents or Fukushima–size accidents. The basis for this recommendation includes world-wide experience with these catastrophic accidents. This recommendation is independent of particular event sequences and rather takes account of the myriad ways that things that can go wrong resulting in an accident and resulting in a serious breach of containment, regardless of how caused. It also includes consideration of the fact that among the events that may initiate a catastrophe at a CANDU are those that are beyond the control of the operator such as hostile action or unforeseen external weather events or unforeseen combinations of failures including human error.

- **RECOMMENDATION 5:** The authority of Toronto Emergency Planning Officials to immediately initiate the Public Alerting System upon receipt of a notification from OPG for a general emergency with an imminent or ongoing emission should be clearly specified. If it is not intended that this authority be provided to Toronto's officials under the TNERP, this should be stated with a rationale for the discrepancy compared to the DRNERP.

- **RECOMMENDATION 6:** CELA recommends that the CNSC refuse further extension of Pickering's operating licence without the 3 km and 10 km alerting systems fully functional, both within the Region of Durham and within the City of Toronto, with robust evidence that they have been fully tested and are effective to meet the objectives specified in the PNERP, 2009.

- **RECOMMENDATION 7:** CELA also recommends that the emergency response plans time-frames be compressed so as to provide alerts to the public, and instructions to the public on protective actions required in as short a time frame as possible, preferably less than 30 minutes from the onset of the accident. Methods to compress this time frame should be considered and tested, and their efficacy should be one of the points of evaluation by the CNSC in the licence applications by the operators.

- **RECOMMENDATION 8:** CELA recommends that as an interim measure, the CNSC should require that OPG in conjunction with the City of Toronto, conduct outreach and

notification to members of the public resident in Toronto (at a minimum within the Primary Zone), as to the availability of KI and provide advice as to where it may be obtained.

- **RECOMMENDATION 9:** The applicability of Durham's Annex D to the residents of Toronto in the Primary Zone must be clarified. Alternatively, the same provisions for KI distribution, consent and information letters for school age children, and other matters dealt with in Annex D must be specified in the TNERP.

- **RECOMMENDATION 10:** CELA recommends that the CNSC should require the operator to systematically evaluate and report back to the CNSC the percentage of households within the 10 km Primary Zone, both within the Region of Durham and the City of Toronto, who have obtained KI tablets in advance, as well as the percentage of institutions covered by the plan who have them on hand in sufficient quantities to cover all of their residents or students. Based on this evaluation, CELA recommends that the CNSC require the approach that was taken in France be taken in Canada for the 10 km zone around each operating nuclear generating station, to undertake and ensure 100% pre-distribution of KI tablets to the residents in the Primary Zone and that this requirement be included in the licensing conditions for the Pickering NGS.

- **RECOMMENDATION 11:** CELA recommends that the CNSC require OPG to include in its outreach material to the public, in conjunction with regional emergency response officials, explanations about the capability of sheltering and its limitations as described in the IAEA Guide GS-G-2.1 and to reinforce instructions as to steps to take for rapid and effective evacuation in the case of notification of a significant emergency.

- **RECOMMENDATION 12:** CELA recommends that the Pickering Operating licence should not be extended without the Provincial Radiation Health Response Plan and the municipal Radiation Health Response Plans in place.

- **RECOMMENDATION 13:** CELA recommends that in view of the experience at Chernobyl and Fukushima, the CNSC should request that the province immediately revisit the 50 km secondary ingestion zone with a recommendation to change it to 100 km. This should be done as part of detailed planning for severe offsite accidents so that appropriate monitoring of food, agricultural products, milk, and water is established and in place in the event of such an accident.

- **RECOMMENDATION 14:** CELA recommends that the CNSC require that the nuclear emergency planning zones be expanded. CELA submits that the 10 km Primary zone should be extended to 30 km and the 50 km Secondary zone should be extended to 100 km.

- **RECOMMENDATION 15:** CELA recommends that the CNSC should require OPG to work with the local municipalities to ensure the public clearly understands what plans are in place to assist them with evacuation from the Primary Zone if they do not have their own transportation. The details of those plans should be clearly specified in the Durham and Toronto Nuclear Emergency Plans, and widely communicated to the public in outreach and education.

- **RECOMMENDATION 16:** CELA recommends that the CNSC should require OPG to communicate to the public in annual outreach and education, the fact that the nuclear emergency response plans expect the public to make their own arrangements in the event of evacuation, and for those who cannot, what is expected to be provided by the municipalities. The appropriateness of this approach should further be discussed with the public in terms of future nuclear emergency planning.

- **RECOMMENDATION 17:** CNSC should require OPG to conduct studies and to work with offsite emergency responders, the municipalities and the Province to ensure that there are realistic evacuation plans in the case of a severe accident with early large release, as well as in the case of plans for twenty kilometer and 50 kilometer evacuation zones around the Pickering NGS.

- **RECOMMENDATION 18:** CELA recommends that the CNSC require the applicant to conduct a study as to the awareness of the Pickering Nuclear Plant of people beyond the Primary Zone at Pickering, and as to their likely response in the event that a general emergency is declared and the Primary Zone is evacuated. The CNSC should require the applicant to evaluate the impact of increased evacuation zones of twenty and fifty kilometers on evacuation time estimates, as well as any other needed adjustments that would result from larger evacuation zones to the emergency plans surrounding Pickering such as locations of Emergency Workers Centres, numbers of emergency workers required for evacuation management, traffic routes, size of evacuation centres, and locations and capacity of Decontamination and Monitoring Units, and to report its findings to the CNSC and to the provincial EMO, the City of Toronto, and the Region of Durham.

- **RECOMMENDATION 19:** CELA recommends that CNSC direct the applicant to work with the municipalities to consult with the surrounding communities on specific plans for family reunification following evacuation in the event of a severe nuclear emergency.

- **RECOMMENDATION 20:** Explanations about what “self-decontamination” means; how to do so; and a statement as to its efficacy should be included in the Toronto Nuclear

Emergency Response Plan and in outreach and education to the public about implementation of the plan.

- **RECOMMENDATION 21:** The CNSC should confirm that OPG's automatic gamma monitoring is in place at Pickering, and require the automatic exchange of its data with the regulator as suggested by the IRSS and Fukushima Task Force reports.

- **RECOMMENDATION 22:** CELA recommends that the CNSC request that the Provincial Nuclear Emergency Plan expand its monitoring provisions and ingestion control zones to a distance of 100 km from the NGS, and that the province undertake appropriate measures to ensure that monitoring can be done following an accident within that 100 km zone for agricultural produce, foodstuffs, milk and water.

- **RECOMMENDATION 23:** CELA recommends that the DNERP, 2011 should explicitly outline the measures in respect of controlling ingestion food and water that may be required in the case of a severe nuclear emergency of the type outlined in ICRP Publication 109.

- **RECOMMENDATION 24:** Risks of exceeding maximum exposure limits must be discussed with workers in advance of any accident. Methods to review risks and obtain consent to exceed those limits should be explicitly clarified in the Durham Plan. Similar provisions must be included in the Toronto Plan if it is intended that there may be emergency or other workers who volunteer to exceed maximum exposure limits during an emergency.

- **RECOMMENDATION 25:** The Fukushima Task Force / IRSS recommendations to establish additional dose limits for workers during and following nuclear emergencies in Canada should be addressed by the CNSC as soon as possible.

- **RECOMMENDATION 26:** CELA recommends that the CNSC should require annual conduct of exercises dealing with full scale severe event multi-unit accident scenarios along with conclusive demonstration of their effectiveness as a licence condition for the Pickering NGS. Furthermore, the CNSC should require inclusion of members of the surrounding community and public interest organizations so as to increase input into and confidence in the results. CELA also recommends that their results should be made public, along with lessons learned, and improvements recommended as a result of the exercises; and that the CNSC should require reporting of implementation of those improvements on an annual basis as part of the oversight that it should undertake with respect to offsite emergency planning.

- **RECOMMENDATION 27:** The response times required by these IAEA Safety Requirements and Guideline documents GS-R-2 and GS-G-2.1 should be included in the Provincial and municipal emergency plans for Pickering. In particular, the CNSC should require that these response times are met and demonstrated as part of its licensing decision for the Pickering NGS.

- **RECOMMENDATION 28:** CELA submits that the CNSC should not grant the licence to OPG beyond the current licence period without verifying "through tests and assessments" the adequacy of the emergency plans in place for the Pickering NGS, both on-site and off-site, to respond to severe nuclear emergencies.

- **RECOMMENDATION 29:** CELA submits that even without additional regulatory amendments recommended by the Fukushima Task Force and the IRSS, the CNSC already has jurisdiction to consider the adequacy of the emergency plans in place at Pickering in deciding whether to issue the licence requested, and/or whether to impose additional requirements by way of licence conditions to better protect health, safety and the environment. (Sections 3, 9, 24 of the *Nuclear Safety and Control Act*, S.C., 1997, c. 9)

- **RECOMMENDATION 30:** CELA urges that the Fukushima Task Force recommendations for CNSC oversight of the offsite nuclear emergency response plans be pursued forthwith by way of amendment of the CNSC regulations and requirements there-under. This particularly includes the recommendation for description of the regulatory requirements to address radioactive hazards during an emergency **in greater detail**. This also includes the recommendation of the Task Force to enhance regulatory oversight with periodic safety reviews and to increase requirements for "requirements and expectations for both design basis and beyond design basis accidents``.

A. INTRODUCTION

This application concerns a request by Ontario Power Generation to the CNSC to renew its operating Pickering NGS licence for five years, as a combined licence for Pickering A and Pickering B. This time frame will take the plant beyond its design life for the Pickering B units. These are the oldest operating nuclear power reactors in Canada. The original Pickering Generating Station licence application to operate Unit 1 was submitted to the then Atomic Energy Control Board on August 14, 1970; the construction permit had been issued February 24, 1966. The original application to operate Unit 5 was

submitted to the then Atomic Energy Control Board on May 6, 1980; the original construction permit had been issued July 19, 1974.

In this submission, CELA reviews the proposal to extend the Pickering Nuclear Power Plant station operating licence for the next five years, and in particular, the proposal to extend its operations beyond the design life of the pressure tubes (and other components) which is intended by OPG for this licence term and one more licence term thereafter. CELA's focus is on the question of whether the CNSC should grant this licence in light of the question of the adequacy of emergency planning at the Pickering site, and in light of the size of the population in the vicinity of the Pickering site. In particular, CELA will compare both emergency planning and siting issues to international nuclear standards and guidance, as well as to international experience and independent reviews as to the requirements for emergency planning. Some of the post-Fukushima lessons learned that are so far available will be particularly important in CELA's review.

CELA will also provide comments on the role of the CNSC as regulator in respect of emergency planning in response to Nuclear Power Plant threats and will urge the CNSC to exercise a stringent oversight role as to whether emergency planning and preparedness has been proven prior to exercising its discretion to provide a further operating licence to the Pickering NGS. In particular, CELA will submit that emergency planning and preparedness has not been sufficiently demonstrated with any adequate amount of detail in respect of severe "Beyond Design Basis Accident" offsite accidents that may occur at the Pickering NGS such as occurred at Fukushima and Chernobyl. While effort and planning has been expended in respect of "Design Basis Accidents", there is a long history of downplaying the likelihood of very severe accidents that may result in serious and extensive offsite contamination and consequences. Accordingly the level of emergency planning and preparedness is insufficient, with only very generalized plans so far in place, in particular beyond the 3 and 10 km response zones. Furthermore, even within the 10 km zone which has traditionally been considered in the Pickering emergency planning, CELA will submit that the level of response and preparedness is inadequate.

For example, the requirements for alerting are not even fully in place in that 10 km zone despite decades of plant operation, and there has not been sufficient preparation for the evacuation that would certainly occur "voluntarily" (as the industry puts it), beyond the 10 km zone. Even for the population within the 10 km zone, the time frame for evacuation, depending upon sector and scenario extends between 4 and 37 hours for complete evacuation. In the case of early large release of radionuclides in a severe accident, we argue this extended evacuation time frame would cause an unacceptable impact to people in terms of the gamma radiation and other potential radiation exposure while the evacuation is underway. In the meantime, "sheltering in place" would provide only limited assistance, depending on the radionuclide release scenario, time frame for the release of a radioactive plume, and type of building that people are "sheltering" inside. Another example of the insufficiency of preparedness for a severe

accident is the lack of pre-distribution of KI, and the insufficient quantities of KI in stock compared to the population even within the 10 km zone.

CELA will also argue that the population in the vicinity of the NGS, both within 10 km, as well as within 20 km and 30 km must be much more engaged, informed, and involved in all aspects of emergency planning in respect of accidents that could occur at the Pickering NGS. For example, it has been CELA's anecdotal experience that many residents of Durham region are unaware of provisions in the Nuclear Emergency Response Plan that anticipate that they will find their own accommodation with friends and family in case of evacuation; that they may be asked to "self-decontaminate" in some scenarios, and what that means; that KI is effective only if taken before or immediately upon commencement of a release; they are unaware of the transportation plans that would be available if they do not have their own vehicles; and they are concerned about family reunification in the event of evacuation scenarios in which members of their family are evacuated separately from the family such as from schools and long term care institutions.

In preparation for this review, and building upon detailed review of emergency planning for the Darlington refurbishment, CELA has collected and collated an extensive collection of relevant emergency planning standards, guides and documents from international, national, provincial and municipal sources. These materials will be available in the library of the Resource Library for the Environment and the Law, housed at CELA's offices after the May, 2013 Day Two Hearing of this Application. They are indexed and catalogued and the catalogue will be available online at www.ecolawinfo.org. In addition this particular index of nuclear emergency planning standards and documents will also available online on CELA's website at www.cela.ca . CD's of these documents and hard copies are now housed in the library which is open to the public (prior contact with CELA is advised to ensure that the library is not in use for meetings at the time of the visit).

CELA undertook this project after finding in earlier work that the necessary documents pertaining to emergency planning for nuclear power plant accidents are widely scattered and it did not appear that there was any single location where they were all housed together. The assembly of these materials, from international through to local, permits us to provide more comprehensive and documented comment on the sufficiency of emergency planning for the Pickering life extension. However, CELA also wanted to build on the work it earlier did for the Darlington refurbishment EA on the topic of emergency planning, and in turn, this collection will assist greatly in future comment on this topic in other licence applications relating to nuclear power plant operations. This work was supported by an award by a CNSC funding panel for this Application. This allowed CELA to undertake a short term contract with project counsel Kyra Bell-Pasht to examine and obtain the international, U.S., Canadian, provincial and municipal emergency planning standards and guidance documents. CELA is also in the process of supplementing this collection of current materials with historical materials as to some of the origins of the decisions relating to emergency planning preparedness in Canada and in Ontario in particular. This

latter process will be ongoing beyond the timeframe of this hearing into the current Pickering NGS licence application, but we believe it is of assistance to attempt to discover why some of the historical decisions were made as they continue to significantly influence current approaches to emergency planning (despite the lessons of Chernobyl and Fukushima).

CELA hopes that future approaches to emergency planning and preparedness in Canada will be significantly augmented in light of the Fukushima accident, and one of the early lessons from that accident which has been widely noted by Japanese officials and others, is that very severe accidents were not given sufficient credit and thus were not taken seriously; a state which strongly influenced emergency planning. Several of the reviews of the accident so far, including the review of the Japanese Diet Independent Commission noted that the lack of sufficient emergency planning was a significant contributor to the consequences of the accident.

CELA wishes to point out that in our opinion there are significant comparables between the regulatory and industry environment and attitude in Japan pre-Fukushima and elsewhere among "western" nuclear power operating states, including Canada. One of the significant findings of the Fukushima accident which was echoed in a recent IAEA conference on nuclear regulation post Fukushima (hosted in Ottawa by the CNSC) was that public confidence in the industry and the regulator are essential, but these were severely harmed during that accident by lack of transparency and credible information.

It is ironic that in building the repository of historical documents as to the basis of the emergency planning basis in Ontario, CELA had been advised by Emergency Measures Ontario that it must seek certain requested historical documents (i.e. Working Group #3 Report on the basis of emergency planning) through Ontario's Freedom of Information and Protection of Privacy Act. This would certainly have delayed provision of these documents beyond the time frame of this licence hearing. Fortunately colleagues at Greenpeace Canada were able to obtain copies of the Working Group 2 and Working Group 3 reports from their storage for CELA. CELA objects to the position taken by Emergency Measures Ontario which directed us to use FOI to obtain this document which is an integral aspect of understanding the basis for emergency planning in Ontario. Furthermore it is explicitly referenced in the current Provincial Nuclear Emergency Plan, 2009 as providing the basis for the Protection Action Levels set out in that Plan.

CELA is of the view that this issue of the basis for emergency planning is of significant public import and will persist in seeking additional historic materials and will include them in the emergency planning document collection that will be available in our library.

B) REVIEW OF EMERGENCY PLANNING AND PREPAREDNESS ISSUES AT PICKERING

1. Emergency Planning Introduction

The necessity for sufficiently detailed Emergency Planning and Preparedness is the reality that if there were a catastrophic accident at one of Ontario's nuclear power plants, widespread health, safety and environmental consequences would be expected unless immediate and effective steps were taken for public protection. For example, as long ago as 1988, Commissioner Kenneth Hare reported in The Safety of Ontario's Nuclear Power Reactors (Ontario Nuclear Safety Review, 1988) that the health effects from a catastrophic accident at the Pickering nuclear power plant could amount to 37.5 prompt fatalities; 6011 early injuries; and 9,700 cancer deaths if most of the fission product inventory escaped[1] and a plume was directed across Metropolitan Toronto (at page 162, Table 15). In such a catastrophic scenario these numbers would be increased today as a result of population growth.

The aim with emergency planning and preparedness should be to avoid as many of these health effects as possible[2]. This can only be accomplished if the emergency planning is designed and implemented so as to be effective in such a catastrophic case. Hare stated on this point that "the most significant result {from the sensitivity analysis of the accident scenarios discussed} was that "prompt use of emergency measures, such as evacuation, greatly reduces both health and economic consequences." (At page 163)

For the reasons that follow, CELA has serious concerns about the sufficiency of the emergency planning and preparedness in place surrounding the Pickering NGS.

[1] The Hare report also describes the assertion that the "probability of losing a high fraction of radioactive inventory from a CANDU reactor core is much lower" than from a Pressurized Water Reactor; however the report also notes that "there may be other beyond-design-basis accidents that will involve serious consequences going well beyond those discussed in this chapter." At page 163, Hare, Vol. 1, 1988

[2] A very surprising, and in CELA's view, unacceptable, additional justification of nuclear emergency response planning and preparedness in Ontario was set out in the 1987 Ministry of the Solicitor General Brief to the Hare Commission, which stated that in addition to safeguarding health, safety and well-being of the people of Ontario in the event of a nuclear accident, the other reason was "To protect Ontario's large investment in its nuclear industry by, firstly contributing to the maintenance of public support for the program, and secondly, in case of an accident, minimizing the possibility of adverse public reaction afterwards, by demonstrating and ability to effectively protect people from harm and risk." (Hare Commission, 1988, Vol. 1 at 227)

2. **Size of Accident and Basis of Emergency Planning at Ontario's Nuclear Power Plants including the Pickering NGS**

- CELA submits that the CNSC should require and verify that Ontario's nuclear emergency planning and preparedness will be sufficient to respond to, and significantly mitigate the consequences of a catastrophic accident such as those that occurred at Fukushima in 2011 or Chernobyl in 1986. It is important that OPG be able to plan for its on-site response in the case of a catastrophic accident in order both to undertake significant accident management and undertake mitigation, but also to work with offsite authorities in supporting the emergency response off-site.

- The reason that the size of the accident matters as a design basis for emergency planning is that the calculated consequences to be averted are wildly divergent in a catastrophic scenario compared to the Design Basis Accident scenario. This directly affects emergency planning decisions and whether specific emergency preparation and planning measures are considered "worthwhile" by the planners. Accordingly if a lower size accident is used for planning, fewer resources, less detail, and less preparation results. This has been the case in the past in Ontario's nuclear preparedness. Post-Fukushima it is essential that changes be made forthwith to this approach.

- A stark example of the difference in consequences that may be calculated depending on the size of the accident assumed for emergency planning was demonstrated in the Hare Commission Report (Ontario Nuclear Safety Review 1988) noted above.[3] The lower releases predicted by the design basis scenario result in far lower consequences and we submit, appear to have motivated the operator, provincial authorities and even the regulator to accept planning for a far less serious accident than the catastrophic scenario.

[3] Other estimates demonstrate an even greater range depending upon the scenario. Peter M. Fraser, in Vol. II, App. II to the ONSR, "A Review of the Design-related Aspects of the Safety of Ontario Hydro's Nuclear Generating Station", reviewed the Lonergan et al and the Ontario Hydro estimates of possible consequences that had been commissioned and submitted to the ONSR. He summarized, after comparing assumptions, rebuttals etc., that depending upon weather conditions, prompt fatalities from a severe accident could range from zero to a few thousand; latent cancer could range from a few hundred to as many as 13,000; and economic damage could range from a low of $100 million in favourable weather conditions to as high as $12 billion (and he noted that this figure is consistent with Ontario Hydro estimates); the figure would be higher if stricter decontamination levels were used. (at II/138) (Figures 1987 dollars.)

- The International Atomic Energy Agency conducts regular "missions" among regulators of nuclear power around the world, reviews their regulatory programs, and makes recommendations to the regulator. There was an IAEA Integrated Regulatory Review Service (IRSS) review conducted in Canada from November 28-December 9, 2011 (this was a follow up to an earlier mission)[4]. That IRRS 2011 report noted (page 63) that a post-Fukushima task force established by the CNSC examined accidents more severe than those previously considered credible by CNSC and that accordingly the design basis for certain stations needs to be updated. It stated with approval that the task force made 13 recommendations dealing with defence in depth and emergency preparedness. (The Fukushima Task Force[5] recommendations will be further reviewed and referenced herein.)

- OPG indicates it is required to maintain an emergency response plan for an on-site response to a Design Basis Accident – this is defined as a "loss of coolant accident with one contaminated casualty" – see Document P-Corr-00531-03669, the December 21, 2011 Sustainable Operations Plan for Pickering A and B.[6] The May 30, 2012 Ontario Power Generation document, "Emergency Response Organization Staffing Basis for Responding to Design Basis Accidents" outlines some of the history of the selection of a "design basis" for emergency planning at the Pickering NGS (as well as Darlington). It reinforces the point that the emergency planning approach by OPG (formerly OH) has for decades been to respond to a design basis accident (although the authors failed to find a documented rationale for the choice of accident). Much of the history reveals that OPG, and before it OH, was of the view that emergency planning on-site for a severe accident beyond design basis was unnecessary because of the "low probability" of such accidents; furthermore much of the history demonstrates that OH was making submissions and representations that it was not necessary to plan for a beyond design

[4] IAEA-NS-IRSS-2011/08 Report of Integrated Regulatory Review Service (IRRS) Follow Up Mission to Canada, November 28 – December 9, 2011 (Department of Nuclear Safety and Security, IAEA).

[5] CNSC Fukushima Task Force Report INO 0824 (CNSC, October, 2011).

[6] Ontario Hydro 1993a Materials Relating to Environmental and Health Effects of Nuclear Generation. Ontario Hydro, and Ontario Hydro 1993b Overview of Ontario Hydro's Nuclear Generation Program, Appendix 4 prepared for Nuclear Liability Act trial, 1993.

basis accident. See Document N-REP-03490-0432605 and the literature review conducted therein.[7]

- The tendency of public authorities to accept that accident planning proceed on the basis of less severe accidents was evident in the 1988 Hare report when the Commissioner reported that there was a "widely shared belief that a severe accident in Ontario is unlikely and that money should not be spent in large amounts on structures that will probably never be used." (Hare, 1988, Vol. 1 at 169) Commissioner Hare continued in his comments to disagree with this view and to state that "a severe accident is indeed unlikely, but the province must equip itself to deal with the possibility--and with the overspill from any severe accident on the US side of the border." (Ibid p. 169)[8]

[7] See also Overview of Ontario Hydro's Nuclear Generating Program, May 1, 1993, Appendix 4, "Emergency Preparedness." (Ontario Hydro, 1993, Prepared for Nuclear Liability Act trial). That document noted that "the most common approach in establishing a basis {for emergency preparedness} is to estimate the consequences of postulated accidents and then introduce an emergency preparedness safety factor. Ontario Hydro evaluated the consequences of postulated accidents in a report entitled "The Assessment of Radiation Dose to the Public Arising from Postulated Accidents at Pickering NGS as an input to Emergency Planning." – (cited in the footnote as Dinnie, K.J., et al, Ontario Hydro Nuclear Studies and Safety Department, Report No. 85088, Feburary 1985.) CELA will obtain this document to include in its archive of Nuclear Emergency Planning documents as part of the history of the basis for nuclear emergency planning in Ontairo.

[8] This was still an issue for Dr. Paul Rosenberg when he testified in 1993 in evidence at a trial dealing with the federal Nuclear Liability Act that Working Group 8 had been called to consider greater accidents than the "maximum planning accident" post Chernobyl, and to make recommendations about the planning basis. They considered the "worst credible radioactivity emission" and recommended it be the basis for planning, not for long term consequences, but for early response. Dr. Rosenberg stated that the decision rested with the Solicitor General of Ontario and cabinet, to increase the design accident, and as of that date (1993) that had not happened. He also stated that Ontario Hydro had actively resisted increasing the planning basis and they had argued that due to the low probability they calculated (less than one in a million reactor years), resources be better used for primary prevention, operator safety and the response and planning already done. At page 939-40 of Dr. Rosenberg's testimony Nov. 3, 1993. (Working Group #8 was established by the Ontario cabinet, to advise on an upper limit for detailed emergency planning and preparedness in Ontario, whether any consequence mitigation measures needed to be adopted as a result of the upper limit recommended in addition to the PNERP, and in recommending an upper limit to consider "not only a scientific assessment of the risks of various types of accidents, but also risk, such as those due to hostile action, which cannot be scientifically assessed... probably effectiveness of emergency improvisation, safety margins, and any other factors..." Working Group #8, 1988 at 12). It appears to CELA on the basis of documentation we have been able to find, obtain and examine, that even Working Group 8`s recommendations never were adopted by the Ontario cabinet; and the province continued its planning based on a less severe accident as planning basis.

- The Provincial Nuclear Emergency Response Plan, 2009, uses as a "Basis of Planning" a "basic offset effect to serve as the main basis for nuclear emergency management." It states that the rationale is because of the "inverse relationship between the probability of occurrence of an accident and the severity of its likely consequences" and that "judicious choice must be made" to select the basis of planning since resources are not available for all possible events. (At 2.3) The basic offsite effect accident is described in the PNERP, 2009, as characterized by one or more of : i) a warning period before offsite effects occur; ii) main hazard from external exposure and inhalation of radionuclides; iii) doses would be low (not over 250 mSv at plant boundary); iv) very low level environmental contamination; v) low level radioactive emissions to environment over some time – days or weeks; vi) impact confined to the Primary Zone (10 km). (At 2.3.3 (b)) The PNERP, 2009, states that "**detailed** planning and preparedness shall be carried out in Ontario for dealing effectively with the basic offsite effect of a nuclear installation accident. The aim of this is to ensure, to the extent possible, that no person offsite will be exposed to intolerable levels of radiation as a result of such an accident." (At 2.3.3. (c)) (emphasis added).

- The PNERP, 2012 states that, with low probability, an accident could occur "which could result in a more severe offsite effect." It is defined as one or more of: i) the time between the accident and release of radioactivity may be generally limited {also sometimes described in other regulatory and industry documents as "early release"}; ii) radiation doses could be high, greater than 250 mSv at the plant boundary; iii) radioiodines and particulates could form a component of the radioactive emission; iv) environmental contamination could be significant; v) area affected could be larger than for the basic offsite effect. (At 2.3.3 (d)). For these more severe but less probable accidents, the province outlines a limited number of issues for which to undertake preparedness: " i) timely public alerting and direction; ii) prioritizing evacuations for those closest to the hazard; iii) radiation monitoring and if necessary, decontamination; if needed, medical assessment, treatment and counselling." (At 2.3.3.(e)) The PNERP states that the detailed planning and preparedness "will establish an effective basis to deal with an emergency caused by any type of nuclear installation accident." Despite this provision, CELA is concerned that this detailed planning is not yet in place for a very severe catastrophic accident as discussed throughout this submission. For example, the inability to assess the extent to which the province and emergency responders are prepared to deal with item iv) because of the lack of available Radiation Health Plans is one indicator that the province still does not have that capability in place. This is discussed further later in this submission.

- This level of planning for less severe accidents arose as a result of the recommendations of Working Group #3, tasked by the Solicitor General in Ontario to advise on the "extent to which planning should be conducted, in any detail, in preparation for an accident at a nuclear generating station as a result of which radioactive material in excess of normal amounts is emitted from the station." Working Group #3 stated that it had not "attempted to define the worst possible accident", saying that "worse accidents appear so unlikely that it would appear to be uneconomical to plan for them." (at 4) It is important to note expressly that Working Group #3 took comfort from the lack of empirical data with few observed accidents to that point with severe radiological consequences – as it met in 1984, its deliberations preceded the Chernobyl accident of 1986, and of course, the Fukushima accident of 2011. Working Group #3 noted at that time that "no one can put hard numbers on probabilities of accidents with severe consequences; and that risk estimates are just that – estimates." (at 5)[9] It is also critical to notice that Working Group #3 stated that its comments that the Ontario plants were performing "better than design basis" were made at a time when there was not yet experience with aging and that Ontario would have to "watch the situation closely and if it appears necessary modify its plans accordingly." (at 11) Furthermore, Working Group #3, on which PNERP, 2009's Protection Action Levels is stated to be based, turns out to have based its assumptions on more optimistic views of worldwide nuclear reactor safety than reality. It stated that "we recommend 250 mSv at the plant boundary, recognizing the experience in the future may cause this to be modified either way." (at 14)

[9] Now that we have unfortunately had world-wide empirical evidence as nuclear power plant accidents, there is an empirical basis for estimation of the observed frequency of severe accidents with offsite consequences. CELA submits that the observed frequency of severe catastrophic accidents overwhelms the justification to base emergency planning on the severe accident "probability" calculations which are inherently fraught. With this level of **observed** severe accident frequency, it is imperative that any jurisdiction choosing to continue operating nuclear power plants is obligated to provide accident planning and preparedness that would realistically respond to such accidents with sufficient resources, specificity and realism to be effective at significantly reducing consequences. Continued reliance on the argument that such accident planning should not be pursued because it is costly must be discontinued. Arguments that such planning is not "cost-effective" relies on probability estimates that have been proven false given empirical accident experience. Continued maintenance of such arguments unsupportably places the real risks of serious harm from such accidents on innocent bystander members of the public.

- CELA submits that the acceptance of less severe accidents as an emergency planning basis for detailed planning is a fundamental error in energy policy and regulatory oversight. It was based in part on early operating experience when the plants were newer and there were fewer "reactor years" of operation, and in part on questionable probability calculations. CELA submits that the planning basis must now be revised based on real-world experience. CELA requests the CNSC to require detailed emergency planning and preparedness, including requiring the operator and emergency planning authorities to undertake updated severe accident consequence calculations, with the emergency plans to be submitted to the CNSC for evaluation as to their effectiveness in a catastrophic scenario, along with a judgment as to whether to approve continued operation of the site in accordance with that evaluation. At this time, and until such emergency plans are in place and proven to be effective for a catastrophic accident, the site should not be licensed for continued operation.

- The attitude in which lower levels of preparedness have until this point been accepted in Ontario is reminiscent of that described at an IAEA Regulator`s Conference hosted by the CNSC in Ottawa in April 2013, at which Toshimitsu Homma of the Japan Atomic Energy Agency stated in a Conference Panel on Emergency Management that the most important lesson of Fukushima was that before the accident, ``There was an implicit assumption that such a severe accident could not happen and thus insufficient attention was paid to such an accident by authorities.``[10]

[10] It is all the more concerning that a less severe accident - i.e. the LOCA with one contaminated casualty, as opposed to a severe offsite or catastrophic accident – has been used as the basis for detailed emergency readiness by OPG and emergency planners in Ontario given that almost identical statements were made by the Porter Royal Commission on the Electric Power Planning in the Commissioner's concluding report where under the title of "Mind-Set Syndrome", he quoted the Presidential Commission on the Three Mile Island accident which occurred in 1979. The TMI Commission noted that "the belief that nuclear power plants are sufficiently safe grew into a conviction.... The Commission is convinced that this attitude must be changed to one that says nuclear power is by its very nature potentially dangerous, and therefore, one must continually question whether the safeguards already in place are sufficient to prevent major accidents." The Porter Commission went on to state that "This syndrome, we believe applies in some degree to Ontario Hydro." These statements by the TMI Commission and the Porter Commission were made in 1979 and 1980. The lessons that were supposed to be learned at that time, according to the comments of Mr. Homma of Japan had apparently been forgotten, if they were ever truly internalized. Similar sentiments about Ontario Hydro's mind-set were expressed by Dr. Paul Rosenberg in his 1993 testimony when he testified that the first thing Ontario Hydro might do "would be to change their approach or their attitude towards serious accidents because they consistently use the maximum planning accident as the basis for their discussion with the regions, the municipalities, the province, and assure us that things are well planned for and under control." (at page 941). CELA has an ongoing concern that this type of "mind-set syndrome"

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2. **Current State of Emergency Planning Readiness at the Pickering NGS**
    - In the July 4, 2012 OPG Application at issue here, Attachment 6 outlines the Fukushima Project Update. It indicates that "significant work" is proceeding to upgrade emergency planning in response to severe accidents, including multi-unit scenarios; further exercises are planned; "coordination enhancements" continue; Severe Accident Management Guidelines are being implemented in phases through 2014 and 2015, among other things;
        - OPG is working to establish a Regional Emergency Response Support Centre with "industry partners"
        - They are working on a mutual assistance agreement between utilities.
        - They have initiated planning for enhanced communication capabilities to support emergency response (with interim steps having been taken).
        - Drills are being planned to "ensure capability and readiness" to respond beyond design basis accidents, including severe accidents. (Attachment 6 to July 4, 2012 Application)

      This list indicates that a great deal of work remains to be done in order that OPG be in a position to respond to very severe accidents in terms of emergency planning and preparedness.

    - A similar concern exists with respect to whether there is confidence in the ability of offsite emergency responders to respond to severe accidents with offsite consequences. For example the IAEA's Integrated Regulatory Review Service (IRRS) report post Fukushima (November – December 2011) called on the CNSC to do a "national assessment of nuclear power plant off-site emergency plan that includes all relevant organizations". (at page 10) It made a specific recommendation: "**The Government of Canada should assure** that the review and assessment of off-site emergency plans for nuclear power plants includes all relevant authorities, are comprehensive, and that the relevant organizations which implement those plans are capable of performing the assigned duties." (IRSS at Recommendation RF7). (emphasis added)

    - **RECOMMENDATION:** CELA submits that this licence should not be granted until all of the measures list by OPG in its application in Appendix 6, along with other recommendations made by the 2011 IRSS Report, the 2011 CNSC Fukushima Task Force and recommendations herein are actually in place and demonstrated to the regulator, with evidence, to be effective. CELA also submits that it is critical that this evidence be made public. Members of the surrounding communities must be able to understand what is in place; how effective it is;

what has changed; and on what basis the regulator is judging the emergency plans to be in place.

- These issues are discussed further in subsequent sections of this submission.

3. **Level of Detail, Size of Accident, & Lack of Multi-Unit and Externally Initiated Event Nuclear Emergency Planning**

- The level of detail of Ontario's emergency planning and preparedness is a significant issue. CELA submits that the CNSC must ensure a level of detail with specified time frames, tested and verified, to respond to large offsite severe accidents. CELA submits that the current level of planning in Ontario beyond the 10 km zone has hardly exceeded what Commissioner Hare in 1988 called "a conceptual framework" that would "enable a response to be improvised should an emergency occur before all preparations are complete." (Hare, Vol. 1, 1988, p. 230)[11]
- As described earlier, beyond the "Basic offset accident" for which detailed planning is to be done, PNERP, 2009 provides that "appropriate additional planning and preparedness" shall be in place for the more severe offsite effects described in paragraph 2.3.3. (d) of the plan, namely: i) timely public alerting and direction; ii) prioritizing evacuations for those closes to the hazard; iii) radiation monitoring and, if necessary decontamination; iv) if necessary medical assessment, treatment and planning. (At 2.3.3. (e)). However, this is not detailed planning for a large scale accident, rather the Plan indicates that the detailed planning (presumably for the basic offsite effect accident) will

[11] The Working Group #3 report (1984) is explicitly referenced in PNERP, 2012 as the basis for selection of Protection Action Levels. That report was described in the Working Group # 8 report (1988) as background that had been conducted pre-Chernobyl. They stated that Working Group #3 recommended that "in the case of accidents which were in fact more severe than the MPA {Maximum Planning Accident}, authorities should be able to cope by improvising on the plans which would already be in existence based on the MPA." The MPA was recommended to be one that "gives a dose to an unsheltered person 1 km from the nuclear station (that is, the assumed boundary fence). The 25 rem {250 mSv} was stated to be based on the assumption of good engineering practice and the operating experience to that time, together with the particular properties of CANDU reactors, especially that the moderator could act as an additional heat sink in case of failure of both the normal and the emergency cooling systems (and so prevent severe core damage), and the belief that detailed planning was unnecessary for events of probability less than once per million reactor years in situations where there are about 10 reactors per power station." (Working Group #8 at 8-9, describing Working Group #3's recommendations).

"establish an effective basis to deal with an emergency caused by any type of nuclear installation accident."

- The CNSC Fukushima Task Force, 2011, confirmed that the PNERP, 2009 is "based on a single-unit accident and does not consider multi-unit accidents." (At 45.) The issue of the adequacy of the current emergency planning basis in Ontario was briefly discussed on December 3, 2012 hearings before the CNSC on the Darlington refurbishment application, when a witness[12] from Emergency Measures Ontario discussed their desire to have "a greater inclusivity of events beyond the normal planning horizon". Although they indicated they were satisfied with the responses provided by CNSC staff prior to that hearing in response to a letter[13] they had submitted to the CNSC, they also recognized "this isn't the last time we will be sitting here" and it was not the only opportunity they would have to continue to push what EMO thinks is really important regarding emergency management in terms of how to plan and how to exercise and how to modify the nuclear emergency plans going forward. She stated that they had discussed their concerns with CNSC and that they were "comfortable and were monitoring." In response to a question by the CNSC President about what EMO would be able to do by 2014 for the refurbishment continued operations licence, the witness further stated that they are in a process of evolution – and would want to present a provincial position that represents various aspects of planning that goes well beyond traditional planning scenarios. She commented that they would be working with all partners in that expanded view of the world. She looked forward to being able to speak to that at subsequent hearings and being able to identify any areas of concern as well as hopefully areas of significant progress.

- CELA has not seen evidence that more severe, beyond design basis severe accidents, initiated by a variety of severe external events such as hostile action, extreme weather events and others have been considered in Ontario as a basis

[12] Alison Stuart, ADM and Chief EMO, December 3, 2012, Darlington Refurbishment Hearing before the CNSC

[13] The letter is attached to CMD 12-H13.A in the Darlington Refurbishment and Continued Operations EA CNSC hearing.

for emergency planning[14]. Similarly, CELA has not seen evidence that the consequences of multi-unit events have been considered in Ontario as a basis for emergency planning. To the contrary, the CNSC Fukushima Task Force Report 2011 stated that none of the nuclear power plant operators in Canada had at that time considered `multi-unit accident scenarios in development of their emergency plans``. (at 37) The Task Force stated that it was confident that the operators could respond to a beyond design basis accident ``**provided they are single-unit accidents only**. `` (at 37, emphasis added).

- **RECOMMENDATION:** CNSC should require multi-unit severe accident planning to be demonstrated by OPG, along with the effectiveness of off-site emergency response in such a case. Similarly, CNSC should ensure, contrary to previous practice, that extreme natural hazard initiated events and "gross human error" are also examined in terms of presenting an emergency planning basis, and that the on-site and off-site emergency preparedness and planning are demonstrated to be sufficient and reliable to respond to all of these undesirable scenarios in the event that they lead to severe offsite releases.

- A related concern is that raised by the Fukushima Task Force Report (2011) that OPG can perform "post-accident source term estimation" – however "these are designed for **an accident in only one unit**." (emphasis added) (At 38). As the Task Force noted, this is important information to be able to provide to offsite authorities in the case of a nuclear accident.

- **RECOMMENDATION:** CELA recommends that this post-accident source term information be required by the CNSC as a condition of licensing and that the CNSC require OPG to upgrade their capacity to provide source term information and its basis, for multi-unit accidents, as a condition of the Pickering NGS licence. This should include reassessment of plume and dose modelling for multi-unit accidents at the Pickering NGS (see Task Force Report at 38).

- For severe accident emergency planning, twenty-five years after the Hare commission, CELA is of the view that Ontario still has a "conceptual framework"

[14] Even consideration for Severe Accident Management (i.e. on site response) was not adequately considered, analyzed, nor incorporated into licensing requirements in Canada pre-Fukushima. See Fukushima Task Force, CNSC INFO-0824, October 2011 at 35.

allowing for "improvisation" in the event of a catastrophic accident at Ontario nuclear power plants, including the Pickering NGS. It appears to CELA, that the pre-Chernobyl, pre-Fukushima recommendation of Working Group #3 as to a Maximum Planning Accident has held sway in Ontario for at least the past twenty-nine years, despite all of the recommendations, Commissions, and world-wide accident experience that would suggest that planning for more severe accidents is required. Post Fukushima there has been some discussion about increasing the basis for accident planning, and recommendations to do so, but changes in the Plans, in emergency preparedness on the ground, and in detail of planning are not yet evident or proven. CELA recommends to this Commission that now is the time to end the situation of operating the nuclear power plants without sufficient detailed emergency planning in place. CELA recommends to the CNSC that it deny OPG its operating licence to operate the Pickering reactors beyond their design life unless and until serious, capable, detailed offsite emergency planning for catastrophic accidents is finally in place.

- **RECOMMENDATION:** CELA recommends that the CNSC should require the licensees to demonstrate that there are, in place, properly resourced, sufficiently detailed emergency planning and preparedness plans that would address Chernobyl–size accidents or Fukushima–size accidents. The basis for this recommendation includes world-wide experience with these catastrophic accidents. This recommendation is independent of particular event sequences and rather takes account of the myriad ways that things that can go wrong resulting in an accident and resulting in a serious breach of containment, regardless of how caused. It also includes consideration of the fact that among the events that may initiate a catastrophe at a CANDU are those that are beyond the control of the operator such as hostile action or unforeseen external weather events or unforeseen combinations of failures including human error. There is no policy justification for excluding these types of events from emergency planning and preparedness since it is amply demonstrated (Three Mile Island, Chernobyl, Fukushima, 9/11) that all of them may occur in the real world, with disastrous consequences.[15]

[151515] CELA notes that the Working Group #8 Report included a concept of Worst Credible Radiation Emission in its 1988 report, which it described as "the very worst that could happen: the maximum effects possible from any accident, however caused or however developed" and that it would thus encompass accidents including those that could not be calculated due to lack of quantifiable data as well as those with very low probabilities. For this accident that the Working Group #8 styled "WCRE", it recommended that planning be done to prevent "the worst

4. **PATHWAYS OF EXPOSURE TO RADIATION AND EMERGENCY RESPONSE MEASURES**

- The appropriateness of emergency planning and preparedness must be judged on its ability to avoid health and safety consequences to members of the public in addition to on-site workers and first responders, in a severe accident scenario from impacts in a variety of pathways. They include general gamma radiation from the plume of radioactive materials airborne or deposited on ground and buildings; inhalation of radioactive substances with subsequent radiation from internally deposited materials; skin deposition from externally deposited radioactive material on skin, hair, and clothes; and ingestion of deposited radioactive material as contaminated food and water enter the food chain and water supplies leading to additional exposures from eating and drinking. In the event of a severe nuclear reactor accident the doses and exposure pathways are stated by the ICRP (International Commission on Radiological Protection) Publication 109[16] to likely consist of "an initial, relatively high dose rate, inhalation component from inhalation of short-lived beta/gamma emitters during dispersion of the plume." The ICRP also states that "for a reactor accident, this is likely to be followed by a time period lasting days or weeks when I-131 {a form of radioactive iodine} dominates the exposures, through external irradiation from contamination deposited in the environment and from direct contamination on crops and in milk. In the longer term, external radiation from radioactive isotopes of caesium and ruthenium is likely to become dominant, together with longer term contamination of foodstuff with these radionuclides." (At 61.) Without protective measures taken, the ICRP states that the largest component of projected dose would likely be received from contaminated foods.

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consequences" of this type of accident; namely early morbidity or mortality. Their rationale was that the most severe consequences are "extreme enough to warrant consideration in planning" "however remote their likelihood." Working Group #8 also based this recommendation in part on the fact that provincial and other authorities, when interviewed at this time (1988) , were of the view that their ability to "improvise" for such a severe accident would begin after 24 hours, but "immediate and effective improvisation was not thought to be possible" before 24 hours in the case of a larger than anticipated event. (At 28.) The Working Group decided that "in general no probability could be associated with the WCRE... it represents the bounding case which subsumes all events, however low their probability." (At 62.) The WCRE would result from the "failure of a large number of fuel elements in a short period of time, with a simultaneous breach of containment."

[16] See International Commission on Radiological Protection (ICRP) Publication 109, "Application of the Commission's Recommendations for the Protection of People in Emergency Exposure Situations", 2008 at 62-63.

- The point of emergency planning and preparedness is to implement those measures that would avoid the health and safety consequences of exposure to these radioactive substances, through these pathways. Without any emergency response or protective actions (such as, to move people from those locations where they may be exposed, or to decontaminate or to avoid ingestion), negative health consequences may result.[17] The Province of Ontario's Nuclear Emergency Response Plan (PNERP) (2009) provides that methods of protection from radiation exposure and external contaminating can include "creating distance, by limiting the duration of exposure, and/or by shielding." It states that methods of minimizing or eliminating internal contamination can include preventing ingestion and inhalation. (PNERP, 2009 at 2.2)

- In the following sections, CELA has reviewed material relevant to specific emergency response measures and provides comments in respect of each. The IAEA Standard GS-G-2.1[18] sets out that the "urgent protective measures and counter measures" (GS-G-2.1 at Para. 4.13) include:
    - Isolation of contaminated area
    - Prevention of inadvertent ingestion
    - Evacuation
    - Sheltering
    - Respiratory protection and protection of skin and eyes
    - Decontamination of individuals
    - Prophylaxis with stable iodine
    - Protection of the food supply and prevention of the consumption of significantly contaminated foodstuffs and water

[1717] These potential negative health consequences from ionizing radiation were described in the 1984 Provincial Working Group #8 Report: "Nuclear radiation is potentially hazardous because it has the ability to ionize, and thus to break-up molecules, some of which may be of biological importance. If very many are broken, there may be, within days or weeks, clinical symptoms which, in the worst cases, may result in death. Below these high doses which may result in early morbidity (illness) or mortality (death), nuclear radiation may so disrupt molecules that latent cancer is induced, with the possibility of overt cancer, and possible resulting death, some decades later." (at 3).

[18] International Safety Guide, IAEA GS-G-2.1, Arrangements for Preparedness for a Nuclear or Radiological Emergency, 2007

- Management of the medical response
- Protection of international trade

5. Alerting

- One of the first necessary steps in a nuclear generating station emergency with potential for or actual release of radio-nuclides to the surrounding environment will be the necessity of alerting the public, in addition to notification of necessary authorities. Reviewing the provisions of International Safety Guide, IAEA GS-G-2.1, Arrangements for Preparedness for a Nuclear or Radiological Emergency, 2007, Table 12, Response Time Objectives[19] provides the following objectives relevant to alerting:
  - Classify / Declare the emergency and notify local authorities – within 15 minutes of the time at which conditions indicating that emergency conditions exist are detected
  - Recommend urgent protection action to the public on the basis of the emergency classification – within 30 minutes of the time at which the emergency is classified / declared
  - Initially warn and inform the public within the PAZ and UPZ of urgent protective actions required – less than 1 hour from the time at which initial notification to local authorities was given by the facility

- The PNERP, 2009 contains requirements which could, if effectively implemented, ensure that IAEA GS-G-2.1 is met in terms of alerting times. However, as discussed further below, these requirements are not yet fully in place for the area surrounding the Pickering NGS. The PNERP, 2009 requires that the operator notify the offsite authorities within 15 minutes "of the requirement for notification being recognized". (PNERP, 2009, 4.1) The PNERP, 2009, also requires that the alerting systems must be such as to ensure that "the Primary Zone population that may be required to undertake the initial protective measure of sheltering, evacuation, and/or ingestion of KI can be alerted within 15 minutes of initiation of the system. (PNERP, 2009, 5.7.1.a).

[19] See also IAEA, Updating IAEA-Tecdoc-953, "Method for Developing Arrangements for Response to a Nuclear or Radiological Emergency", (IAEA, October, 2003) at Appendix 10, Response Time Objectives.

- As to the question of how much time might elapse between the operator notification of offsite authorities and a decision to "initiate" the system for alerting, both the Toronto Nuclear Emergency Plan, (TNERP) 2012 and the Durham Region Nuclear Emergency Response Plan, (DRNERP) 2011, Annex A Durham Region Nuclear Notification Procedures, indicate that the Provincial Emergency Operations Centre (PEOC) must decide within 15 minutes of the receipt of an initial notification from the operator, what initial response level to adopt. In the case of "Full Activation" it appears that the intent is that the municipalities will be immediately notified to commence their public alerting system in accordance with the TNERP or the DNERP. [20](TNERP, 2012, page 23; DRNERP, 2011, Annex A, section 3.3)

- The PNERP, 2009 has further detailed requirements in that the operator must provide resources to the municipalities to ensure that the public alerting system in the Contiguous Zone (0 to 3 km) "must provide, within 15 minutes of initiation, warning to practically 100% of the people in the Contiguous Zone at that time, whether they be indoors or outdoors, and irrespective of the time of day or year." (PNERP, 2009, 5.7.2.b). It further requires that the public alerting system in the Primary Zone (3 to 10 km) will be provided, "within 15 minutes of initiation, warning on an area-wide basis to the population in all of the response sectors within that part of the Primary Zone." (PNERP, 2009, 5.7.2.c)

- The Durham Region Nuclear Emergency Response Plan (DRNERP), 2011 at section 4.3 contains the public alerting provisions as are set out in the PNERP, 2009. One distinction of note is that section 4.3.6 states that "In the case of a nuclear emergency with an ongoing or imminent emission of radioactivity the Region is authorized to **immediately** initiate the public alerting system. The PEOC will issue the appropriate Emergency Bulletin." This is further confirmed in the Durham Region Nuclear Notification Procedures, Annex A to the DRNEP, which state that when the notification from OPG is for a general emergency, and there is either an imminent or ongoing emission, Durham "shall **immediately** initiate the Public Alerting System for the appropriate sectors and

[20] In the case of "Partial Activation" by PEOC it is less obvious as to whether and the timing of any public alerting that would occur – this would be in the case of an onsite emergency with no emission occurring - and it appears to be discretionary on the part of the PEOC in that it states that "Consideration shall be given to issuing an Emergency Bulletin and/or news release." (TNERP, 2012, p. 18)

Contiguous Zone." (Emphasis added). (Annex A at 4.4) It is not clear whether provision has been made in the Toronto Nuclear Emergency Response Plan, 2012, for immediate initiation of the public alerting system upon receipt of a similar notification from OPG. This should be clarified.

- **RECOMMENDATION:** The authority of Toronto Emergency Planning Officials to immediately initiate the Public Alerting System upon receipt of a notification from OPG for a general emergency with an imminent or ongoing emission should be clearly specified. If it is not intended that this authority be provided to Toronto's officials under the TNERP, this should be stated with a rationale for the discrepancy compared to the DRNERP.

- In its July 4, 2012 Application for this licence, OPG indicated that additional sirens had been added in 2011 within the 3 km zone when testing indicated that they did not have sufficient coverage to reach all recipients within that zone; subsequently it was determined that even more additional sirens were needed (p. 132). At the time of the preparation of CNSC staff submission CMD 13-H2, the additional sirens were not yet fully in place. In its application, OPG also indicated it was working with Durham Nuclear Emergency Management to update telephone data within the 3 km to ensure indoor alerting (p. 132) OPG also indicated in its application that it was working with a "working group" **toward** arriving at the 10 km notification required by the 2009 Provincial NERP. (p. 132)
- Despite the fact that public alerting requirements were strengthened in the 2009 PNERP, it is nevertheless surprising that this level of public alerting is still not in place since the Pickering NGS has been operating since the 1970's. The requirements for public alerting have been widespread and well understood in jurisdictions operating nuclear power for decades. For example, in the NUREG – 0654 – Rev. 1 (1980), the U.S. guidance included provision that the alerting system be evaluated and that it be capable of alerting the population with both an alert system and with a broadcast message within 15 minutes within a range of 10 miles; while the system should ensure direct immediate coverage of 100% of the population within 15 minutes. (Appendix 3 at 3-3). Similarly, the 1988 Working Group 8 recommendations made twenty-five years ago included ensuring provision of early warning systems for the public. (at (iv))[21]

[21] (Oddly, the 1984 Working Group #3 had initially been asked to make recommendations alerting, but in its report, stated that the province had "intimated" that it do not need to address offsite alerting. (at 30).)

- The urgency of the requirements for public alerting cannot be over-stressed. In the course of the notification and public alerting timeframes, in the event of early release, a considerable amount of population exposure may have occurred, before protective actions may begin to be taken to reduce those exposures.

- **RECOMMENDATION:** CELA recommends that the CNSC refuse further extension of Pickering's operating licence without the 3 km and 10 km alerting systems fully functional, both within the Region of Durham and within the City of Toronto, with robust evidence that they have been fully tested and are effective to meet the objectives specified in the PNERP, 2009.

- **RECOMMENDATION:** CELA also recommends that the emergency response plans time-frames be compressed so as to provide alerts to the public, and instructions to the public on protective actions required in as short a time frame as possible, preferably less than 30 minutes from the onset of the accident. Methods to compress this time frame should be considered and tested, and their efficacy should be one of the points of evaluation by the CNSC in the licence applications by the operators. Reasons for further compression of the time frames for instructions to the public for protective actions are further discussed in the submissions regarding KI distribution, sheltering, and evacuation below.

6. Potassium Iodide (KI) Distribution

- Potassium Iodide (KI) is important because its ingestion helps to block uptake of radioactive iodine in case of a severe offsite accident. Radioactive iodines are among the earliest radionuclides emitted from a nuclear power plant in case of breach of containment or in controlled venting following an accident. Emergency response to protect against radioactive iodine is needed since iodine "concentrates in the thyroid gland... a quarter of all ingested iodine goes to the thyroid under normal circumstances. As a result, when iodine is ingested the thyroid receives a very large dose compared to the rest of the body (roughly 1000 times as much)"[22]. Health Canada states that: "Once in the bloodstream,

[22] Working Group #8, 1988 at 4; see also IAEA Guide GS-G-2.1 at V.17 which states that "The thyroid gland absorbs and concentrates iodine once it has been inhaled or ingested; thus the potential exists for large thyroid doses following the occurrence of severe core damage at a large reactor. A large dose to the thyroid can result in

about 20% of the iodine is absorbed by the thyroid.... It is particularly susceptible to beta and gamma irradiation from radioisotopes of iodine, especially I-131." (Health Canada Guidelines for Intervention During a Nuclear Emergency, 2003 at 21).

- The ICRP notes that Iodine Thyroid Blocking is primarily intended as a short term measure to reduce uptake of radioiodines by the thyroid from inhalation over a few days. The prevention of uptake by ingestion should primarily be accomplished by controlling foodstuffs, milk and water that may be contaminated. (ICRP Publication 109 at 65). IAEA Guide GS-G-2.1 states that radioiodine uptake by the thyroid gland following an accident can be reduced by taking stable (non-radioactive) iodine. It outlines that "to achieve maximum effectiveness, stable iodine must be administered before or soon after the intake of radioiodine. The effectiveness of the measure decreases rapidly with delay, and can be reduced to 50% or less if administered 6 hours after a single intake of radioactive iodine." (at Appendix V, V.15) The IAEA Guide states that its reduction of dose is only 20% 10 hours after the intake of radioiodine and almost zero 24 hours after. (Ibid, V.15) ICRP publication 109 reinforces this – if stable iodine is taken up to 6 hours **before** the intake of radioactive iodine, "the protection provided is almost complete"; if at the time of radioiodine inhalation, its effectiveness is 90%; and 50% within a few hours. The ICRP stated that "to obtain the maximum reduction of the radiation dose to the thyroid, stable iodine should be administered **before** any intake of radioiodine or **as soon as practicable thereafter**." (At 65.) (emphasis added)

- As long ago as 1984, the province of Ontario's Working Group #2 to the Ontario Nuclear Emergency Plan (established by the Solicitor General to make recommendations on the use of stable iodine in case of a nuclear emergency) recommended pre-distribution of KI because it must be ingested very early in or prior to a release from an accident in order to be effective. The Working Group #2 also reviewed the reasons for ingestion of KI for thyroid blocking as a significant preventive measure for public health to prevent early thyroid injury

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deterministic effects in the thyroid gland and radiation induced thyroid cancer. In the event of **actual or possible** core damage, stable iodine prophylaxis should therefore be used: to prevent deterministic effects in the thyroid gland (e.g. hypothyroidism; to reasonably reduce the risk of stochastic effects (e.g. radiation induced thyroid cancer) from the inhalation of radioiodine within or near the facility." (emphasis added).

or longer term thyroid cancer risks. The Working Group stated that "The Group recognized that the cost-benefit ration was high, but that it would be prudent to consider pre-distribution." (at Recommendation #3) Provincial Working Group #2 also stated in 1984 stated that "if there is any use at all by KI as a blocking agent it would have to be by pre-distribution to an area considered to be at risk." – this was based on the time frame in which KI must be taken to be effective, and that if the warning time available before release is as little as thirty minutes, then "that will not be sufficient for house-to-house distribution from a central stockpile." (At 6).

- CELA submits that KI MUST be pre-distributed because it must be ingested before or shortly after a radioactive release, and if necessary during a release[23]. It would not be reasonably feasible to quickly obtain KI after such a severe accident that requires ingestion of potassium iodide. In that scenario people will likely be required to shelter in place and/or evacuate so it will not be possible to attend pharmacies to obtain it, nor would it be practical to have extensive distribution at that time.[24] In any event there is no possibility this could happen on time for the affected population numbers if there was not adequate pre-distribution. The IAEA Guide GS-G-2.1 stresses that other organs (bone marrow, lungs and other organs) are not protected by KI and therefore "sheltering or evacuation of people at risk of life threatening doses should not be delayed for the provision of stable iodine prophylaxis." (at V.21)

- There is a further concern about the adequacy of KI availability. This is highlighted by comparing the numbers of KI pills available. The CNSC staff submission noted that there is an inventory of 325,000 potassium iodide tablets for residents of the 10 km zone around Pickering (page 62 of the CNSC's submission CMD 13-H2.) This compares to the population of approximately 260,000 in the 10 km zone[25] but does not take account of the potential

[23] IAEA Guide GS-G-2.1 at V.19; See also Working Group #8, 1988 at 6.

[24] Linda Harvey, Physicians for Global Survival, personal communication with Janet McNeil of Durham Nuclear Awareness, April 2013; see also Working Group #8 Report 1988 where it notes that Emergency Planning Ontario considered the lower Protection Action Level for thyroid blocking to be "only for advising persons already in possession of potassium iodide pills to ingest them." (at 19)

[25] DRNERP 2011 and TNEP 2012 sources for total population numbers within 10 km of the Pickering NGS.

necessity for repeat doses nor for provision beyond the 10 km primary zone to the high populations in Scarborough and Pickering in the event of an offsite emergency requiring broader KI distribution.

- People may voluntarily attend one of five pharmacies at any time to request KI pills, and there has been pre-distribution to institutions.[26] The pharmacies are listed in Annex D to the DNERP. Companies may call the Region for additional quantities. None of the five pharmacies listed in the DNERP, 2011 are in the City of Toronto; the TNERP, 2012 does not list pharmacies available for the public to obtain KI and presumably Toronto residents may attend at one of the pharmacies in Pickering to do so. This should be clarified and Toronto area pharmacies should be added to the distribution channels, particularly in Scarborough. Annex D of the DNERP requires of the Durham Emergency Measures Office is to place public notices in local media twice per year about the availability of KI. No similar provision appears in the TNERP, 2012. Oddly, the TNERP, 2012 deals with thyroid blocking only in respect of its own City of Toronto staff. (4.5.4 (d))

- **RECOMMENDATION:** CELA recommends that as an interim measure, the CNSC should require that OPG in conjunction with the City of Toronto, conduct outreach and notification to members of the public resident in Toronto (at a minimum within the Primary Zone), as to the availability of KI and provide advice as to where it may be obtained.

- While Annex D to the DRNERP contains a provision for a KI information letter and consent form to be sent every year to every parent of all of the school children in the Primary Zone, there is no comparable provision in the TNERP and it should be clarified if Durham's Annex D is meant to apply to the City of Toronto residents and institutions within the Primary Zone, or if there are alternate provisions and requirements, and where they are located. This concern is applicable to all of the provisions in Annex D including pre-distribution to institutions. Durham's Annex D on its face does not appear to apply to City of Toronto (Scarborough) residents and this gap must be addressed by comparable provisions for them.

[26] CNSC Staff Submission CMD 13-H2 at 62; See Annex D to the DNERP, 2011, "Potassium Iodide Distribution Procedures."

- **RECOMMENDATION:** The applicability of Durham's Annex D to the residents of Toronto in the Primary Zone must be clarified. Alternatively, the same provisions for KI distribution, consent and information letters for school age children, and other matters dealt with in Annex D must be specified in the TNERP.

- The lack of a comprehensive KI pre-distribution approach at Pickering could be compared to the approach taken by France as described by J.C. Niel[27], in Ottawa during remarks made on April 10, 2013 during a session on Emergency Management. He stated that the approach taken by France for KI distribution was first to mail all of the residents in the protective action zone coupons to redeem at local pharmacies for KI for the household, at no charge. After finding that the uptake was insufficient, they then mailed every single household the KI doses needed to ensure that they would have them on hand in the event of a severe accident.

- The CNSC Fukushima Task Force Report, 2011 noted that the effectiveness of the approach of stocking the KI tablets at local pharmacies, as opposed to pre-distribution to all households "has not been confirmed." (at 52) It is notable that the CNSC 2011 Fukushima Task Force reported that Ontario is the only nuclear province in Canada that does not pre-distribute KI to the residents in the surrounding planning zones. (at 47)

- **RECOMMENDATION:** CELA recommends that the CNSC should require the operator to systematically evaluate and report back to the CNSC the percentage of households within the 10 km Primary Zone, both within the Region of Durham and the City of Toronto, who have obtained KI tablets in advance, as well as the percentage of institutions covered by the plan who have them on hand in sufficient quantities to cover all of their residents or students. Based on this evaluation, CELA recommends that the CNSC require the approach that was taken in France be taken in Canada for the 10 km zone around each operating nuclear generating station, to undertake and ensure 100% pre-distribution of KI

[27] J.C. Niel, of the Autorite' de surete' Nucle'aire (ASN) at the IAEA International Conference on Effective Nuclear Regulatory Systems hosted by the CNSC in Ottawa, April 8-12, 2013.

tablets to the residents in the Primary Zone and that this requirement be included in the licensing conditions for the Pickering NGS.

7. Re sheltering in place and evaluation of its effectiveness

- Sheltering is not defined specifically in the PNERP, 2009 Glossary, nor in the Glossary to the IAEA Safety Guide GS-G-2.1. However, it is listed in the latter as one of the urgent protective measures to consider following a nuclear emergency. That Guide GS-G-2.1 states that "substantial sheltering is provided by large multi-story structures without any special features." (Table 13). The Guide states that sheltering will provide "some protection against all of the major exposure pathways during the early phase of an emergency"; but that the "effectiveness of sheltering varies greatly." Variables cited include the type of release, the type of construction of the building, and the exposure pathway. However, it also notes that after a few hours the reductions in doses are no longer evident and after that time, doses may become greater than those outside if some of the contaminants from the plume are "trapped in the shelter"; if the plume has passed it states that the shelters may then need to be aired out. (at Appendix V, V.3)

- IAEA Guide GS-G-2.1 reviews the protection available with different types of shelters. It states that "typical European and North American homes and their basements" "may not provide adequate protection". Within the first 3 km from the site in particular this type of shelter may not be able to reduce "the risk of severe deterministic effects." The IAEA guide indicates that sheltering in this type of structure should be used if evacuation is impossible or while preparing to evacuate. The Guide states that "substantial" shelter may be provided inside the halls of "large multi-storey buildings or large masonry structures away from walls or windows" which may provide a ten-fold reduction in external and inhalation dose. The Guide states this type of protection can be used for short periods, for up to a day, subject to monitoring. (At Table 11, Page 97) "Special shelters" are defined as those designed specifically to provide dose reduction "by a factor of more than 100".

- ICRP Publication 109 also states that buildings constructed of wood or metal (as opposed to solidly constructed buildings) "are not generally suitable for use as protective shelters against external radiation, and buildings that cannot be made substantially airtight are not effective in protecting against any exposures." (at 65) Accordingly, ICRP Publication 109 implies that for these

types of buildings the main utility is to advise people to "go inside and listen to their radios for further instructions." (at 66) Health Canada's Guidelines for Intervention During a Nuclear Emergency (H46-2/03-326E, 2003) state that sheltering should only be used for one day and should not extend beyond two days. (at 18)

- Given the significant limitations of sheltering, CELA observes that there must be significant planning, attention and resources in order to ensure rapid, timely evacuation. In the time frames required for evacuation, however, there may nevertheless be significant exposures to the public whether trying to evacuate or sheltering in place, but taking many hours to do so. This is further discussed in our comments on evacuation. It is very important that emergency planning officials and the public understand that, for example in large early release scenarios, it may not be possible to prevent all of the exposures to the public from those releases because sheltering will not be fully effective and evacuation takes time.

- The DNERP, 2011 provides for sheltering at section 4.7.1 without acknowledging the limitations set out by the IAEA Guide or the ICRP Publications reviewed above. On the contrary, the description implies that sheltering will be effective without any discussion as to the type of building, time frame etc. It does provide direction to close doors, dampers and windows and to turn off furnaces and air conditioners, and does recommend going to a basement or ground floor room with no windows.

- **RECOMMENDATION:** CELA recommends that the CNSC require OPG to include in its outreach material to the public, in conjunction with regional emergency response officials, explanations about the capability of sheltering and its limitations as described in the IAEA Guide GS-G-2.1 and to reinforce instructions as to steps to take for rapid and effective evacuation in the case of notification of a significant emergency.

8. Medical treatment and availability

- The IAEA Safety Guide GS-G-2.1 states that there should be a referral hospital outside of the ``UPZ`` (Urgent Protective Zone – analogous to Ontario`s Primary Zone) that can provide "highly specialized treatment for a limited number of exposed and/or contaminated persons..." (at 4.46)

- The PNERP 2009 states that the Ministry of Health and Long Term Care will develop a Radiation Health Response Plan. (At 5.1.0). It is to be an Implementing Plan to the PNERP, 2009. Emergency Measures Ontario advises CELA that this Plan is not yet completed as of April, 2013.[28] The TNERP, 2012, does not indicate what the referral hospital for its residents would be in case of a severe accident; rather it refers to their Radiation Health Response Plan. (TERP, 2012 at 4.5.6) Toronto Emergency Measures also advises CELA that this Plan is not yet ready as of April, 2013. The Implementation Plan for the Pickering Nuclear Generating Station under the PNERP, 2009 (to which the reader is referred in TNERP, 2012 at 2.3 regarding Protective Measures), does not have any additional specificity on this question.
- It is not currently possible for CELA to evaluate or comment on the level of treatment available to the public and the level of protection arising there-from on the question of treatment for contaminated persons after a nuclear emergency. Nor is it possible for CELA to evaluate whether the treatment available in the event of an accident at the Pickering NGS is in compliance with IAEA GS-G-2.1 as the provincial plans and Toronto`s and Durham`s Radiation Safety plans are apparently not completed on this issue.

- Valid questions which we have not been able to answer based on the available materials include:
  - Are there in place plans for treating members of the public, either injured or suffering from radiation syndromes beyond decontamination and assessment centres? This is not evident. Provincial Working Group # 9 (another document which CELA will be seeking to obtain for our emergency planning archive) apparently recommended that there be capacity to assess a thousand members of the public and treat for radiation syndromes up to 50 members. In referring to this in 1993 testimony, Dr. Paul Rosenberg stated that there was a lack of readiness in

[28] We have not so far been able to obtain any current version of this plan. It would appear that it is in the process of being updated according to an overview presented by the MOHLTC in December, 2012 where it stated `` In 2012, the MOHLTC undertook a major update to the Radiation Health Response Plan (RHRP), a plan required by the Provincial Nuclear Emergency Response Plan. This health plan describes how Ontario's health system responds to a radiological/nuclear incident of a deliberate or accidental nature and the conditions under which precautionary and protective actions are ordered for the general public and health workers. The update includes a major review of roles and responsibilities, hospital response and resources, evacuation planning, occupational health and safety, monitoring and decontamination units, use of potassium iodide and communications. Technical/expert working groups focusing on these various issues were convened from across the health system. Their input has ensured that a robust plan will be released in early 2013.``

place for that number of people. CELA notes that currently there still does not appear to be such a capability as we have seen no reference in emergency planning documentation to any capacity to handle these numbers of contaminated victims.

- Does the primary hospital for Pickering or Toronto have sufficient response capacity which would not be overwhelmed by a few injured and contaminated patients? Which hospitals are designated for this response capacity?
- Are arrangements for treating more seriously radiated or injured workers, as well as members of the public, adequately in place? We have not seen evidence in the emergency plans that this has been addressed.
- CELA submits that these are the types of questions which must be asked, and answered satisfactorily, with proof, before the CNSC continues with the Pickering licensing application beyond the design life of the plant.[29]

- The concern about the ability to handle the medical treatment of injured and contaminated members of the public is not alleviated by examining the provisions of the Durham Region Nuclear Emergency Plan. The Durham Region Nuclear Emergency Plan contains a brief reference to monitoring at decontamination centres and issuance of instructions to the public. It has a generalized direction if unable to attend at decontamination centres, to "go to a destination of their choice, shower and bag their clothes." It also states that "Details of personal decontamination procedures will be provided through Emergency Bulletins from the PEOC as will the locations of MDUs when they are operational." (at page 31) It is further stated in that Emergency Plan that if there is "a reasonable possibility of significant radiation exposure, the Ministry of Health and Long-Term Care (MOHLTC) will implement the Provincial Radiation Health Response Plan. This includes monitoring for internal contamination, maintaining a database of potentially affected people, counselling and public health information program". However, as noted earlier, the Provincial Radiation Health Response Plan is apparently not complete according to advice provided by EMO to CELA in April, 2013.

[29] Evidence of Dr. P. Rosenberg, Nov. 3, 1992, pages 922-932 ; See also the Recommendation of Working Group #8, 1988 that the province take appropriate measures to provide "the need for adequate medical facilities to deal with possible acute radiation exposure." At 90.

- There are also serious questions to ask about whether the emergency plan has contemplated enough ambulance transport to transport more than two or three workers; and about whether it has contemplated the consequences of taking ambulances out of service after transport due to radioactive contamination. Another concern is whether the ambulance crews would accept a contaminated worker given workplace standards for workplace safety in Ontario. This should be explicitly addressed in the planning, and ambulance worker safety also addressed. There is also a concern about whether there is provision for transporting members of the general public who have received an initial dose of radiation that would require treatment (because the planning accident has until now assumed there would not be any people in that situation). These questions cannot be evaluated at present without the Provincial Radiation Health Response Plan and this is a significant deficiency in the Emergency Planning presently in place in Ontario, and therefore in the ability to respond adequately to a severe offsite nuclear accident at the Pickering NGS.

- **RECOMMENDATION:** CELA recommends that the Pickering Operating licence should not be extended without the Provincial Radiation Health Response Plan and the municipal Radiation Health Response Plans in place.

9. Size of emergency planning zones

- IAEA Safety Guide GS-G-2.1 at 75-78 – provides that the UPZ (Urgent Protection Action Planning Zone) radial distance could be between 5 and 30 km. The reason for this zone is to be able to shelter, monitor, take protective actions and evacuate to significantly reduce risk of doses.

- The same emergency planning zone radii have been in place since the 1988 Working Group #8 report (a 10 km primary zone to plan to prevent plume exposure including evacuation; a 3 km contiguous zone with increased level of planning and preparedness; and a 50 km secondary zone (re ingestion control from contaminated food and water).[30] In Ontario, the 50 km secondary ingestion zone was recommended by Working Group #8 on the assumption that the accident of concern would be a “puff” release. (At 24.)

[30] Working Group #8, 1988 at 18

- **RECOMMENDATION:** CELA recommends that in view of the experience at Chernobyl and Fukushima, the CNSC should request that the province immediately revisit the 50 km secondary ingestion zone with a recommendation to change it to 100 km. This should be done as part of detailed planning for severe offsite accidents so that appropriate monitoring of food, agricultural products, milk, and water is established and in place in the event of such an accident.

- These zones in general appear to have originated in untested assumptions such as those set out in the U.S. Nuclear Regulatory Commission's "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants", (U.S. NRC / FEMA 1980), NUREG-0654; FEMA-REP-1 Rev. 1. This document stated that "The choice of the size of the Emergency Planning Zones represents a judgment on the extent of detailed planning which must be performed to assure an adequate response base." (at 11) NUREG-0654 described an NRC / EPA Task Force on Emergency Planning (NUREG-0396 1978) which had "selected a radius of about 10 miles for the plume exposure pathway and a radius of about 50 miles for the ingestion exposure pathway." (at 11) This Report asserted that projected doses from the traditional design basis accidents would not exceed Protective Action Guide levels outside the {10 mile} zone" and the same for "projected doses from most core melt sequences"; that immediate life threatening injuries from worst core melt sequences would generally be inside that zone; and that detailed planning within that 10 mile zone would provide "a substantial base for expansion of response efforts in the event that this proved necessary." (at 12)

- These zones have not been altered despite the experience of Chernobyl, or now Fukushima, to this date. In other words, emergency planning zones in Ontario and specifically around the Pickering NGS have not been re-examined in light of actual experience with severe nuclear power plant accidents in which radionuclides breached containment. The Fukushima Task Force Report (CNSC, 2011) noted that at day 5 after the onset of the Fukushima accident, authorities extended the evacuation zone to 30 km around the plant. One month later, some residents at even greater distances were moved as a result of discovering higher levels of radiation in those areas. (at p. 8)

- Dr. Robert Goble, 1993[31] modelled cases which varied in estimating where population dose fell, depending on weather conditions – in some scenarios most of the dose occurred within 100 km of the reactor while in others over 50% occurred beyond 100 km. These scenarios illustrate the necessity to seriously consider and provide detailed plans for emergency planning zones well beyond the 10 km Primary zone and the 50 km ingestion zone currently contemplated.

- **RECOMMENDATION:** CELA submits that it is now incumbent on the CNSC to require that the emergency planning zones be expanded before proceeding with licensing of the Pickering NGS since it is evident on the experience of Fukushima, that evacuation well beyond 10 km is required in certain serious accident scenarios. CELA submits that if emergency planning were undertaken for severe offsite multi-unit accidents, as recommended by the CNSC Fukushima Task Force report (at page 39), it would be evident that emergency planning zones must extend significantly beyond their current limits. CELA submits that the 10 km Primary zone should be extended to 30 km and the 50 km Secondary zone should be extended to 100 km. (By way of comparison to Ontario, the Fukushima Task Force Report indicated that Quebec's Ingestion Control Zone is 70 km. (at 47))

10. **Evacuation**
    - Evacuation is one of the most immediate actions to be taken in the event of a general emergency at a Nuclear Generating Station. ICRP Publication 109 indicates that the purpose of evacuation is to provide "rapid, temporary removal of people from an area to avoid or reduce short-term radiation exposure in an emergency exposure situation." ICRP states that it is "most effective if it can be taken as a precautionary measure before there is any significant release of radioactive material." (at page 66)

    - Health Canada's Guidelines for Intervention indicate that "the goal of evacuation is to avert elevated short-term doses arising mainly from the radioactive plume (external irradiation and inhalation) and from radionulides deposited on the ground (external irradiation). Evacuation has the potential to avert most or all doses if carried out in the pre-release phase of an accident.

[31] Goble 1993 Report for NLA Trial, April 1993 "Potential Consequences of Severe Accidents at Canadian Nuclear Power Plants – Implications for Nuclear Liability Act."

Evacuation is effective for reducing exposures in cases where the release is of uncertain size or duration." (at 18) The Health Canada Guidelines indicate that evacuation should not last more than one week; if conditions prevent return after a week, then the next measure would be longer term relocation. (p. 19) (Relocation, which is not addressed in this submission by CELA, is indicated by the Health Canada Guideline to be a longer term action from weeks to months to avert doses occurring over that time frame.) The Health Canada Guideline states that "If times longer than a year are indicated, then permanent resettlement would need to be considered." (p. 19))

- The Pickering A Safety Report noted that a 50 km radius of Pickering includes almost all of Metro Toronto, the southeast part of the Regional Municipality of York and the Regional Municipality of Durham. In 2001, 3.2 million people lived with 40 km of the Pickering plant. (At p. 40) The population within the 10 km primary zone for the Pickering NGS totals 256,361 people, (2006 population numbers), approximately 60,000 of whom live within the City of Toronto sectors of the primary zone. When Pickering NGS employees are included, the total is 260,861. (The numbers are somewhat less during evenings after 6 pm and nights). These population figures do not include the 15 km or 20 km population numbers in the event that evacuations were ordered for those distances. Nor do these figures include significant numbers of "shadow evacuations", meaning people choosing voluntarily to leave the area beyond the officially declared evacuation zone. (See further comments below on shadow evacuations.) By 2026, the population of Durham Region is projected to be 949,100 according to the Pickering A and B Safety Reports[32].

- A critical issue to determine, then, in order to evaluate effectiveness of evacuation as a protective measure in various scenarios is the time required for evacuation. Just within the 10 km zone, the highest times to evacuate, with last vehicle to clear the Primary Zone, are estimated in the Durham Region Nuclear Emergency Evacuation Information, Annex B to the DRNERP. (Annex B is dated 2008.) The highest times to evacuate vary by scenario and range from 4.77

[32] Figure 2-3 in the Pickering B Safety Report, 2012 NK30-SR—1320-00001 Rev. 4 shows the population trends of Metro Toronto and Durham Region since the 1970s when the plant was originally sited. (P. 88 of 110)

hours up to 36.58 hours in one scenario; several scenarios exceed 20 hours. In other words, on the assumptions made for that study, the residents of Durham Region within 10 km of the Pickering NGS could evacuate over times ranging from just under 5 hours, to almost 37 hours, depending on circumstances. Variables include weather, time of year, time of day. (at p. 89) Times for lesser percentages of the population to evacuate will be less; for example the times for 50% of the population to evacuate may be calculated as was done in the Evacuation Time Estimates Technical Support Document for the Pickering B Refurbishment application (2008)[33]. In that study, based on the population and employment numbers in 2006, it was estimated that the various protective zones could evacuate 50 per cent of their population to the edge of the 10 km zone in times ranging from one hour 10 minutes to two hours 45 minutes. (Table 7-1A). However, that table did not include the combination of midweek evening poor (rain or snow) time estimates in that OPG study. Times increased for the calculation of clearing 100% of the evacuating population, to a high of six hours 30 minutes, but again did not include the midweek evening poor road conditions scenario in the relevant table (Table 7-1D). Table 2-1 which outlines the Evacuation Scenario Definitions for that study did not include a winter, evening rain or snow scenario, which appears to be a significant omission in that during early evening, roads may be already congested at the outset of an emergency. This may explain the discrepancy we note below.

- CELA observes that there are highly significant discrepancies between the highest time to evacuate scenarios contained in the Durham Region Evacuation Information Annex and the 2008 OPG Technical support document just referenced. The CNSC staff submission CMD 13-H2 indicated that CNSC obtained an independent expert review of the 2008 study and based on that review, "it can be conservatively estimated that the 10 km zone could be evacuated in less than 13.5 hours using projected regional data." Meanwhile, the OPG CMD 13-H2.1 claimed evacuation of the primary zone within 6 to 7.5 hours (and 9 hours by the year 2025) taking account of weather and time of day. (At 65). CELA notes that there remains a significant discrepancy between both of these estimates as well as between these estimates and the DNERP Annex B and requests that the CNSC require the applicant to outline a comparison between the factors affecting the time estimates contained in the DRNERP and

[33] Evacuation Time Estimates Technical Support Document for Pickering B Refurbishment for Continued Operation Environmental Assessment NK30-REP-07701-00016, September 2008

the 2008 study and subsequent peer review results. In particular, it is not evident that the 2008 study included any particular consideration of evacuation from institutions; compared to the DNERP, 2011, which does include a listing of institutions such as schools, long term care facilities, hospitals, and others, in each sector. The 2008 OPG study appears to be based on car traffic and also does not indicate what assumptions were made in the study for evacuation of people without household automobiles; if they were included it was not explicitly stated.

- The Pickering Implementation Plan under the PNERP provides that both Toronto and Durham are to provide for mass transportation. The TNERP states that evacuees who require transportation to leave the Primary Zone will be assisted "according to the Mass Evacuation Transportation OSF" operational support function. CELA has not yet been able to obtain this Plan under the TNERP and presumes that it is not ready yet since Toronto EMO sent CELA the available Operational Support Function plans and Annexes in April, 2013, along with the advice that the rest of them are not yet ready. Similarly, the DNERP, 2011 states that "Durham Region must have a plan for the pickup of people without vehicles and their transportation out of the PZ." It is not evident in the Durham Plan what those plans are or where those plans would be located by members of the public.

- **RECOMMENDATION:** CELA recommends that the public should clearly understand what plans are in place to assist them with evacuation from the Primary Zone if they do not have their own transportation. What those plans are should be clearly specified in the Durham and Toronto Nuclear Emergency Plans, and widely communicated to the public in outreach and education. It is not clear from the 2008 OPG Pickering evacuation time estimates study that transit dependence was calculated.

- The ability of people without cars to evacuate is a significant concern. The U.S. Nuclear Regulatory Commission requires explicit calculation of numbers of households with no vehicles; with unsupervised latchkey children; with one vehicle at work that would not return; with residents who have limitations on driving such as elderly who do not drive at night; with specialized transportation needs such as wheelchair vans or ambulances. It also specifies that a summary of the total number of vehicles available to support evacuation of transit

dependent residents, and people with accessibility needs must be done.[34] A related question is the sufficiency of arrangements for transportation of residents of special facilities (institutions) and schools during an evacuation. The same US Evacuation Time Estimate Criteria provides that the numbers of residents and students should be calculated and numbers of bus runs should be calculated in evacuation time estimates. (At 14-15)

- The Durham Region Nuclear Evacuation Information Annex B, Jan. 2008, does provide this type of information (although it likely should be updated at this point, five years later). For each sector, it lists the special care facilities (child cares, retirement homes), schools, all with numbers of residents, students, staff, as well as recreation centres, parks, and locations of emergency services, works, services, and vital services such as health centres. It also notes motels and hotels when present in the sector. It may be that this information was utilized in the time estimates to evacuate each sector contained in that plan, and that should be explicitly stated.

- It is not apparent that the Toronto Nuclear Emergency Response Plan has collected comparable information for these populations of vulnerable residents, and this should be done. The Toronto NERP states that the City is to assist the School Boards to develop their emergency plans for movement of students to pre-arranged host schools and if necessary to Monitoring and Decontamination Units; and that Long Term Care Facilities are to have pre-arranged reciprocal arrangements with like facilities outside the "Hot Zone" to accommodate their residents. (at 4.7.3) Students are to be the responsibility of their school staff until collected from the host school by their guardians / parents. CELA questions whether parents in the Primary Zone are aware of these arrangements, and reminded of them periodically. Questions as to methods of transportation for those lacking personal vehicles, or whose household vehicles cannot return due to the evacuation should be answered clearly, to provide advance information to parents as to how they will be able to collect their

[34] NUREG/CR-7002, "Criteria for Development of Evacuation Time Estimate Studies", 2011 at 14.

children. It is not evident in the Toronto NERP if all of these arrangements are currently in place[35].

- The Durham Emergency Evacuation Information, Appendix A, notes an optimal evacuation route for each sector. The Toronto Emergency Response Plan states that there is to be a Joint Traffic Control Plan developed by a Joint Traffic Control Committee as provided for in the Pickering Implementation Plan under the PNERP, 2009 (referenced at 4.6.3 of the Toronto plan.) However, it is not apparent whether the Joint Traffic Control Plan is completed yet as it was not among the TNERP documents sent to CELA by Toronto EMO in April, 2013. It is supposed to provide for priority evacuation of any Response Sectors and timing and order of sector evacuations is to be determined by the PEOC in conjunction with the Joint Traffic Control Committee. (4.9.3, 4.9.4 of the Toronto Plan).

- In the event of Full Activation of the emergency plans, both the Toronto and Durham plans note that the main road and rail routes through the Primary Zone will be closed to through traffic: Highway 401, Highway 2, CN Rail and CP Rail. (TNERP at 4.6) In addition the Lake Sectors in the Primary Zone will be cleared of boats through Canadian Coast Guard and Toronto and Durham Police marine units.

- It is not clear that members of the public know in general that in the event of an evacuation they are expected to "make their own arrangements for food and lodging" and that the host communities will make arrangements for those "without resources". (DNERP, 2011 at 4.8.4 and 4.8.7; TNERP, 2012, at 4. 7.1 (e)).

- **RECOMMENDATION:** CELA recommends that the CNSC should require OPG to communicate to the public in annual outreach and education, the fact that the nuclear emergency response plans expect the public to make their own arrangements in the event of evacuation, and for those who cannot, what is expected to be provided by the municipalities. The appropriateness of this

[35] The Child Care Nuclear Emergency Response Guidelines, Annex F to Part II of the DRNEP, 2007 says it was divided into two parts; CELA was so far unable to obtain and review the second part being the child care Evacuation and Sheltering Guide described.

approach should further be discussed with the public in terms of future nuclear emergency planning.

- As noted earlier under the topic of sheltering, a significant issue of ongoing concern with all of the evacuation time estimates is that in the event of an early release, there would be considerable periods of exposure to the evacuating public. This is not acknowledged by OPG in its CMD13-H2.1 in which it states that the time estimates are "well within the anticipated "hold-up" of radionuclides within station containment following a nuclear event." (at 65) This is no doubt due to OPG's continued assumption that there will not be a severe catastrophic accident with early release and it does not use such an accident in its emergency planning basis as discussed earlier in this submission.

- **RECOMMENDATION:** CNSC should require OPG to conduct studies and to work with offsite emergency responders, the municipalities and the Province to ensure that there are realistic evacuation plans in the case of a severe accident with early large release, as well as in the case of plans for twenty kilometer and 50 kilometer evacuation zones around the Pickering NGS.

11. **Re shadow evacuation** issues
    - "Shadow evacuation" refers to the people who voluntarily leave the area following a nuclear incident or accident, beyond those who are asked by the authorities to do so. In the Fukushima accident, for example, there were considerable "shadow evacuation" populations, especially women and children.

    - The U.S. Nuclear Regulatory Commission requires its licensees to include a shadow evacuation of twenty percent of the public to a distance of 15 miles from the Nuclear Power Plant in its traffic estimates and planning. ("Criteria for Development of Evacuation Time Estimate Studies.") NUREG/CR-7002, November, 2011. The U.S. General Accounting Office has just released a report (March 2013) in which it reviewed, among other things, the extent to which the U.S. regulator, the NRC understands public awareness as to how to respond in case of a nuclear power plant emergency. It found that there had not been an evaluation of people's understanding beyond the established 10 mile emergency planning zone. See GAO-13-243, U.S. General Accounting Office, Report to Requestors, NRC Needs to Better Understand Likely Public Response to Radiological Incidents at Nuclear Power Plants. (March 2013) The General Accounting Office recommended that the U.S. NRC conduct an evaluation in the

area beyond the 10 mile zone, of people's likely responses in respect of evacuation, during a nuclear emergency, and determine how the rate of shadow evacuations would affect their evacuation time estimates and plans. While the NRC requires licensees to include factors for an additional shadow evacuation within 15 miles of another 20% of that population, the GAO is concerned that the NRC does not have a basis to determine if this requirement is sufficient or reasonable. (At 26).

- The TNERP, 2012 comments that shadow evacuations may occur and contribute to evacuation times. Specific areas next to the Primary Zone are identified in the Plan. (at 4.7.1) A similar comment is included in the DNERP, 2011 (at 4.8.2). The Toronto plan indicates that traffic control will be initiated when the emergency requires evacuation, or "when spontaneous evacuations begin to occur." (at 4.9) The 2008 OPG report on evacuation done for the Pickering refurbishment stated that it included a factor for "some portion" of shadow evacuations out to a 15 km radius from the plant. (at ES-2)

- It is not apparent that there is evidence that the CNSC or OPG or municipal emergency planning officials have tested the state of information and knowledge on the part of the public around the Pickering NGS beyond the 10 km zone. It can be expected that there could be considerable populations of people involved in shadow evacuations given the population numbers located adjacent to the 10 km Primary Zone. Another five kilometers into the City of Toronto extends even further into the former City of Scarborough, extends to approximately to Brimley Ave. and encompasses the neighbourhoods of Guildwood and Scarborough Junction. Five more km to a radius of 20 km west from the Pickering NGS extends to Toronto's Woodbine Ave. and the Don Valley Parkway north of that. It is also reasonable to assume that people will voluntarily evacuate even in greater distances throughout at least the eastern side of the City of Toronto in case of a general emergency at Pickering.

- **RECOMMENDATION:** CELA submits that a similar recommendation to the one made by the U.S. General Accounting Office to the U.S. Nuclear Regulatory Commission is relevant in this case: that the CNSC require the applicant to conduct a study as to the awareness of the Pickering Nuclear Plant of people beyond the Primary Zone at Pickering, and as to their likely response in the event that a general emergency is declared and the Primary Zone is evacuated. The CNSC should require the applicant to evaluate the impact of increased evacuation zones of twenty and fifty kilometers on evacuation time estimates, as well as any other needed adjustments to the emergency plans surrounding

Pickering such as locations of Emergency Workers Centres, numbers of emergency workers required for evacuation management, traffic routes, size of evacuation centres, and locations and capacity of Decontamination and Monitoring Units, and to report its findings to the CNSC and to the provincial EMO, the City of Toronto, and the Region of Durham.

12. Family reunification

- Family reunification would be one of the most significant issues that people are concerned with following an evacuation. This is recognized in the TNERP, 2012, but no provisions are included about how reunification will be accomplished other than that there will be a number of factors affecting reunification. (at 4.7.1 (d)) A similar treatment is included in the DNERP, 2011 (at 4.8.3).

- **RECOMMENDATION:** CELA recommends that CNSC direct the applicant to work with the municipalities to consult with the surrounding communities on specific plans for family reunification following evacuation in the event of a severe nuclear emergency.

13. Decontamination

- IAEA Guide GS-G-2.1 outlines some approaches to radioactive decontamination. Apart from people who have been heavily contaminated, such as potentially some of those on-site, it recommends that changing clothes, showering and washing exposed skin will reduce levels of contamination and prevent further spread of contamination in a nuclear emergency. (2.2.4)[36]
- The PNERP, 2009 includes decontamination, "removal of deposited radioactive material" on the list of specific protective measures available. In terms of personal monitoring and decontamination, the PNERP states that "evacuees **who are not likely to be contaminated** will be advised to evacuate...undertake self-decontamination." Self-decontamination is described consistently with the IAEA guide. The PNERP states that monitoring and decontamination units should be set up and the affected public directed to those centres if possible. (emphasis added) PNERP 2009, Para. 6.7.5
- The DRNERP considers the potential for contamination from loose particulate on people in the event of an ongoing emission; and also the possibility of

[36] See also ICRP Publication 109 at 66.

internal contamination. (At Para. 4.10). It states that "if evacuees cannot clear the affected area before an emission, they may be directed to proceed for monitoring and decontamination." If units for monitoring and decontamination are not yet set up, they will be advised to "go to a destination of their choice, shower and bag their clothes." Further details and direction will be provided through the PEOC; the priority is to ensure people leave the affected area as soon as possible. (At Para. 4.10.4)

- The TNERP, 2012 states that when evacuations are underway during an emission, the first priority is to "leave the affected area as quickly as possible." It states that evacuees will be advised "via an operational directive" to go to a facility for monitoring and decontamination or to self decontaminate, and that details will be provided through emergency bulletins along with advice as to where to go for follow-up "assurance monitoring". The TNERP, 2012 states that "given the population density, self-decontamination may be the primary means of decontamination, if required." (At 4.7.1 (b)). However, it does not contain the explanation about what self-decontamination means and how to carry it out.

- **RECOMMENDATION:** Explanations about what "self-decontamination" means; how to do so; and a statement as to its efficacy should be included in the Toronto Nuclear Emergency Response Plan and in outreach and education to the public about implementation of the plan.

14. **Monitoring**
    - OPG has now installed "Near Boundary Gamma Monitoring System" and indicated in its application for this licence that it expected it to be in full use in the last quarter of 2012 (July 4, 2012 Application for Renewal of the Pickering A and B Operating Licence P-CORR-00531-03719, Att. 3 p. 130).

    - The IRSS report noted that in some countries the governmental and licensee monitoring is automatically exchanged (page 58). Automatic boundary monitoring was recommended as well by the CNSC Fukushima Task Force (at 38). The availability of this data is extremely important during emergencies as well as during routine operations.
    - The Toronto NERP references "Assurance Monitoring" led by Ministry of Labour in the province in areas adjacent to a radioactive release where protective measures are not required, "aimed at assuring the public that air, food and water are safe." (at 4.10.5)

- **RECOMMENDATION:** The CNSC should confirm that the automatic gamma monitoring is in place at Pickering, and require the automatic exchange of its data with the regulator as suggested by the IRSS and Fukushima Task Force reports.

15. C**ontrol of agricultural products**
    - IAEA Safety Guide GS-G-2.1 outlines expectations for including arrangements to ensure that the public will be instructed not to eat or drink potentially contaminated food, milk and water in the event of a major release. It noted that radiation induced thyroid cancers following the Chernobyl accident occurred mainly **at distances more than 50 km** from the plant, and that "the most effective protective action to prevent or reduce these thyroid cancers would have been to restrict the consumption of potentially contaminated food and milk." (At V.24)

    - CELA notes that the 50 km secondary zone around the Pickering NGS, which is stated to be primarily for ingestion control, would not encompass this situation in which most of the impacts from ingestion following Chernobyl were actually beyond 50 km. Following the experience at Fukushima this is an appropriate response since there were hotspots located as far away as 50 and 80 km.

    - ICRP Publication 109 outlines the preventive agricultural actions that would reduce or prevent doses from ingestion: banning consumption of locally grown food; covering open wells; sheltering animals and animal feed; control of milk; avoiding drinking of milk from animals grazing on potentially contaminated pasture; not eating fresh vegetables, fruit or other food that may have been outside during the release; monitoring of drinking water particularly in case of run-off; and continuing restrictions until sampling shows return to established limits. (at 67)

    - The PNERP, 2009, includes Protection Action Levels (PALS) for ingestion control (food and water) at Annex E; and sets out the levels for foods for general consumption, milk, infant foods and drinking water at which items would be banned. It states that these effective dose PALS were "adopted by the Province in 1984 upon the recommendation of Provincial Working Group #3 and are

generally consistent with Health Canada Intervention levels (2003) and IAEA Safety Series No. 115 (2004).[37]

- The DNERP, 2011 has a brief reference to banning consumption of local water, milk, meat and produce in the section dealing with Partial Activation of the Plan, as a Precautionary Measure. It indicates that the PEOC would discuss with the Regional Emergency Operations Centre the implementation of precautionary measures and communicate them to the public by emergency bulletins issued by the PEOC. There is no mention of food and water bans in the Full Activation section of the DNERP, 2011. The TNERP, 2012 contains an outline under both the Partial Activation and Full sections of the plan, with a list of potential precautionary measures to be considered by the PEOC and does list "clearing the milk storage of dairy farms; banning consumption of any item of food or water that may have been exposed outdoors; banning consumption and export of locally-produced milk, meat, produce, milk-and-meat producing animals" among the precautionary measures that may be indicated. The TNERP indicates that these would be the subject of PEOC emergency bulletins and that the City of Toronto would follow the Province's operational directives regarding implementation. (TNERP, 2012 at 4.3 (e) and 4.5.4 (b))

- **RECOMMENDATION:** CELA recommends that the CNSC request that the Provincial Nuclear Emergency Plan expand its monitoring provisions and ingestion control zones to a distance of 100 km from the NGS, and that it undertake appropriate measures to ensure that monitoring can be done following an accident within that 100 km zone for agricultural produce, foodstuffs, milk and water.

- **RECOMMENDATION:** CELA recommends that the DNERP, 2011 should explicitly outline the measures in respect of controlling ingestion food and water that may be required in the case of a severe nuclear emergency of the type outlined in ICRP Publication 109.

[3737] The PNERP at Annex E, states that the IAEA document International Basic Safety Standards for Protection Against Ionizing Radiation and for Safety of Radiation Sources, IAEA, Safety Series No. 115, 2004 validates the provincial PALS for food and water consumption.

16. **Worker safety**

- The Emergency Worker Protection Plan and Procedures (Annex C to Part II of the DRNEP) states that "until notified otherwise, the Emergency Worker Centres shall enforce a maximum exposure limit of no more than 50 MSv." (At 3.1.1.) Emergency workers (other than police officers already issued personal protective equipment) must first report to the designated Emergency Worker Centres before entering an emergency response sector within the 10 km Primary Zone that is designated a colour representing above background levels of radiation. (Green is at or below background; Orange is background up to 5 mSv per hour; Red is over 5 mSv per hour.) Emergency workers include police, fire, works, transit, OPG and possibly others such as utilities. (Annex C) In sectors designated Orange, workers are to carry dosimeters, check them every hour, and leave the sector if a reading reaches 40 mSv or upon reaching four hours in the sector. In the Red zone, workers are to be accompanied by a knowledgeable escort; are to check dosimeters every 30 minutes, and shall leave after a maximum of one hour. (DNERP Annex C at 3.3.1) Workers report through the Emergency Worker Centres again on leaving the sector. There are default Sector Safety Status ratings for the outset of an emergency until data is available; safety status is to be updated hourly if there is an emission over land occurring in the Primary Zone. (Annex C at 3.2.3)

- Annex C to the Durham plan states that the maximum exposure limit "may only be exceeded in cases of extreme necessity (e.g. to save life or prevent serious injury) by **volunteers** who clearly understand the level of risk they will be facing. (Annex C at 3.1.3) It is not evident how volunteers will be obtained and how their understanding of the level of risk and consent to same is to be assured. Approval from the Regional Emergency Operations Centre must be obtained before emergency workers may be dispatched into a sector where the dose is likely above 50 mSv. (Annex C at 3.1.3)

- **RECOMMENDATION:** Risks of exceeding maximum exposure limits must be discussed with workers in advance of any accident. Methods to review risks and obtain consent to exceed those limits should be explicitly clarified in the Durham Plan. Similar provisions must be included in the Toronto Plan if it is intended that there may be emergency or other workers who volunteer to exceed maximum exposure limits.

- The IRSS report (page 58) referenced and encouraged implementation of the Fukushima Task Force report recommendation that there be additional dose limits established for workers both during and following emergencies in Canada. The Fukushima Task Force, 2011 also recommended (at 54) that the CNSC review the *Radiation Protection Regulations*, section 15 as to potential revisions to "ensure consistency with international guidance." Section 15 provides for the exceeding of applicable dose limits during control of emergencies, and these limits are far higher (ten times higher) than the limits otherwise applicable to workers as provided elsewhere in those *Regulations.* While this is not specific to the Pickering NGS, it is relevant to the context of emergency planning at any of the plants.

- **RECOMMENDATION:** The Fukushima Task Force / IRSS recommendations to establish additional dose limits for workers during and following nuclear emergencies in Canada should be addressed by the CNSC as soon as possible.

17. Frequency of practising emergency planning / drills

- The Ontario Solicitor General advised in its 1987 report to the Hare Commission that exercises were to be held yearly for each facility both onsite and offsite. It would appear from the evidence that this advice had been allowed to lapse at least as to offsite drills in the years since that statement. (See Hare 1988 Vol. 1 at page 227)

- OPG stated that it has conducted drills with offsite agencies in 2008, 2010 and 2012 (CMD 13-H2.1 at 64). However, the IAEA's IRSS Report to Canada (November – December 2011) recommended that Canada "conduct full scale emergency exercises on a periodic basis" (at pages 10 and 70.) The Fukushima Task Force Report, 2011, it noted that "the last full scale nuclear exercise in Ontario was in 2007." (at 46) It is evident then, that the drills OPG says it conducts with offsite agencies are not full scale nuclear exercises. The Task Force further stated that "federal and provincial nuclear emergency planning authorities are not making regularly scheduled full scale NPP exercises a priority." (At 52). This was echoed by the IRSS report which also called for full scale nuclear emergency planning drills to be conducted regularly. It indicated that this should include federal, provincial, municipal and licensee. (IRSS, Recommendation RF8)

- The CNSC's Fukushima Task Force Report, 2011, found that, "Emergency response organizations are capable of responding to single-unit, beyond-design-basis events. Evaluation and revision of emergency plans in regard to multi-unit accidents and severe external events, including an assessment of the minimum complement requirements, have not been performed. As a result, it has not been conclusively demonstrated that emergency response organizations will be capable of responding effectively in a severe event and/or multi-unit accident."(at 39) It also found that "the performance of the emergency response organization under severe event or multi-unit accident conditions has not been challenged by designing and conducting exercises that are based on such conditions." (at 40)

- The CNSC Staff CMD 13-H2.B referenced that a "Unified Response Exercise" is planned for May 2014 and stated that "work has begun on coordinating the interfaces" between the various agencies. (At 8). CELA notes that this exercise will be conducted two and a half years after the receipt of the 2011 Fukushima Task Force Report and three years after the Fukushima accident. CELA does not consider this time frame to be responsive to the Task Force criticism of insufficient prioritizing in Canada of such emergency planning exercises.

- **RECOMMENDATION:** CELA recommends that the CNSC should require annual conduct of exercises dealing with these types of full scale severe event or multi-unit accident scenarios for each plant along with conclusive demonstration of their effectiveness as a licence condition for Pickering in this application. Furthermore, the CNSC should require inclusion of members of the surrounding community and public interest organizations so as to increase input into and confidence in the results. CELA also recommends that their results should be made public, along with lessons learned, and improvements recommended as a result of the exercises; and that the CNSC should require reporting of implementation of those improvements on an annual basis as part of the oversight that it should undertake with respect to offsite emergency planning.

18. **Response time**
    - Capacity of operators and responders to respond and carry out all functions in a timely way for Beyond Design Basis accidents is a significant issue in terms of the effectiveness of emergency planning and preparedness. IAEA Safety Requirements GSR-R-2, "Preparedness and Response for a Nuclear or Radiological Emergency" states that "For facilities in threat category I or II

{which includes nuclear power plants} the threat assessment shall demonstrate for the range of postulated emergencies that identification, notification, activation and other initial response actions **can be performed in time** to achieve the practical goals (see para.2.3) of emergency response." (At Paragraph 4.26.) (Emphasis added). The practical goals in Para. 2.3 include among others, regaining control of the situation, preventing and mitigating consequences; and preventing health effects, both as to early injuries and as to long term effects such as cancers.

- In this respect, it should be noted in particular, that IAEA GSR-R-2 requires, in a section on mitigative action, that "Arrangements shall include emergency operating procedures and guidance for the operator on mitigatory actions for severe conditions, for the full range of postulated emergencies, **including accidents beyond the design basis**." (At paragraph 2.39.) (Emphasis added). However, there is no evidence that OPG has taken this approach, and as reviewed elsewhere in this report, has focussed its emergency planning on-site for design basis accidents.

- In particular, IAEA Guideline GS-G-2.1, "Arrangements for Preparedness for a Nuclear or Radiological Emergency" sets out Response Time Objectives (At Appendix VI, Table 12; pages 104-108). They are applicable for "selected critical response functions or tasks" for nuclear power plants and others. This IAEA Safety Standard states that they should be used as part of the performance objectives for a response capability and should be used as part of evaluation criteria for exercises.
- However, there is no evidence that these response time objectives have been established for the Pickering plant (or within the Durham NERP, the Toronto NERP or the provincial nuclear emergency response plan). Moreover there is no indication that they have been used or documented in emergency response evaluation; nor that the regulator, CNSC has required demonstration of response time objectives as part of its criteria in licensing the Pickering nuclear power plant.
- Some of the matters of particular concern to the surrounding community in the event of a severe, beyond design basis accident, as to capacity to respond in a timely manner, and which should therefore be demonstrated by the operator; and required by the regulator to be verified include, among others (from IAEA GS-G-2.1 Table 12):

- Classifying / declaring the emergency, within 15 minutes "from the time at which conditions indicating that emergency conditions exist are detected"
- Notifying local authorities in the Precautionary Action Zone and the Urgent Protective Action Planning Zone, within 15 minutes from the time of declaring the emergency
- Recommending urgent protective actions for the public on the basis of the emergency classification, within 30 minutes from the time of classifying / declaring the emergency.

- **RECOMMENDATION:** The response times required by these IAEA Safety Requirements and Guideline documents GS-R-2 and GS-G-2.1 should be included in the Provincial and municipal emergency plans for Pickering. In particular, the CNSC should require that these response times are met and demonstrated as part of its licensing decision for the Pickering NGS.

C. Safety –

There are a large number of extremely serious safety issues facing the NGS at Pickering. For these reasons, among others, CELA urges the CNSC not to grant the requested Licence to Operate to OPG. Rather CELA urges that the CNSC require OPG to provide a plan for an orderly closure and decommissioning of all of the units at Pickering. OPG is planning to operate the Pickering B reactor beyond the 210,000 "Equivalent Fuel Power Hours (EFPH) hours "assumed design life". (See E Docs 4057120 Submission of Technical Basis for Continued Operation of Pickering B Units 5-8 Pressure Tubes Dec. 14, 2012 OPG to M. Leblanc at p. 1). The plan to operate beyond the design life of the plant is of extremely serious safety significance. Some of the indications of the rapidly increasing safety risks include:

- Unexpected recent results include the discovery of slight bowing and a thicker black deposit than previously observed on fuel elements removed from the reactor (Dec 11 SCR report on Nov. 30 observations – Edocs 4052277)
- Ever more complex aging management requirements – for example see OPG Aging Management Process 2011 (E Docs 3832128) and OPG Integrated Aging Management (E Docs 3725316), Heat Transport System Aging Analysis with impacts on safety margins and increasing uncertainties along with need for additional

research and potential adjustments including to trip set points and operating constraints (E Docs 3588658).

- Adverse effects on the effectiveness of station shutdown systems as a result of aging (See CNSC submission March 2011 Regulatory Oversight Plan re Pickering B End of Life (E Docs 3669120, p. 11))
- Lack of two entirely independent shutdown systems at Pickering A (Pickering A 2010 Safety Report E Docs 3069405, p. 28)
- Shared Vacuum building and pressure relief duct between Pickering A and B stations in the context of an aging set of reactors (Pickering A 2010 Safety Report E Docs 3069405, p. 28)
- shared safety systems: emergency coolant injection and vacuum building (Pickering A Safety Report, p. 21)
- Probabilistic Safety assessments are inherently incomplete.[38]

D. Sufficiency of Information Base for Licensing

There are a number of areas where the information on critical issues is not complete, and is not necessarily expected to be available by the time of the Day Two Hearing. CELA submits that the Panel should not make a decision on extending the operation of the Pickering Plant beyond its design life without having this additional information.

- Examples of these deficiencies in the record include:
    - The not yet available update of the 2009 Pickering A PSA, particularly in respect of both internal and external events, including seismic, high winds, fires, floods and other hazards (See CMD 13-H2.B, CNSC Staff Supplementary Submission, at p. 5), now not expected until end of 2014 for certain elements rather than end of 2013.
    - The Pickering B updated PSA has been provided, but CNSC staff state they will not have completed a detail review of it until June, 2014; however CELA submits this staff review

[38] A list of reasons that Probability Risk Assessments cannot provide a complete assessment of accident risk was provided in the Working Group #8 Report: There are types of accidents that are often explicitly excluded such as those caused by earthquakes, fires, floods; there are types of initiating causes not considered because they are difficult to quantify e.g. deliberate hostile action; gross human error; there are combinations of events that escape consideration; there are many areas have no statistical or experimental data available and so reliance is placed on judgment; and there are calculated combinations of events put below a certain level of probability because they are considered "highly speculative" at those "low levels". (At 23.)

is essential information for the Panel prior to authorizing the extended operating life. (CMD 13-H2.B at p. 5)

- The Pickering B PSA results are not inclusive of all threats and hazards; for example they do not include in the quantitative results malfeasance or terrorism.
- OPG's supplementary submission (CMD 13-H2.1B at p. 11) states that a Nuclear Response Multi-Agency Reference Manual in respect of emergency planning to provide a "baseline of roles and responsibilities for external agencies" is in preparation and will be presented to the Commission at a meeting in August, 2013. This follows the scheduled completion of this hearing but CELA submits should be available prior to completion of this licence hearing as it is a matter of significant import for the relicensing.
- The lack of understanding the "black deposit" issue on discharged fuel bundles form Unit 1.
- The latest update of the Heat Transport System aging strategy (expected to be updated in 2015 for the period 2016-2020); CNSC staff reviews of preliminary assessments are not due until December 2013.
- The several units that lack Passive Autocatalytic Recombiners for hydrogen mitigation, (planned to be done in 2013 and 2014)
- Specific issues noted in the CNSC CMD13-H2 that must be satisfactory before proceeding: Steam Line Break (at p. 28); Channel Voiding during a Large Loss of Coolant Accident (at p. 28); review and acceptance of the results of the fuel-channel life cycle project that was due to be completed by March 2013 (at p. 87).
- Hazard Analysis, internal, external and malevolent including airplane crashes; completion of which is expected mid to end of 2013 (CMD13-H2 at p. 30).
- Hold points are planned in respect of regulatory oversight of aging of fuel channels (CMD 13-H2 at 42); specifically "four hold points for end of assumed design life of each of the Pickering B units." (at 87)
- The following selected Fukushima Action Items are outstanding as listed in OPG's CMD 13-H2.1B; they are of sufficient import that they should be resolved prior to issuance of the requested licence extension:
    - FAI 1.3.2 Where the existing means to protect Containment integrity and prevent uncontrolled releases

of radioactive products in beyond design basis accidents including severe accidents are found inadequate, a plan and schedule for design enhancements to control long term radiological releases and, to the extent practicable, unfiltered releases. December 2015.

- FAI 2.1.1 Re-evaluation, using modern calculations and state of the art methods, of the site specific magnitudes of each external event to which the plant may be susceptible. December 2013.

- FAI 3.1.2 For multi-unit stations, provide plans and schedules for the inclusion of multi-unit events in SAMGs. December 2013.

- FAI 3.2.1 An evaluation of the adequacy of existing modeling of severe accidents in multi-unit stations. The evaluation should provide a functional specification of any necessary improved models. December 2012.

- FAI 4.1.1 – An evaluation of the adequacy of existing

  Emergency plans and programs. December 2012.

E. Siting

- One of the key requirements of the IAEA Safety Requirements Site Evaluation for Nuclear Installations, NS-R-3 (2003), is to analyze "the characteristics of the population of the region and the capability of implementing emergency plans over the projected lifetime of the plant." (At 2). That document states that it is primarily concerned with low probability severe events. It states, "population growth and population distribution shall be monitored over the lifetime of the nuclear installation." (At 3.) It further states that, if after evaluation no measures can be taken to keep the "radiological risk to the population associated with accident conditions, including those that could lead to emergency measures being taken" acceptably low, then "the site shall be deemed unsuitable for the location of a nuclear installation of the type proposed." (Excerpts at 9.) The concern with the ability to implement an emergency plan is also emphasized in the new Draft IAEA Safety Standard "Safety Aspects in Siting for Nuclear Installations", DS433, October 10, 2011. (At 50)

- Given the existing population density in area of Pickering (as reviewed earlier in the discussion on evacuation), the Pickering NGS is no longer a suitable site for operation of a nuclear power plant; particularly for operation of a multi-unit station. As noted earlier, Durham Region's population as a whole as of 2009 was 614, 970; projected to grow to 949,100 by 2026, and within 40 km of the Pickering site were 3.2 million people back in 2001. These population numbers are too high to be located in close proximity to nuclear generating stations. [39] [40]

    - The Province of Ontario's Places to Grow process has continued to propose considerably increased population numbers for Durham over the coming year. The trends in population density show Durham region have increased and continuing to increase population density. As noted earlier, there are sectors around Pickering in which the estimates indicate that evacuation in certain conditions could take from 4 to 37 hours according to the DRNERP as reviewed above in the discussion with respect to evacuation.

    - Working Group # 8 in 1988 recommended that the province take appropriate action in "the advisability of restricting new housing construction near nuclear facilities." A similar recommendation was made by the Joint Review Panel in the Darlington New Build EA Report. It not now being possible to prevent this housing construction, and heavy population density having built up in the Pickering area, including both in the Cities of Pickering and Toronto (Scarborough), the CNSC should not authorize the further licensing of this plant beyond its design life and should not extend its operating license beyond 2014.

    - As outlined in the Pickering A and B Safety Reports, there is also a considerable workforce in the area. There are also major transportation routes of national importance that would be disrupted in the event of a

[39] Figure 2-3 in the Pickering B Safety Report, 2012 NK30-SR—1320-00001 Rev. 4 shows the population trends of Metro Toronto and Durham Region since the 1970s when the plant was originally cited. (P. 88 of 110)

[40] See also Page 89 of the Pickering A safety report – which provides a graph of demographic data in the broader circumference around the Pickering site.

severe accident at Pickering, including Highway 401, Highway 2 and the CN and CP Rail lines.

- In addition there are a large number of major airstrips and airports in the area.[41] The presence of this multiplicity of air traffic would both represent a major disruption of commercial aviation traffic in the event of a severe offsite accident at Pickering, and also poses an ongoing risk to the plant itself. IAEA Safety Guide NS-G-3.1 states that "the potential for aircraft crashes that may affect the plant site should be considered in the early stages of the site evaluation process and it should be assessed over the entire lifetime of the plant." (At 22).[42]

- The area is also the location of Canada's newest national (urban) park, as well as to a large number of recreational areas important to the GTA and especially the Scarborough and Pickering communities as listed in the Pickering A Safety Report.

- CELA submits that the Pickering site would never be authorized today for a new nuclear facility. For the same reasons, neither should it be granted a licence to operate beyond the design life of the Plant. CELA submits that the Pickering NGS no longer meets the safety expectations of the public nor of siting standards by its location in such a highly populated region as a result of which expeditious evacuation is not possible.

F. Re recommendations for community engagement

- In reviewing the materials relevant to emergency planning at the Pickering NGS and in Ontario generally, CELA noted that there is insufficient consultation with the public as to the choices made; and there is insufficient communication with the public as to the plans and their details once they are developed. It is a matter of significant concern as to the extent to which the public in both Durham Region and the City of Toronto is aware of, and engaged in providing input to the content of the nuclear emergency

[41] Pickering A Safety Report, Table 19

[42] IAEA Safety Guide NS-G-3.1, "External Human Induced Events in Site Evaluation for Nuclear Power Plants." (IAEA, 2002).

plans. This in itself increases the risks and potential consequences from a severe offsite accident at the Pickering nuclear plant.

- Many residents of Durham region are unaware of provisions in the Nuclear Emergency Response Plan that anticipate that they will find their own accommodation with friends and family in case of evacuation; that they may be asked to "self-decontaminate" in some scenarios, and what that means; that KI is effective only if taken before or immediately upon commencement of a release; they are unaware of the transportation plans that would be available if they do not have their own vehicles; and they are concerned about family reunification in the event of evacuation scenarios in which members of their family are evacuated separately from the family such as from schools and long term care institutions.

- IAEA Publication "Lessons Learned from the Response to Radiation Emergencies (1945 – 2010), (IAEA, August 2012) includes a comment in the chapter "providing information and issuing instructions and warnings to the public", about the importance of providing information to the public on protective actions to be taken in event of an emergency in **advance** of any emergency for threats such as Nuclear Power Plants. They stated that "This will engender confidence – the knowledge that the officials have their interest at heart – and, by doing so, improve compliance with protective action recommendations in the event of a real emergency. In addition, there will be a better understanding of the systems used to warn them of an emergency." (At 27) CELA agrees with this assessment but we do not see a sufficient level of advance communication with the public in the 10 km zone around the Pickering NGS, both within the Region of Durham and within the City of Toronto, to feel confident that people sufficiently understand the protective actions to be taken in the event of a Pickering NGS emergency. CELA recommends that the CNSC require extensive public engagement to be undertaken by OPG as a condition of any further operating licence of the Pickering NGS, to include specific explanation of the protective actions that may be required, why, and how they would be communicated and in what eventualities.

- This recommendation is reinforced by the comment in ICRP Publication 109[43] which recommends engagement with stakeholders and discussions of the plans, including with members of the public. The rationale is that "Otherwise, it will be difficult to implement the plan effectively during the response. The overall protection strategy and its

[43] International Commission on Radiological Protection, "Application of the Commission's Recommendations for the Protection of People in Emergency Exposure Situations", (ICRP Publication 109, 2008)

constituent individual protective measures should have been worked through with all those potentially exposed or affected, so that time and resources do not need to be expended during the emergency exposure situation itself in persuading people that this is the optimum response." (at 42)

G. REGULATORY OVERSIGHT: DECISION OF THE CNSC IN THIS APPLICATION

CELA urges the CNSC to exercise its role as regulator in respect of emergency planning in response to Nuclear Power Plant accident threats at the Pickering station. CELA urges the CNSC to exercise a stringent oversight role as to whether emergency planning and preparedness have been proven prior to exercising its discretion to provide a further operating licence to the Pickering NGS.

- The IAEA Standard, Preparedness and Response for a Nuclear or Radiological Emergency, Series No. GS-R-2, Safety Standards (Vienna: IAEA, 2002) sets out expectations as to the responsibility of the regulator. A more complete copy of this excerpt is provided as Appendix A to this submission. It is the regulator's responsibility, among other things, to do the following (excerpts from GS-R-2 paragraphs 3.8 to 3.12:
    - The regulatory body shall require that arrangements for preparedness and response be in place for the on-site area for any practice or source that could necessitate an emergency intervention.
    - The regulatory body shall ensure that such emergency arrangements are integrated with those of other response organizations.
    - The regulatory body shall ensure that such emergency arrangements provide a reasonable assurance of an effective response, in compliance with these requirements, in the case of a nuclear or radiological emergency.
    - The regulatory body shall require that the emergency arrangements "shall be tested in an exercise before the commencement of operation [of a new practice]. There shall thereafter at suitable intervals be exercises of the emergency [arrangements], some of which shall be witnessed by the regulatory body."
    - In fulfilling its statutory obligations, the regulatory body… shall establish, promote or adopt regulations and guides upon which its regulatory actions are based;… shall provide for issuing, amending, suspending or revoking authorizations, subject to any necessary conditions, that are clear and unambiguous and which shall specify (unless

elsewhere specified):… the requirements for incident reporting;…and emergency preparedness arrangements.
- In planning for, and in the event of [a nuclear or radiological emergency], the regulatory body shall act as an adviser to the government.
- The regulatory body shall ensure that the co-ordinated arrangements are implemented adequately by the operators.

- The Fukushima Task Force 2011 discussed the lack of specific regulatory requirements for operators for emergency planning and the lack of specific and detailed requirements as well as the lack of sufficient regulatory oversight given the gap in the regulatory framework. (CNSC Fukushima Task Force Report 2011 at 40). CELA concurs with this concern, as in reviewing G-225 "Emergency Planning at Class I Facilities and Uranium Mines and Mills" and RD-353, "Testing the Implementation of Emergency Measures", we observed that the requirements were too high-level and non-specific to provide useful measures against which the nuclear emergency plans applicable to an accident at Pickering could be compared and tested. The Fukushima Task Force reiterated this concern in its chapter reviewing the Canadian nuclear regulatory framework in view of lessons learned from the Fukushima accident. It again stated that the CNSC should require offsite emergency plans to be submitted along with applications to construct or operate nuclear power plants. (At 53).

- The Fukushima Task Force report stated that: ``Federal and provincial nuclear emergency planning could be strengthened through establishing a formal, transparent, national-level oversight process for offsite nuclear emergency plans, programs and performance, and through scheduling of regularly planned full-scale exercises.``[44] The IRSS report noted these Fukushima Task Force made recommendations that the CNSC should require the submission (to the CNSC) of the provincial nuclear emergency response plans. The IRSS report encouraged this to be done. (At 58) In the presentation by CNSC at the March, 2013 inter-jurisdictional emergency planning workshop, the responsibility of regulators to ensure emergency response capability and these Fukushima Task Force and IRSS recommendations were also noted.

- The IRSS report (conducted of CNSC from Nov 26 to Dec 2, 2011) also noted that there are a multiplicity of agencies and levels of government with responsibilities in nuclear emergency planning in Canada and recommended that the CNSC should "verify the requirements and

[44] (CNSC Fukushima Task Force Report, CNSC INFO-0824, October 2011 at iv, v)

standards described in the offsite emergency plans are met, through tests and assessments." (at page 59)

- **RECOMMENDATION:** CELA submits that the CNSC should not grant the licence to OPG beyond the current licence period without verifying "through tests and assessments" the adequacy of the emergency plans in place for the Pickering NGS, both on-site and off-site, to respond to severe nuclear emergencies.

- **RECOMMENDATION:** CELA submits that even without additional regulatory amendments recommended by the Fukushima Task Force and the IRSS, the CNSC already has jurisdiction to consider the adequacy of the emergency plans in place at Pickering in deciding whether to issue the licence requested, and/or whether to impose additional requirements by way of licence conditions to better protect health, safety and the environment. (Sections 3, 9, 24 of the *Nuclear Safety and Control Act*, S.C., 1997, c. 9)

- **RECOMMENDATION:** CELA urges that the Fukushima Task Force recommendations for CNSC oversight of the offsite nuclear emergency response plans be pursued forthwith by way of amendment of the CNSC regulations and requirements there-under. This particularly includes the recommendation for description of the regulatory requirements to address radioactive hazards during an emergency **in greater detail**. This also includes the recommendation of the Task Force to enhance regulatory oversight with periodic safety reviews and to increase requirements for "requirements and expectations for both design basis and beyond design basis accidents``. (Task Force at v).

H. Conclusion and Recommendations

- **RECOMMENDATION 1:** CELA submits that this licence should not be granted until all of the measures list by OPG in its application in Appendix 6, along with other recommendations made by the 2011 IRSS Report, the 2011 CNSC Fukushima Task Force and recommendations herein are actually in place and demonstrated to the regulator, with evidence, to be effective. CELA also submits that it is critical that this evidence be made public. Members of the surrounding communities must be able to understand what is in place; how effective it is; what has changed; and on what basis the regulator is judging the emergency plans to be in place.

- **RECOMMENDATION 2:** CNSC should require multi-unit severe accident planning to be demonstrated by OPG, along with the effectiveness of off-site emergency response in such a case. Similarly, CNSC should ensure, contrary to previous practice, that extreme natural hazard initiated events and "gross human error" are also examined in terms of presenting an emergency planning basis, and that the on-site and off-site emergency preparedness and planning are demonstrated to be sufficient and reliable to respond to all of these undesirable scenarios in the event that they lead to severe offsite releases.

- **RECOMMENDATION 3:** CELA recommends that this post-accident source term information be required by the CNSC as a condition of licensing and that the CNSC require OPG to upgrade their capacity to provide source term information and its basis, for multi-unit accidents, as a condition of the Pickering NGS licence. This should include reassessment of plume and dose modelling for multi-unit accidents at the Pickering NGS as recommended by the Fukushima Task Force.

- **RECOMMENDATION 4:** CELA recommends that the CNSC should require the licensees to demonstrate that there are, in place, properly resourced, sufficiently detailed emergency planning and preparedness plans that would address Chernobyl–size accidents or Fukushima–size accidents. The basis for this recommendation includes world-wide experience with these catastrophic accidents. This recommendation is independent of particular event sequences and rather takes account of the myriad ways that things that can go wrong resulting in an accident and resulting in a serious breach of containment, regardless of how caused. It also includes consideration of the fact that among the events that may initiate a catastrophe at a CANDU are those that are beyond the control of the operator such as hostile action or unforeseen external weather events or unforeseen combinations of failures including human error.

- **RECOMMENDATION 5:** The authority of Toronto Emergency Planning Officials to immediately initiate the Public Alerting System upon receipt of a notification from OPG for a general emergency with an imminent or ongoing emission should be clearly specified. If it is not intended that this authority be provided to Toronto's officials under the TNERP, this should be stated with a rationale for the discrepancy compared to the DRNERP.

- **RECOMMENDATION 6:** CELA recommends that the CNSC refuse further extension of Pickering's operating licence without the 3 km and 10 km alerting systems fully functional, both within the Region of Durham and within the City of Toronto, with robust evidence that they have been fully tested and are effective to meet the objectives specified in the PNERP, 2009.

- **RECOMMENDATION 7:** CELA also recommends that the emergency response plans time-frames be compressed so as to provide alerts to the public, and instructions to the public on protective actions required in as short a time frame as possible, preferably less than 30 minutes from the onset of the accident. Methods to compress this time frame should be considered and tested, and their efficacy should be one of the points of evaluation by the CNSC in the licence applications by the operators.

- **RECOMMENDATION 8:** CELA recommends that as an interim measure, the CNSC should require that OPG in conjunction with the City of Toronto, conduct outreach and notification to members of the public resident in Toronto (at a minimum within the Primary Zone), as to the availability of KI and provide advice as to where it may be obtained.

- **RECOMMENDATION 9:** The applicability of Durham's Annex D to the residents of Toronto in the Primary Zone must be clarified. Alternatively, the same provisions for KI distribution, consent and information letters for school age children, and other matters dealt with in Annex D must be specified in the TNERP.

- **RECOMMENDATION 10:** CELA recommends that the CNSC should require the operator to systematically evaluate and report back to the CNSC the percentage of households within the 10 km Primary Zone, both within the Region of Durham and the City of Toronto, who have obtained KI tablets in advance, as well as the percentage of institutions covered by the plan who have them on hand in sufficient quantities to cover all of their residents or students. Based on this evaluation, CELA recommends that the CNSC require the approach that was taken in France be taken in Canada for the 10 km zone around each operating nuclear generating station, to undertake and ensure 100% pre-distribution of KI tablets to the residents in the Primary Zone and that this requirement be included in the licensing conditions for the Pickering NGS.

- **RECOMMENDATION 11:** CELA recommends that the CNSC require OPG to include in its outreach material to the public, in conjunction with regional emergency response officials, explanations about the capability of sheltering and its limitations as described in the IAEA Guide GS-G-2.1 and to reinforce instructions as to steps to take for rapid and effective evacuation in the case of notification of a significant emergency.

- **RECOMMENDATION 12:** CELA recommends that the Pickering Operating licence should not be extended without the Provincial Radiation Health Response Plan and the municipal Radiation Health Response Plans in place.

- **RECOMMENDATION 13:** CELA recommends that in view of the experience at Chernobyl and Fukushima, the CNSC should request that the province immediately revisit the 50 km secondary ingestion zone with a recommendation to change it to 100 km. This should be done as part of detailed planning for severe offsite accidents so that appropriate monitoring of food, agricultural products, milk, and water is established and in place in the event of such an accident.

- **RECOMMENDATION 14:** CELA recommends that the CNSC require that the nuclear emergency planning zones be expanded. CELA submits that the 10 km Primary zone should be extended to 30 km and the 50 km Secondary zone should be extended to 100 km.

- **RECOMMENDATION 15:** CELA recommends that the CNSC should require OPG to work with the local municipalities to ensure the public clearly understands what plans are in place to assist them with evacuation from the Primary Zone if they do not have their own transportation. The details of those plans should be clearly specified in the Durham and Toronto Nuclear Emergency Plans, and widely communicated to the public in outreach and education.

- **RECOMMENDATION 16:** CELA recommends that the CNSC should require OPG to communicate to the public in annual outreach and education, the fact that the nuclear emergency response plans expect the public to make their own arrangements in the event of evacuation, and for those who cannot, what is expected to be provided by the municipalities. The appropriateness of this approach should further be discussed with the public in terms of future nuclear emergency planning.

- **RECOMMENDATION 17:** CNSC should require OPG to conduct studies and to work with offsite emergency responders, the municipalities and the Province to ensure that there are realistic evacuation plans in the case of a severe accident with early large release, as well as in the case of plans for twenty kilometer and 50 kilometer evacuation zones around the Pickering NGS.

- **RECOMMENDATION 18:** CELA recommends that the CNSC require the applicant to conduct a study as to the awareness of the Pickering Nuclear Plant of people beyond the Primary Zone at Pickering, and as to their likely response in the event that a general emergency is declared and the Primary Zone is evacuated. The CNSC should require the applicant to evaluate the impact of increased evacuation zones of twenty and fifty kilometers on evacuation time estimates, as well as any other needed adjustments that would result from larger evacuation zones to the emergency plans surrounding Pickering such as locations of Emergency Workers Centres, numbers of emergency workers required for evacuation management, traffic routes, size of evacuation centres, and locations and capacity of Decontamination and Monitoring Units, and to report its findings to the CNSC and to the provincial EMO, the City of Toronto, and the Region of Durham.

- **RECOMMENDATION 19:** CELA recommends that CNSC direct the applicant to work with the municipalities to consult with the surrounding communities on specific plans for family reunification following evacuation in the event of a severe nuclear emergency.

- **RECOMMENDATION 20:** Explanations about what "self-decontamination" means; how to do so; and a statement as to its efficacy should be included in the Toronto Nuclear Emergency Response Plan and in outreach and education to the public about implementation of the plan.

- **RECOMMENDATION 21:** The CNSC should confirm that OPG's automatic gamma monitoring is in place at Pickering, and require the automatic exchange of its data with the regulator as suggested by the IRSS and Fukushima Task Force reports.

- **RECOMMENDATION 22:** CELA recommends that the CNSC request that the Provincial Nuclear Emergency Plan expand its monitoring provisions and

ingestion control zones to a distance of 100 km from the NGS, and that the province undertake appropriate measures to ensure that monitoring can be done following an accident within that 100 km zone for agricultural produce, foodstuffs, milk and water.

- **RECOMMENDATION 23:** CELA recommends that the DNERP, 2011 should explicitly outline the measures in respect of controlling ingestion food and water that may be required in the case of a severe nuclear emergency of the type outlined in ICRP Publication 109.

- **RECOMMENDATION 24:** Risks of exceeding maximum exposure limits must be discussed with workers in advance of any accident. Methods to review risks and obtain consent to exceed those limits should be explicitly clarified in the Durham Plan. Similar provisions must be included in the Toronto Plan if it is intended that there may be emergency or other workers who volunteer to exceed maximum exposure limits during an emergency.

- **RECOMMENDATION 25:** The Fukushima Task Force / IRSS recommendations to establish additional dose limits for workers during and following nuclear emergencies in Canada should be addressed by the CNSC as soon as possible.

- **RECOMMENDATION 26:** CELA recommends that the CNSC should require annual conduct of exercises dealing with full scale severe event multi-unit accident scenarios along with conclusive demonstration of their effectiveness as a licence condition for the Pickering NGS. Furthermore, the CNSC should require inclusion of members of the surrounding community and public interest organizations so as to increase input into and confidence in the results. CELA also recommends that their results should be made public, along with lessons learned, and improvements recommended as a result of the exercises; and that the CNSC should require reporting of implementation of those improvements on an annual basis as part of the oversight that it should undertake with respect to offsite emergency planning.

- **RECOMMENDATION 27:** The response times required by these IAEA Safety Requirements and Guideline documents GS-R-2 and GS-G-2.1 should be included in the Provincial and municipal emergency plans for Pickering. In particular, the CNSC should require that these response times are met and demonstrated as part of its licensing decision for the Pickering NGS.

- **RECOMMENDATION 28:** CELA submits that the CNSC should not grant the licence to OPG beyond the current licence period without verifying "through tests and assessments" the adequacy of the emergency plans in place for the Pickering NGS, both on-site and off-site, to respond to severe nuclear emergencies.

- **RECOMMENDATION 29:** CELA submits that even without additional regulatory amendments recommended by the Fukushima Task Force and the IRSS, the CNSC already has jurisdiction to consider the adequacy of the emergency plans in place at Pickering in deciding whether to issue the licence requested, and/or whether to impose additional requirements by way of licence conditions to better protect health, safety and the environment. (Sections 3, 9, 24 of the *Nuclear Safety and Control Act*, S.C., 1997, c. 9)

- **RECOMMENDATION 30:** CELA urges that the Fukushima Task Force recommendations for CNSC oversight of the offsite nuclear emergency response plans be pursued forthwith by way of amendment of the CNSC regulations and requirements there-under. This particularly includes the recommendation for description of the regulatory requirements to address radioactive hazards during an emergency **in greater detail**. This also includes the recommendation of the Task Force to enhance regulatory oversight with periodic safety reviews and to increase requirements for "requirements and expectations for both design basis and beyond design basis accidents``.

I. Decision Requested:

CELA requests that the CNSC not issue the licence requested by OPG to operate the Pickering Units A and B for a further five years. Rather, CELA requests that the CNSC order OPG to prepare an application for the orderly closure and decommissioning of the Pickering Nuclear Generating Station.

All of which is respectfully submitted this 3rd day of May, 2013:



CANADIAN ENVIRONMENTAL LAW ASSOCIATION

Per

Theresa A. McClenaghan

Executive Director and Counsel

Appendix A – Excerpt from IAEA GS-R-2 "Preparedness and Response for a Nuclear or Radiological Emergency, Series no. GS-R-2, Safety Standards (Vienna: IAEA, 2002).

"3.8. **The regulatory body shall require** that arrangements for preparedness and response be in place for the on-site area for any practice or source that could necessitate an emergency intervention. For a facility in threat category I, II or III "Appropriate emergency [preparedness and response] arrangements shall be established from the time that nuclear fuel [or significant amounts of radioactive or fissile material] is brought to the site, and complete emergency preparedness as described here shall be ensured before the commencement of operation." (Ref. [12], Para. 2.36.) **The regulatory body shall ensure that such emergency arrangements are integrated with those of other response organizations as appropriate before the commencement of operation**. **The regulatory body shall ensure that such emergency arrangements provide a reasonable assurance of an effective response, in compliance with these requirements, in the case of a nuclear or radiological emergency. The regulatory body shall require that the emergency arrangements "shall be tested in an exercise before the commencement of operation [of a new practice]. There shall thereafter at suitable intervals be exercises of the emergency [arrangements], some of which shall be witnessed by the regulatory body."** (Ref. [12], para. 2.37.)
3.9. **"In fulfilling its statutory obligations, the regulatory body… shall establish, promote or adopt regulations and guides upon which its regulatory actions are based;… shall provide for issuing, amending, suspending or revoking authorizations, subject to any necessary conditions, that are clear and unambiguous and which shall specify (unless elsewhere specified):… the requirements for incident reporting;… and emergency preparedness arrangements**." (Ref. [10], para. 3.2.)
3.10. "In planning for, and in the event of [a nuclear or radiological emergency], the **regulatory body shall act as an adviser to the government** and [response organizations] in respect of nuclear safety and radiation protection." (Ref. [10], para. 6.6.)
3.11. The national co-ordinating authority and the response organizations shall ensure that the arrangements for response to a nuclear or radiological emergency are co-ordinated with the arrangements for response to conventional emergencies. The **regulatory body shall ensure that the co-ordinated arrangements are implemented adequately by the operators**.
3.12. In the event of a nuclear or radiological emergency the time available for decision making and for implementing an effective strategy for response may be short. It is therefore important that an appropriate management system be used. All organizations that may be involved in the response to a nuclear or radiological emergency shall ensure that appropriate management arrangements are adopted to meet the timescales for response throughout the emergency. Where appropriate, the management system shall be consistent with that used by other response organizations in order to ensure a timely, effective and co-ordinated response." **(Emphasis added)**



Grinding to a Halt:

Evaluating Canada's Worst Bottlenecks

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January 2017

Acknowledgments

This study was conducted by CPCS on behalf of the Canadian Automobile Association. The study's analysis relied on a variety of data sources. Notably, the vehicle speed data were provided by HERE North America, LLC (HERE), a leading supplier of digital maps, location-based services and traffic management data. Traffic volume data were provided by various provincial and local government departments of transportation.

The CPCS team would like to thank the CAA for commissioning the study as well as HERE and the government departments that provided the data necessary for our analysis.

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Executive Summary

This Study, the first of its kind in Canada, collected and analyzed speed and volume data on highways in urban areas across the country to identify the worst highway bottlenecks across the country. Specifically, we collected and analyzed data from the following Census Metropolitan Areas (CMA) for this purpose: Vancouver, Calgary, Edmonton, Regina, Winnipeg, Toronto (including the Hamilton and Oshawa CMAs), Ottawa, Montreal, Quebec City and Halifax.

How this study is different from others

While other studies have attempted to estimate congestion levels at the city or region-wide level, this Study is unique in that it identifies and compares congestion levels on specific stretches of highway across Canada. These bottlenecks were identified as stretches of highway that are routinely and consistently congested throughout the course of a weekday, as opposed to stretches that are congested only at limited times of day or days of a week. To identify the bottlenecks, we compared actual average hourly speeds to a baseline speed on each segment for each hour of the day. This Study uses a baseline speed which makes our estimate of the congestion costs associated with the top bottlenecks conservative relative to other studies that have calculated congestion costs region-wide. A key point is that this methodology is applied consistently across all urban areas, allowing for a comparative ranking of top bottlenecks across the country.

Canada's Worst Bottlenecks

Canada's worst highway bottleneck is the stretch of Highway 401 that cuts across the north part of the City of Toronto. This bottleneck alone costs commuters over 3 million hours annually. In total, five of the top ten bottlenecks are found in the Toronto area. The stretch of Highway 40 into downtown Montreal is the third worst bottleneck in the country, costing commuters nearly 2 million hours of delay annually. Although the City of Vancouver does not have non-signalized highways serving the downtown core, stretches of two main arteries (Granville St. and West Georgia St.) are congested enough to fall within the top ten bottlenecks in the country.

Our estimates of total delay are significantly impacted by the choice of the baseline speed to which actual speeds are compared. For example, we selected the main artery that serves Vancouver's downtown core in order to make the results broadly comparable to Canada's other large cities, despite the fact that it is signalized. These and other main arteries have significantly lower maximum speeds and throughput potential than limited access highways. As such, our estimate of total delay on these arteries are much lower than they would have been if they were compared with the throughput potential of a limited access highway. In other words, although the ranking of the Vancouver bottlenecks are not as severe as they are in Toronto and Montreal, the actual vehicle speeds that drivers experience into and out of

downtown Vancouver are in fact as bad as or worse than they are in those two cities.

Region-Wide Congestion

Although calculating region-wide congestion measures is not the primary focus of this Study, our data also allows for developing such measures. In order to do so, we calculated Travel Time Indices (TTI) for each of the urban areas that were included in our dataset. The TTI is the travel rate during a specified period of time relative to the travel rate in free-flow conditions. For example, if it takes 45 minutes to travel between points A and B during the morning peak and it takes 30 minutes to travel between the same points during free-flow conditions, the TTI is 45 / 30 = 1.50.

The TTI can be used to estimate how much the typical motorist's commute time would be reduced in each city if free-flow conditions prevailed (noting the free-flow conditions at all hours is not a reasonable expectation).

Unsurprisingly, the typical Toronto area motorist spends the most additional time per day relative to a two-way 60 minute free-flow commute. In typical peak period traffic conditions, what would be a 60 minute two-way commute becomes a 96 minute commute (for 36 additional minutes in total). Hamilton (which is part of the Greater Toronto and Hamilton Area) appears next (25.3 minutes), followed by Montreal (24.2 minutes) and Vancouver (24 minutes).

Comparison With US Bottlenecks

Compared with US bottlenecks, the 401 bottleneck ranks among the top ten (Canada and US combined), while Montreal's top bottleneck ranks among the top 20. In terms of total hours of delay, the 401 bottleneck compares with the worst bottlenecks in the New York metro area, while the Highway 40 bottleneck compares with the worst bottleneck in Boston.

Acronyms

AADT	Average Annual Daily Traffic
AHUA	American Highway Users Alliance
ATRI	American Transportation Research Institute
CMA	Census Metropolitan Area
DVP	Don Valley Parkway (or Don Valley Parking Lot)
FFS	Free-Flow Speed
FHWA	US Federal Highway Administration
GIS	Geographic Information Systems
GTHA	Greater Toronto and Hamilton Area
HCM	Highway Capacity Manual
HOV	High Occupancy Vehicle
MTS	Maximum Throughput Speed
VKT	Vehicle Kilometres Travelled

Key Messages

- This Study, the first of its kind in Canada, identifies the worst highway bottlenecks across the country.
- These bottlenecks were identified as those stretches of highway that are routinely and consistently congested throughout the course of a weekday, as opposed to stretches that are congested only at limited times of the day or days of a week.
- Canada's worst highway bottleneck is the stretch of Highway 401 that cuts across the north part of the City of Toronto. This bottleneck alone costs commuters over 3 million hours annually. In total, five of the top ten bottlenecks are found in the Toronto area.
- The stretch of Highway 40 into downtown Montreal is the third worst bottleneck in the country, costing commuters nearly 2 million hours of delay annually.
- Although the City of Vancouver does not have non-signalized highways serving the downtown core, stretches of two main arteries (Granville St. and West Georgia St.) are congested enough to fall within the top ten bottlenecks in the country.
- Compared with US bottlenecks, using a similar methodology, the 401 bottleneck ranks among the top ten (Canada and US combined), while Montreal's top bottleneck ranks among the top 20.
- In terms of total hours of delay, the 401 bottleneck compares with the worst bottlenecks in the New York metro area, while the Highway 40 bottleneck compares with the worst bottleneck in Boston.
- Although it is not the primary purpose of the Study, our data also allows for developing region-wide congestion measures. According to these measures, what would be a 60 minute two-way commute in free-flow conditions becomes a 96 minute commute in the Toronto area, an 84.2 minute commute in Montreal and an 84 minute commute in Vancouver.

Project Objective

Traffic congestion studies often publish region-wide estimates of congestion. These aggregated estimates are helpful for comparisons between cities [1, 2]. However, alleviating congestion requires a more detailed understanding of precise bottlenecks or chokepoints, to enable specific targeted interventions. The American Highway Users Alliance (AHUA) recently commissioned such a study of bottlenecks on US highways, garnering nationwide policy and media attention [3].

The objective of this Canadian National Bottleneck Study ("Study") is therefore to identify and rank the top highway congestion bottlenecks, the first of its kind to do so in Canada. Specifically, we collected and analyzed data from the following urban areas for this purpose: Vancouver, Calgary, Edmonton, Regina, Winnipeg, Toronto, Ottawa, Montreal, Quebec City and Halifax. The Study estimates the impacts of congestion for major bottlenecks in terms of time (hours lost), monetary cost (economic opportunity cost of the lost time), and environmental effects (excess fuel consumption, total CO2 emissions). This nationwide analysis of Canadian highway bottlenecks will help policymakers further investigate and develop solutions for those locations where congestion is the most severe.

Purpose of this Report

In this report, we summarize the approach we followed to identify the major highway bottlenecks. We discuss the concept of congestion and its effects, the Study methodology, how it differs from other studies, and the congestion impacts of the major bottlenecks.

Study Key Questions

At the start of the project, we developed a number of key questions to help guide the Study effort. These questions shaped how we looked at the data, and how we present the results. The key questions are:

- What are highway bottlenecks?
- How do we measure congestion?
- What causes highway congestion?
- What are the effects of congestion?
- Why study congestion now?
- Which roads should we include?
- How should the results of this Study be used?
- How should we identify, classify, and rank bottlenecks nationally?
- What are the specific impacts of these bottlenecks, and the potential benefits of alleviating them?

What are highway bottlenecks?

Bottlenecks are severe traffic chokepoints where demand far exceeds available highway capacity. As an example, the United States Federal Highway Administration (FHWA) states that recurring bottlenecks account for the largest share of road delay in the US (40%), far exceeding traffic incidents (25%), inclement weather (15%), construction (10%) or other causes.[4] This Study focuses on recurring bottlenecks in major urban areas across Canada. Note that we primarily examine highways (all limited-access expressways, a few signalized highways) in this Study, leaving out local roads and highway access roads and ramps. Highways are our primary focus because in most urban areas the majority of vehicle kilometers travelled (VKT) occur on highways. Furthermore, free-flow and maximum throughput speeds (MTS) are generally similar across highways, whereas free-flow speeds (FFS), or the average speed at which motorists would travel if there was no congestion or other adverse conditions (such as construction or poor weather), and MTS vary considerably across arterial, collector and local roads. As such, the choices regarding the calculation of free-flow speeds and MTS will heavily influence any comparisons across different road types, rendering the comparisons less objective.

We think of highway bottlenecks as stretches of highway that are routinely and consistently congested. The delays in these stretches are generally more than just a peak-period or rush hour problem. The large number of vehicles passing through bottlenecks experience severe delays, over the 24-hour course of a weekday. Even though bottlenecks are commonly associated with gridlocked conditions, there are many stretches of highway where even minor delays of a few minutes per vehicle add up across the many vehicles traveling those stretches. For example, in its 2014 Cost of Congestion report, the American Transportation Research Institute (ATRI) determined that 89% of truck-related congestion costs were associated with only 12% of the road miles. The case for passenger vehicles is analogous. In fact, in this Study we examined traffic flows and speeds on approximately 3,000 kilometres of highways across Canada, but the total length of the top 20 bottlenecks found is only 65 kilometres.

How do we measure congestion?

A key component of congestion measurement is the baseline speed to which actual speeds are compared. When motorists experience congestion they are likely comparing their actual travel speed to FFS. However, the use of free-flow conditions as a baseline for congestion cost estimates, while practical and familiar, has been questioned by practitioners. Rather, practitioners are interested in the level of "excess" congestion. Economic measures of congestion identify congestion costs and benefits from the reduction of congestion. "Optimal" congestion is the congestion level that would remain after excess congestion was eliminated. This optimal congestion level would vary considerably by time and place. Because

achieving free-flow speeds at all times of day is simply not practical in most urban areas, economists have warned against the use of free-flow as a baseline.

We can see the existence of optimal congestion at work in the form of lineups for many goods and services provided by the private sector (e.g., morning lineups at popular coffee shops, lineups for popular rides at amusement parks). The market response comes in the form of a combination of higher prices for the desired services (generally limited by competitive forces) and an increase in capacity to meet demand. But lineups still persist because it would typically be too expensive to increase fixed capacity to completely eliminate the difference between peak and off-peak period demand. In other words, the users themselves do not see the value of doing this, relative to the costs of doing so. The private service provider makes investment decisions based on the signals given by the lineups, and the willingness-to-pay of customers for faster services balanced against the costs of capacity increases at peak times.

Developing baseline travel speeds based on optimal congestion levels, however, is challenging. True marginal congestion pricing would vary by time and place, depending on individual tolerances for congestion levels and the cost of mitigating congestion with investment in capacity or other remedies.

As such, studies that attempt to measure congestion costs often rely upon rough estimates of optimal travel speeds, based for example on a fraction of observed FFS. Our Study uses the MTS as the baseline speed, which in turn is estimated from FFS, using familiar methodology from the Highway Capacity Manual (additional details are provided in Appendix A). While MTS is not technically an optimal speed, it is likely much closer to the optimal speed than FFS. Furthermore, the use of MTS as a baseline speed is intuitively easy to understand, as it technically represents the speed at which throughput is maximized on the road network. In other words, it's the speed that allows the largest volume of motorists to use a highway at any given time.

We also note that our method of estimating FFS itself (also described in Appendix A) is more conservative than what has been used by some other studies. Further, we acknowledge that there are other potential costs of congestion that are not included in our analysis. For example, while our actual speeds are based on average speeds in each hour of the day, there is naturally some variability in these speeds from day-to-day, making travel times less predictable. This variability likely adds a cost of congestion that is not captured by the delay costs based on average speeds.

These factors combined with the use of the MTS (as opposed to FFS) as the baseline speed makes our estimate of the congestion costs associated with the top bottlenecks a conservative measure. A key point is that this methodology is applied consistently across all urban areas, allowing for a comparative ranking of top bottlenecks across the country.

We also note that FFS, while usually related to the posted speed limit, do not necessarily equal the posted speed limit. Because FFS is based on true observations of actual travel speeds during off-peak (non-congested) periods, FFS may be higher or lower than the posted speed limit, depending on the characteristics of the specific roadway under observation.

What causes highway congestion?

Congestion is a mismatch between highway capacity and demand. In other words, congestion occurs when there are many more motorists attempting to drive a stretch of highway than the available capacity of that stretch. Under these conditions, motorists are forced to reduce speed to accommodate a larger number of vehicles. In addition to the number of vehicles, highway design features such as merging lanes, ramps, and reduced visibility around curves also contribute to congestion as they cause drivers to quickly decrease speed. Weather, visual distractions, accidents, construction and maintenance, and special events may further affect the smooth flow of vehicles. In most cases, these factors do not operate in isolation; a number of them interact to exacerbate congestion [5].

What are the effects of congestion?

Congestion increases the time it takes to get from point A to B, what we commonly refer to as "delays". The lost time impacts both quality of life for individuals and the overall economy. Motorists and passengers give up productive work hours, and precious personal and family time. When trucks are stuck in traffic, the goods they are moving become more costly to businesses and consumers. The lost productivity from delayed passenger trips and freight deliveries harms regional and national economic competitiveness. Along with delays, congestion increases fuel consumption and greenhouse gas emissions. Vehicles idling in traffic consume far more fuel than they otherwise would. And by extension, vehicles emit more greenhouse gases in congested conditions.

Why study congestion now?

Transportation planners have long relied on computer models to predict how passenger cars and trucks would use the highway system, and would design the system accordingly. A number of planning and engineering studies informed these designs, but the costs and effort required made these infrequent. More importantly, there is a missing feedback loop on the difference between the predictions and how drivers actually use the system. This Study is an example of how empirical data, i.e. real-time system wide observations, can close the gap and provide a much-needed feedback loop for both highway planning and operations.

Many public and private actors in the transportation community are now routinely collecting data on traffic and system-wide conditions. Improved sensors and other information and communications technologies have significantly lowered the costs of collecting, storing and sharing these data, popularly called "big data". The collection of real-time probe data from smartphones, personal navigation devices (PNDs) and vehicles provides rich insights on highway speeds, a major input into congestion analysis.

This empirical approach – using data and observations as inputs into models, instead of outdated assumptions - is a substantial improvement over previous analyses of congestion. In fact, the new GPS probe-based data enables more accurate and precise identification of highway bottlenecks. Collecting data year-round enables analysts to hone in on the stretches of highway that routinely experience low speeds, leading to congestion. In sum, the frequency, low-cost, and high reliability of new traffic and speed data dramatically improve our understanding of congestion, and enables congestion analyses to be repeated often.

Which urban roads do we include?

The geographical focus is on urban expressways and some key signalized highways as well as urban arterials. We defined urban areas using the limits of the Census Metropolitan Areas (CMA) for the cities shown in Figure 1. The figure also summarizes their population in 2015 and the approximate highway road kilometers (one-way centerline) we analyzed within these urban areas.

Our algorithms used a boundary of each CMA which is large enough to ensure that the analysis retained any congested stretches near and around a core urban area. We also removed nearby local roads, expressway access ramps and exits so that the lower speeds on those nearby roads did not "contaminate" the congestion analysis, for reasons described earlier.

What data did we use?

This Study uses many different disparate data sources. Much of the analytical work involves cleaning these data, pre-processing them to filter the most useful components, and then combining different data sets so that the information is in one place and used consistently. While this may seem like a linear process, the analysis actually involves many iterations until we are satisfied with the results. We obtained speed observations (described below), volume estimates (Average Annual Daily Traffic), and combined these with other proprietary spatial and map data.

Figure 1. Coverage of urban areas in this Study

CMA	Province	Population (millions)	Total Highway Length (kms)
Vancouver	British Columbia	2.5	206.4
Calgary	Alberta	1.44	245.13
Edmonton	Alberta	1.36	352.18
Regina	Saskatchewan	0.24	146.85
Winnipeg	Manitoba	0.79	168.24
Greater Toronto	Ontario	7.7	641.84
Ottawa-Gatineau	Ontario	1.33	259.69
St. Catharines	Ontario	0.13	73.33
Montreal	Quebec	4.06	561.21
Quebec City	Quebec	0.8	206.03
Halifax	Nova Scotia	0.42	115.26

Source: CPCS analysis of Statistics Canada and proprietary data
*Includes Toronto, Hamilton and Oshawa CMAs

We used speed data collected from GPS probes that are averaged for each five-minute interval in a day, across many weeks in the year. These data were provided by HERE North America, LLC (HERE), a leading supplier of digital maps and traffic management data. In these data sets, the GPS probe-based speeds are allocated to a road network layer called Traffic Message Channel (TMC). We combine these data with other location information from a proprietary CPCS highway data set through a process known as conflation, described below.

We used empirical GPS observations from the year 2015. To eventually develop estimates of delays for weekday travel, we first needed to understand the 24-hour weekday speed profile of different stretches of highway. The 5-minute speed data were averaged for every weekday hour (60 min / 5 min = 12 observations) for weekdays from eight weeks (5 weekdays/week x 8 weeks = 40 weekdays). Thus the average consists of 480 observations. Two weeks for each quarter of the year 2015 were chosen to account for seasonal choices in driving behavior, as well as to avoid statutory holidays. These sampling time periods were: February 2 - 15, May 4 - 17, August 10 - 23, and November 2 – 15. In total, we examined over 15,000 urban segments and almost 180 million speed observations!

The inset box shown on page 8 provides an overview of our approach. Mathematical details are in the Technical Appendix.

How should you use the Study results?

Many provincial and local transportation agencies have begun to rely on similar empirical data to identify localized bottlenecks. Our Study does not intend to replace these local efforts; instead we want to help make visible the most severely congested stretches of the nation's highways. These are the segments we identified that incur more than fifty thousand hours of annual delay. By focusing on the nation's most intensely congested segments, this report is intended to help direct resources to solutions that could add the most value in relieving congestion. This report also reinforces provincial and local efforts to address the most congested areas.

Furthermore, since most highway planning and investment is conducted at the provincial (and to a lesser extent, local) level in Canada, analysis and comparisons of specific highway bottlenecks are usually conducted within provincial or local boundaries. This Study makes these comparisons across the country, using a consistent methodology and traffic speed data from the same source. Nationwide comparisons may be of particular interest for Federal Government, which has increased its involvement and investment in local transportation infrastructure for the purpose of reducing road congestion.

The results are, of course, of interest to individual motorists as well. Using consistent methodology and the same data source to identify and rank bottlenecks across the country allow individual motorists who regularly drive in those bottlenecks to put their own commutes into a Pan-Canadian context.

Our approach to identifying, classifying and ranking highway bottlenecks

CPCS has developed a proprietary screening and prioritization framework for identifying bottlenecks using observed vehicle speeds. Our chosen method allows us to systematically compare and rank highway bottlenecks nationwide. We applied our proprietary approach in six steps:

1. Speed Profiles

We filtered a very large vehicle speed data set to first hone in on the highways of interest, and then filtered further based on time, selecting specific weeks in the year. We applied this process to a highway network comprising over 15,000 highway segments in major cities across Canada, and 180 million speed observations. For each highway segment, we developed a speed profile, i.e. a representation of speeds on a "typical weekday". In other words, the speed profile gives the speed at which a driver could expect to drive on a stretch of highway in a particular hour on a weekday.

2. Delay Estimates

We estimated delays by comparing the observed speed profile for each highway segment to the Maximum Throughput Speed for the same segment. Delay estimates were then adjusted for the relative lengths of highway segments, as well as the estimated volume of vehicles (both cars and trucks) on those segments. The resulting delay metric is Daily Total Delay, measured in hours. See the Technical Appendix of this report for mathematical details.

3. Network Conflation

The aggregate estimate of delay for a freeway segment needs not only the speed profile of vehicles driving that stretch but also the volume of vehicles that could potentially experience delays, denoted by Average Annual Daily Traffic (AADT). Often the relevant variables are stored in different spatial datasets. Conflation is the process of merging spatial data from two or more networks using Geographic Information Systems (GIS) tools and techniques. We merged the speed profiles, congestion estimates, vehicle volumes and observed speeds with CPCS's proprietary data on Canada's highway system to harmonize both congestion-related calculations and spatial and location information. The adjoining Figure 3, shows an example of conflation for two different speed-related data sets.

4. Bottleneck Adjacency Analysis

We first identified the most congested highway segments in each urban area, and then looked upstream and downstream to capture the full effect of a queue, or zone of congestion. The Daily Total Delay for the entire queue is used for the nationwide rankings (see maps).

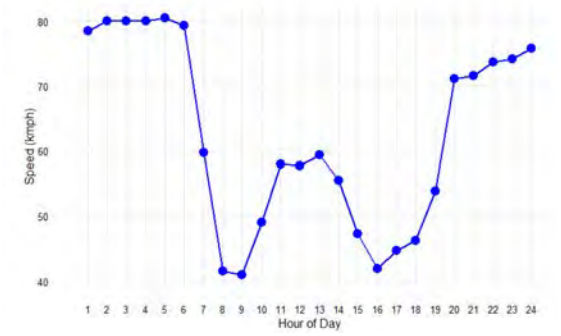
5. Validation of Results

We expected to see slight differences in our results and the congestion studies of provinces and local agencies. There are differences both in the precise locations and estimated lengths of the top-ranking bottlenecks, because of the differences in data and methods. We sought detailed feedback from agencies and representative regional organizations to validate our own findings. We leveraged local knowledge to prepare the profiles for the top 20 bottlenecks.

6. Bottleneck Impacts

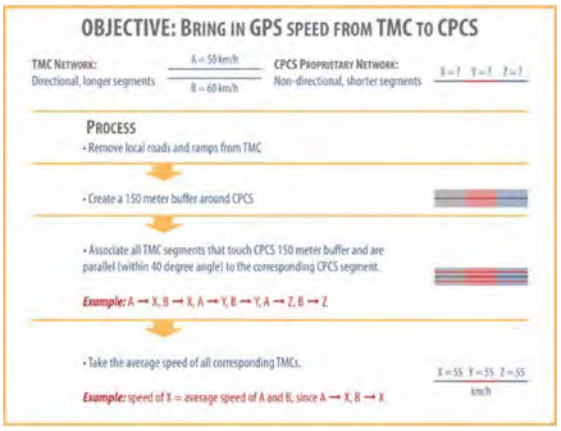
Finally, we calculate the cost of congestion ($), and potential fuel and emissions savings, for each bottleneck. The mathematical relationships for cost impacts and benefits calculations were drawn from peer-reviewed and published materials.

Figure 2. An example of a speed profile for a highway segment



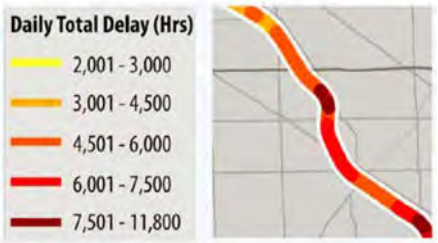
Source: CPCS analysis

Figure 3. Network Conflation Process for Speed Data



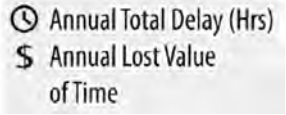
Source: CPCS analysis

Figure 4. An example of a bottleneck "queue" of highway segments with different congestion intensities, shown in the legend



Source: CPCS analysis

Figure 5. Multi-dimensional Congestion Impacts, including costs of congestion (lost value of time), potential fuel and emissions savings



Source: CPCS analysis

Canada's Worst Bottlenecks in 2015

This table lists the worst bottlenecks we found in our analysis. The twenty most severe bottlenecks are in just four cities – Toronto, Montreal, Vancouver, and Quebec City. We also calculated the congestion cost in terms of lost value of time, and the potential emissions and fuel savings from eliminating these bottlenecks. Altogether, the delay costs from these bottlenecks is close to $300 million per year. Eliminating these bottlenecks could save over 22 million litres of fuel per year, or roughly 500 thousand trips to the gas station!

Appendix C contains maps depicting daily hours of delay per kilometer across the entire highway network in each Census Metropolitan Area (CMA) we analyzed.

Figure 6. Canada's worst bottlenecks, 2015

Rank	CMA	Location	Length (km)	Annual Total Delay ('000 hours)	Annual Delay Cost (CAD millions)	Potential Annual Fuel Savings ('000 litres)	Potential Emissions Savings ('000 kg CO2)
1	Toronto	Hwy 401 between Hwy 427 & Yonge St	15.3	3,218	82.28	5,721	15,250
2	Toronto	DVP/404 between Don Mills Rd & Finch Ave	10.5	2,174	55.51	3,478	9,209
3	Montreal	Hwy 40 between Blvd Pie-IX and Hwy 520	10.6	1,956	45.60	4,197	10,901
4	Toronto	Gardiner Expy between S Kingsway & Bay St	7.4	1,076	27.51	1,671	4,447
5	Montreal	Hwy 15 between Hwy 40 & Chemin de la Côte-Saint-Luc	3.9	812	18.93	1,653	4,273
6	Toronto	Hwy 401 between Bay-view Ave & Don Mills Rd	3.3	485	12.40	934	2,510
7	Toronto	Hwy 409 between Hwy 401 and Kipling Ave	1.6	274	6.99	553	1,486
8	Montreal	Hwy 25 between Ave Souligny & Rue Beaub-ien E	2.1	259	6.04	591	1,525
9	Vancouver	Granville St at SW Ma-rine Dr	1.6	245	6.08	679	1,700
10	Vancouver	W Georgia St between Seymour St & W Pender St	1.2	149	3.70	603	1,477

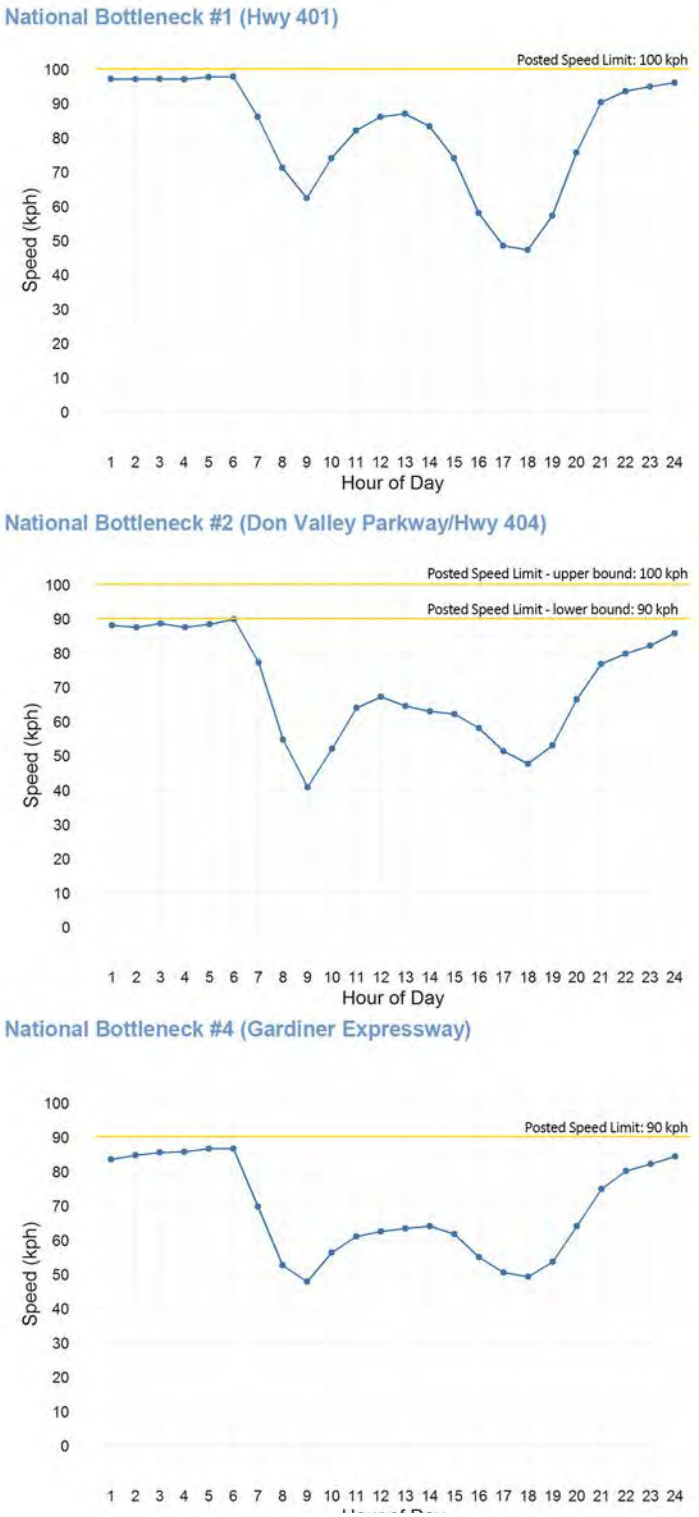
Source: CPCS analysis of data provided by HERE and provincial/local departments of transportation.

Figure 7. Canada's worst bottlenecks, 2015

Rank	CMA	Location	Length (km)	Annual Total Delay ('000 hours)	Annual Delay Cost (CAD millions)	Potential Annual Fuel Savings ('000 litres)	Potential Emissions Savings ('000 kg CO2)
11	Toronto	Hwy 401 between DVP & Victoria Park Ave	1.3	143	3.66	395	1,064
12	Toronto	Black Creek Dr between Weston Rd & Tretheway Dr	0.8	114	2.91	391	986
13	Toronto	Hwy 401 between Mavis Rd & McLaughlin Rd	0.8	103	2.63	164	437
14	Montreal	Hwy 40 between Hwy 520 & Blvd Cavendish	0.9	96	2.23	207	544
15	Vancouver	Granville St between W Broadway St & W 16th Ave	0.6	88	2.19	276	683
16	Montreal	Hwy 20 near 1re Avenue	0.8	84	1.97	174	463
17	Quebec City	Hwy 73 between Chemin des Quatre Bourgeois & Exit to Ave Dalquier	0.7	78	1.81	127	329
18	Toronto	Hwy 401 interchange at Hwy 427	0.6	73	1.87	194	518
19	Toronto	Hwy 400 at Hwy 401	0.6	62	1.60	216	575
20	Vancouver	George Massey Tunnel on Hwy 99	0.6	60	1.50	97	255
Total			65.2	11,546	287	22,322	58,634

Source: CPCS analysis of data provided by HERE and provincial/local departments of transportation.

Figure 8. Toronto 24 Hour Average Speed Profiles



Greater Toronto Area Bottlenecks

#1, #2, #4, #6, #7, #11, #12, #13, #18, #19

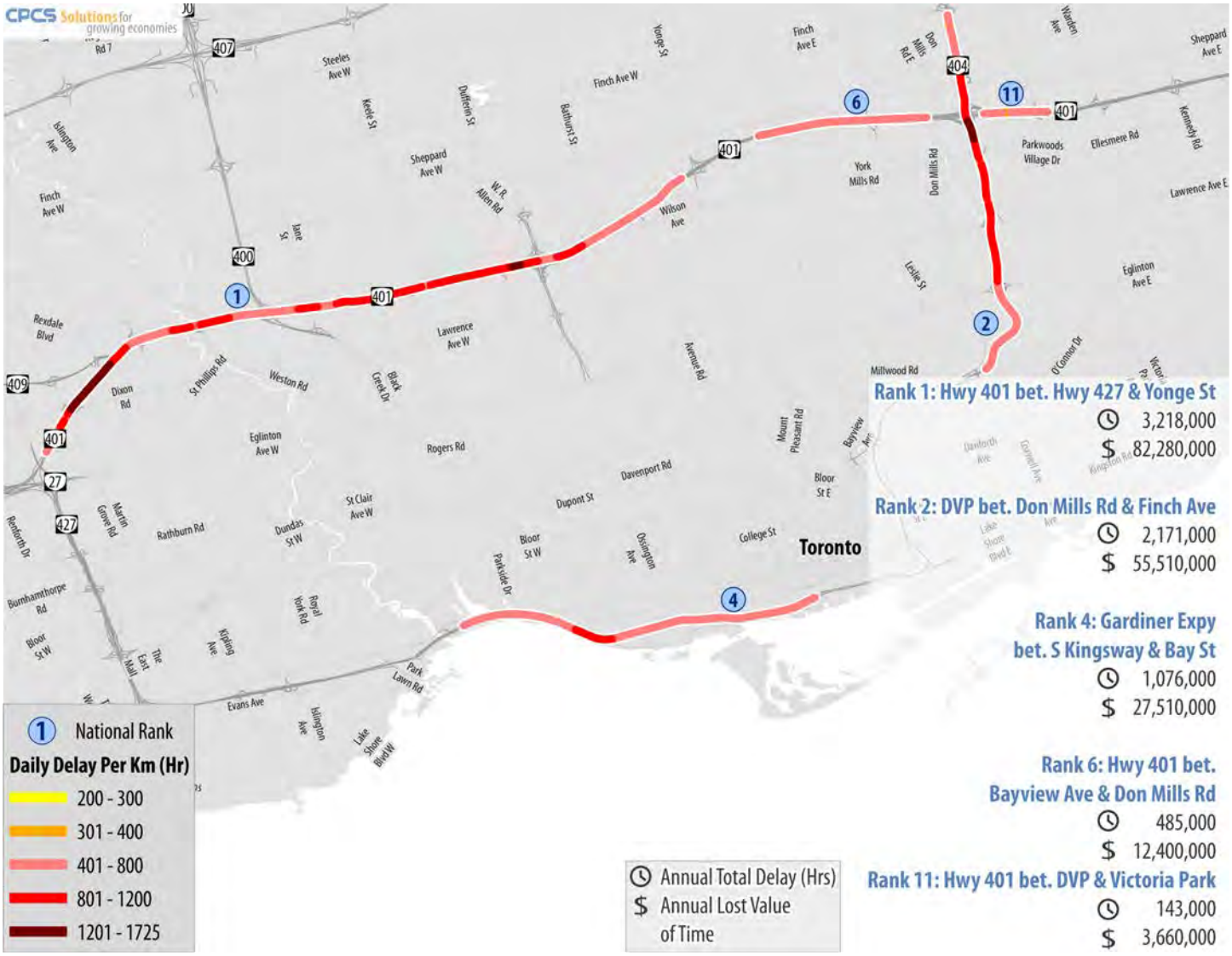
Canada's worst bottleneck is in Toronto – a 15 km stretch of Highway 401 between Highway 427 and Yonge Street. Originally constructed in the 1960s as a bypass to downtown Toronto to the south, activity around Highway 401 quickly flourished to become one of the most developed areas in the country. Today, the bottleneck costs drivers over 3.2 million hours in lost time every year, or $82 million in the lost value of time at average local wage rates.

The second-worst bottleneck, the Don Valley Parkway (DVP) between Don Mills Road and Finch (at which point it is Highway 404), is not far behind. This bottleneck is about 10.5 km long, creating a loss of almost 2.2 million hours annually. Originally planned as one of a series of expressways between downtown Toronto and the growing suburbs in the 1960s, the DVP has instead become the only north-south expressway into downtown. Due to the persistent congestion throughout the day, the DVP has earned the nickname "Don Valley Parking Lot" by local motorists for good reason.

The third-worst bottleneck in the GTHA (and fourth-worst in the country) is the portion of the Gardiner Expressway between South Kingsway and Bay St. in downtown Toronto.

The total hours of delay on the DVP and the Gardiner are not as large as they are on the 401 because they are not nearly as wide and as such, do not carry as much volume. However, the average speeds on the DVP and the Gardiner are lower and more persistently low throughout the day (see Figure 8). While average speeds do drop below 50 kph in the PM peak on the 401, average speeds are below this level in both the AM and PM peak on the DVP and the Gardiner. Further, the travel speeds remain low throughout the day on both the DVP and the Gardiner.

Figure 9. Top Greater Toronto Area Bottlenecks



Source: CPCS analysis of data provided by HERE and provincial/local departments of transportation.

Notably absent from the bottlenecks are any stretches of 407 ETR, a 108 kilometre barrier-free all-electronic toll highway that runs north of the City of Toronto. Our analysis shows no excess congestion whatsoever on 407 ETR, which is itself a result of the impact of road tolls. As such, 407 ETR can easily be called the longest "non-bottleneck" in the GTHA.

Another stretch of highway that is notably absent is any portion of the QEW, which runs west of Toronto through Mississauga towards Hamilton. This highway has recently undergone a significant expansion, with new High Occupancy Vehicle (HOV)

lanes added in both directions towards the end of 2010. Although the highway still sees congestion, it appears as if this new capacity has helped to reduce congestion levels enough so the highway does not rank among the worst bottlenecks in the GTHA.

Figure 10. Additional Bottlenecks in the Greater Toronto Area



Source: CPCS analysis of data provided by HERE and provincial/local departments of transportation.

Montreal Bottlenecks

#3, #5, #8, #14, and #16

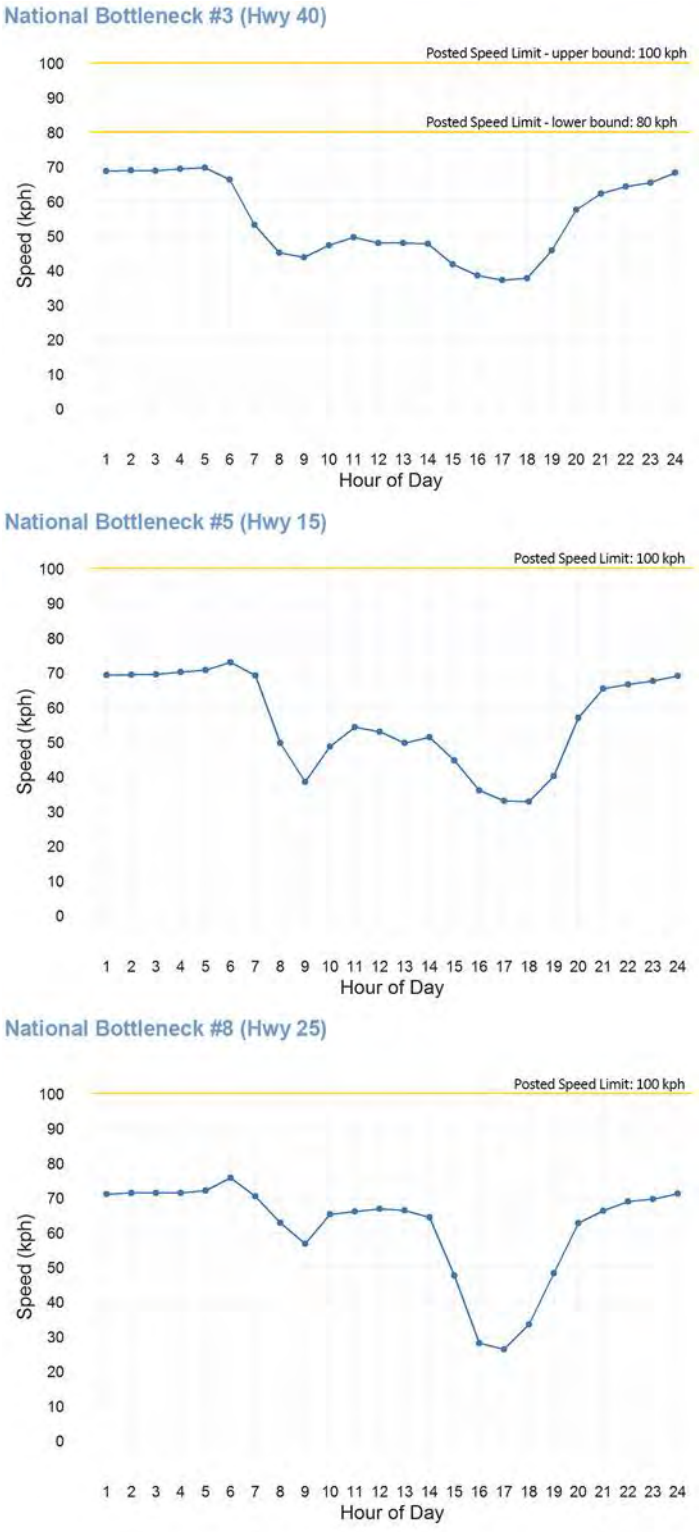
Montreal has five of the top twenty most severe bottlenecks in Canada. The worst of these is a 10 km stretch on the Metropolitan Autoroute (Autoroute 40) between Boulevard Pie-IX and Autoroute 520. On this highway, the busiest section of the Trans-Canada Highway, drivers lose slightly under 2 million hours in delays annually, costing them about $45 million is the lost opportunity cost of time. They could altogether save almost 1.3 million liters of fuel, avoiding over 11 million kilograms of emitted CO2.

Figure 11. Greater Montreal's Top Bottlenecks



Source: CPCS analysis of data provided by HERE and provincial/local departments of transportation.

Figure 12. Montreal 24 Hour Average Speed Profiles



Montreal's other four bottlenecks are shorter, ranging from 800 meters to about 4 kilometers, however they still exacerbate local driving conditions and impose losses. In total, Montreal's five bottlenecks are responsible for over 3 million hours in annual delay, worth about $75 million in lost time. If these bottlenecks were to be addressed, drivers would save almost 7 million liters in fuel per year, or enough to save about 140 thousand trips to the gas station. Related potential emission reductions would be 18 thousand tonnes of CO2, the equivalent of about 4,500 elephants!

Although Montreal's bottlenecks rank behind Toronto's worst bottlenecks generally, the travel speeds on Montreal's bottlenecks are in fact worse (see Figure 12). For example, on the Metropolitan Autoroute average travel speeds are consistently at or below 50 kph throughout the entire business day. In fact, there is almost no distinction between the AM, midday and PM peak periods on this stretch. Rather, that entire period can almost be considered as a single peak traffic period.

In terms of our calculations of total delay, because free-flow and MTS travel speeds are also much lower on Montreal's bottlenecks (than on Highway 401, for example), the total delay relative to MTS on the Montreal bottlenecks is not as severe. In other words, given the road design, urban environment and other factors, the maximum achievable speeds on the Montreal bottlenecks are not as high as they are on Highway 401. Therefore, the total delay relative to these speeds are also not considered to be as severe (although this certainly is no cause for relief for Montreal's motorists!).

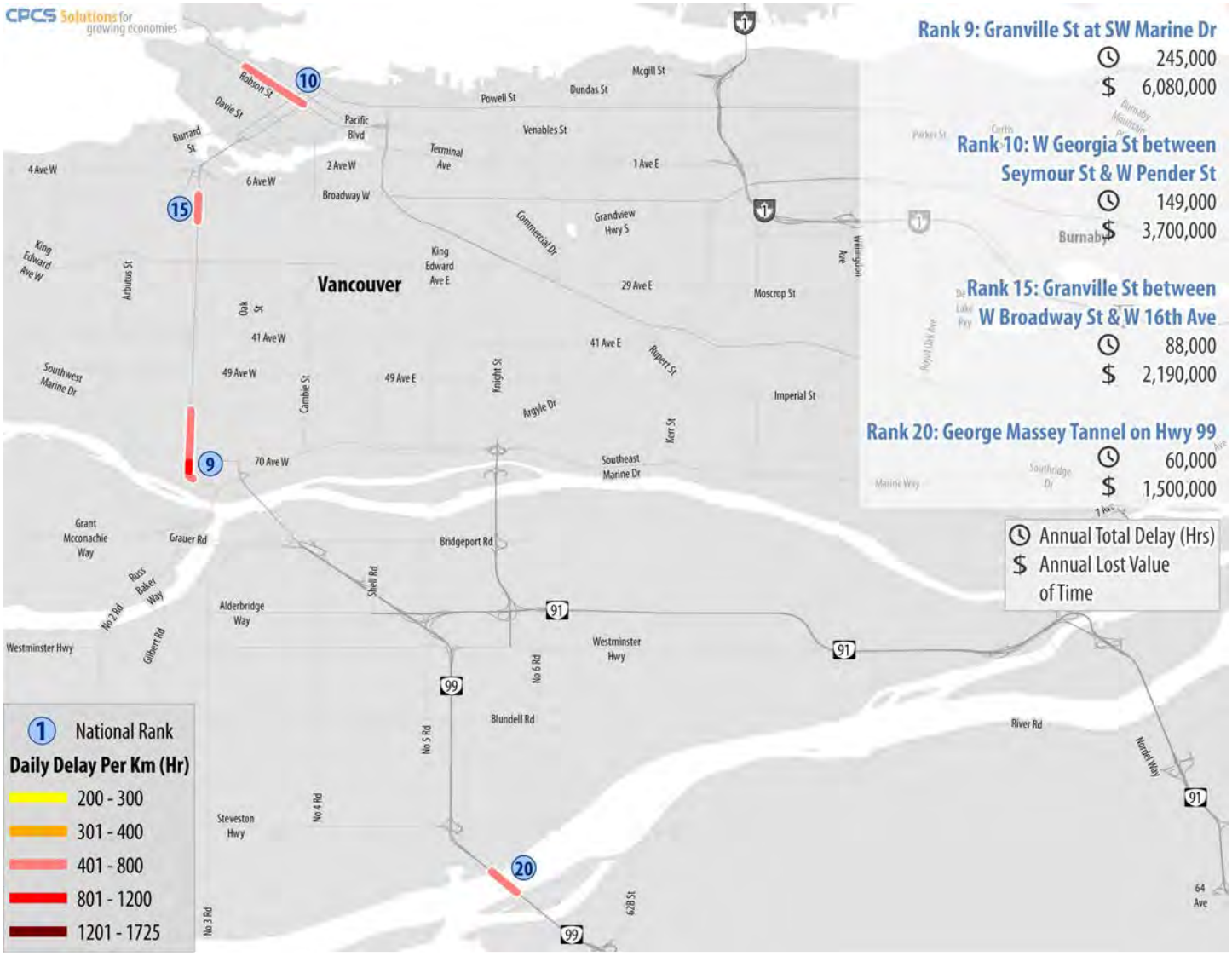
Vancouver

#9, #10, #15 and #20

As already noted, this Study focused on expressways. Unlike Toronto and Montreal, Vancouver does not have any expressways directly serving its downtown area. As such, we choose to include the signalized portion of Highway 99 that runs through downtown Vancouver.

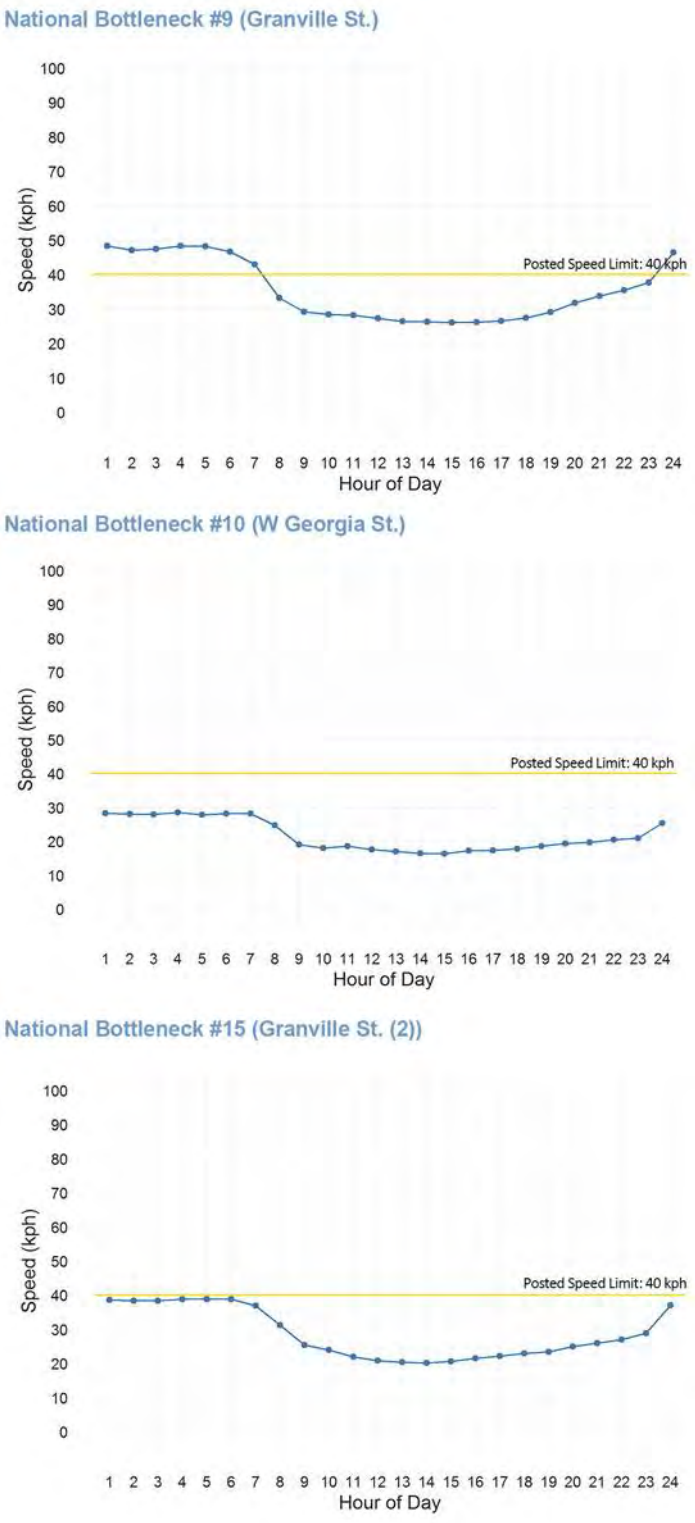
Two of Vancouver's four bottlenecks are on Granville St (part of the signalized portion of Highway 99). The longer of the two (#9) is at SW Marine DR, and about a kilometer and a half in length. The shorter (#15) one is only about half a kilometer long, stretching between W Broadway St and W 16th Avenue.

Figure 13. Greater Vancouver's Top Bottlenecks



Source: CPCS analysis of data provided by HERE and provincial/local departments of transportation.

Figure 14. Vancouver 24 Hour Speed Profiles



The other two bottlenecks are on W Georgia St between Seymour and W Pender (also part of the signalized portion of Highway 99), and the George Massey tunnel corridor on the non-signalized portion of Highway 99 (which contrary to recent media reports does not appear to be the worst bottleneck in the area).

As noted, we selected the main artery that serves Vancouver's downtown core in order to make the results broadly comparable to Canada's other large cities, despite the fact that it is signalized. These and other main arteries have significantly lower maximum throughput potential than limited access highways. As such, our estimate of total delay on these arteries are much lower than they would have been if they were compared with the throughput potential of a limited access highway. In other words, although the ranking of the bottlenecks are not as severe as they are in Toronto and Montreal, the actual vehicle speeds that drivers experience into and out of downtown Vancouver are in fact as bad as or worse than they are in those two cities.

This point is illustrated by the speed profiles shown in Figure 14. Travel speeds throughout the day on these bottlenecks are consistently at or lower than 30 kph. In the case of W Georgia St. which runs through the downtown core, average travel speeds remain at approximately 20 kph throughout the entire business day.

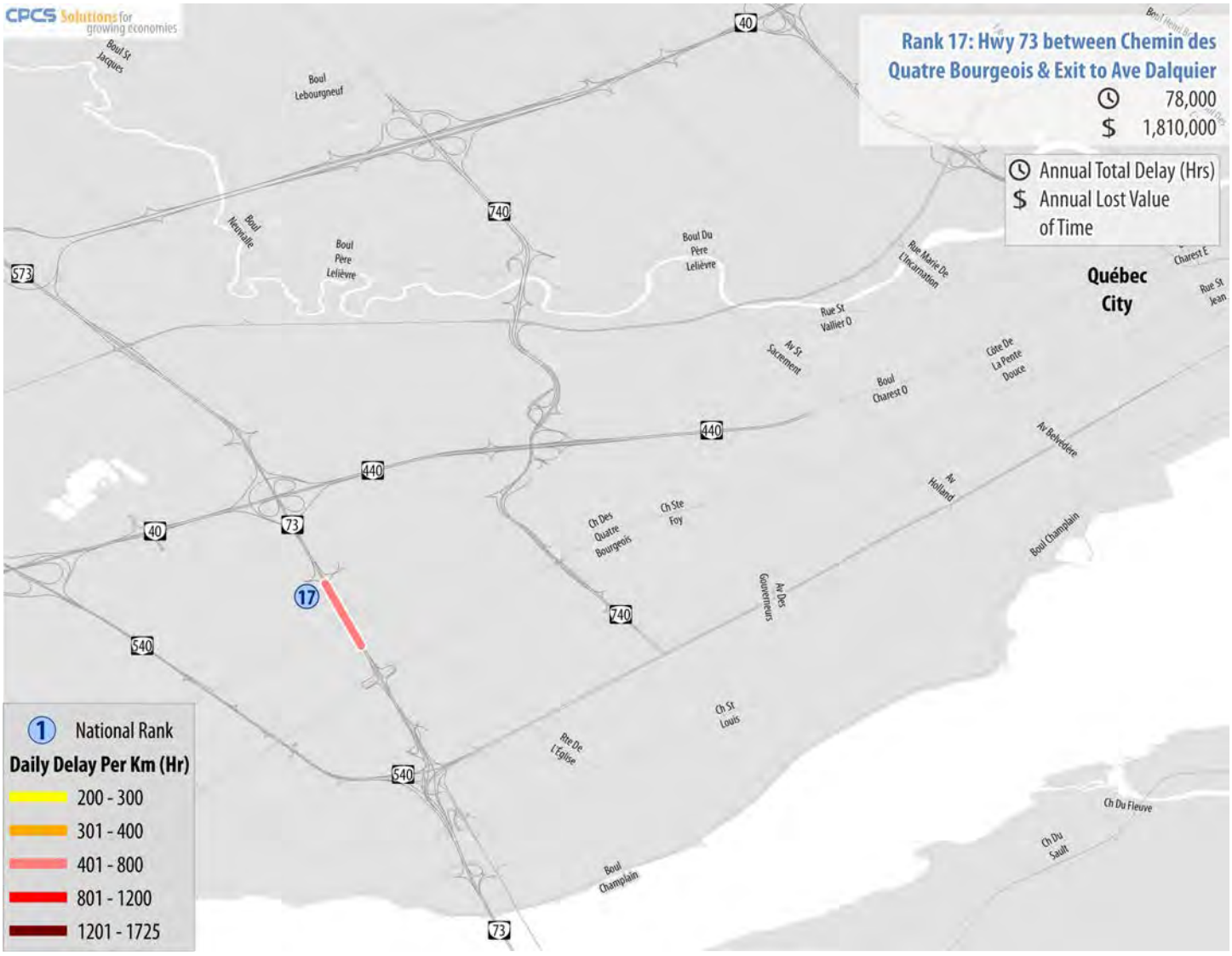
The four kilometers of severe congestion across the four bottlenecks identified cost Vancouver's drivers over $13 million annually. Eliminating these bottlenecks could help recover about half a million hours in lost time and save over 1.5 million liters of fuel per year, which is about 30 thousand trips to the gas station. The related CO2 emissions equal over four thousand tonnes annually, which is approximately the same weight as two thousand cars!

Quebec City

#17

Quebec City is the only medium-sized city in Canada to have a major bottleneck severe enough to rank in the top twenty worst congestion zones in Canada. This bottleneck is less than a kilometer long, on Highway 73 between Chemin des Quatre Bourgeois and the exit to Avenue Dalquier. This single stretch delays drivers by about 78,000 hours annually, at a cost of 1.8 million in the opportunity cost of time. These drivers could save over 1,000 thousand liters of fuel a year, if the congestion were to be relieved in this area.

Figure 15. The Quebec City Area's Worst Bottleneck



Source: CPCS analysis of data provided by HERE and provincial/local departments of transportation.

Other Bottlenecks of Note

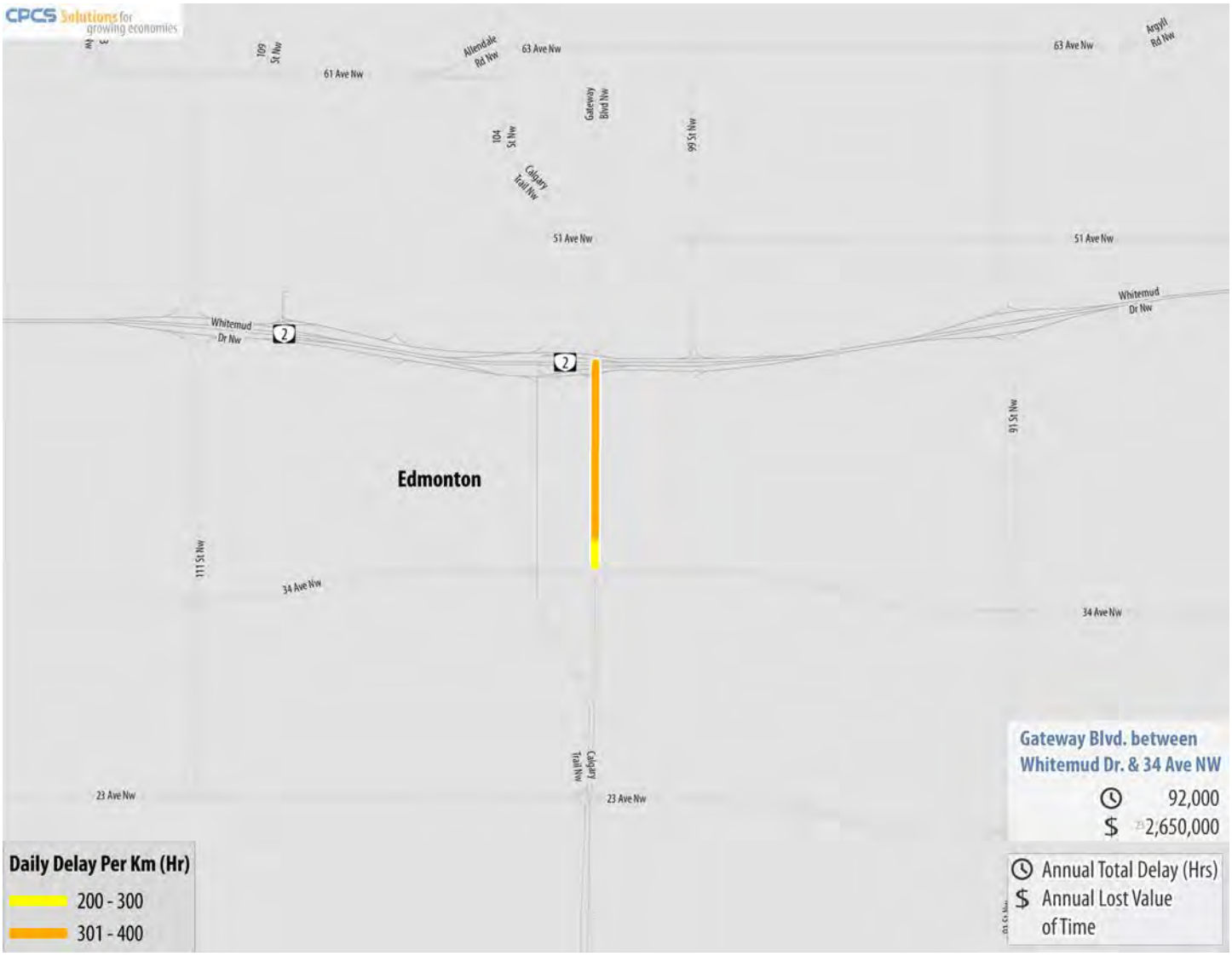
We also found bottlenecks in other cities that were not severe enough in their intensity in any given stretch to rank in the twenty worst. But drivers in these stretches also experience significant congestion. These five bottlenecks are in the Ottawa-Gatineau, Calgary, and Edmonton areas, and shown in the table below as well as the maps that follow.

Figure 16. Other Bottlenecks of Note in Canada

CMA	Location	Length (km)	Annual Total Delay ('000 hours)	Annual Delay Cost (CAD millions)	Potential Annual Fuel Savings ('000 litres)	Potential Emissions Savings ('000 kg CO2)
Ottawa-Gatineau	Hwy 417 between O'Connor St & Bayswater Ave	2.4	127	3.24	277	740
Calgary	Crowchild Trail between University Dr NW & Memorial Dr NW	1.7	114	3.30	436	1,139
Ottawa-Gatineau	Vanier Pkwy between Hwy 417 & Montreal Rd	1.9	106	2.72	449	1,153
Edmonton	Gateway Blvd. between Whitemud Dr. & 34 Ave NW	1.2	92	2.65	374	966
Calgary	Crowchild Trail at 24th Ave NW	0.6	36	1.04	107	282

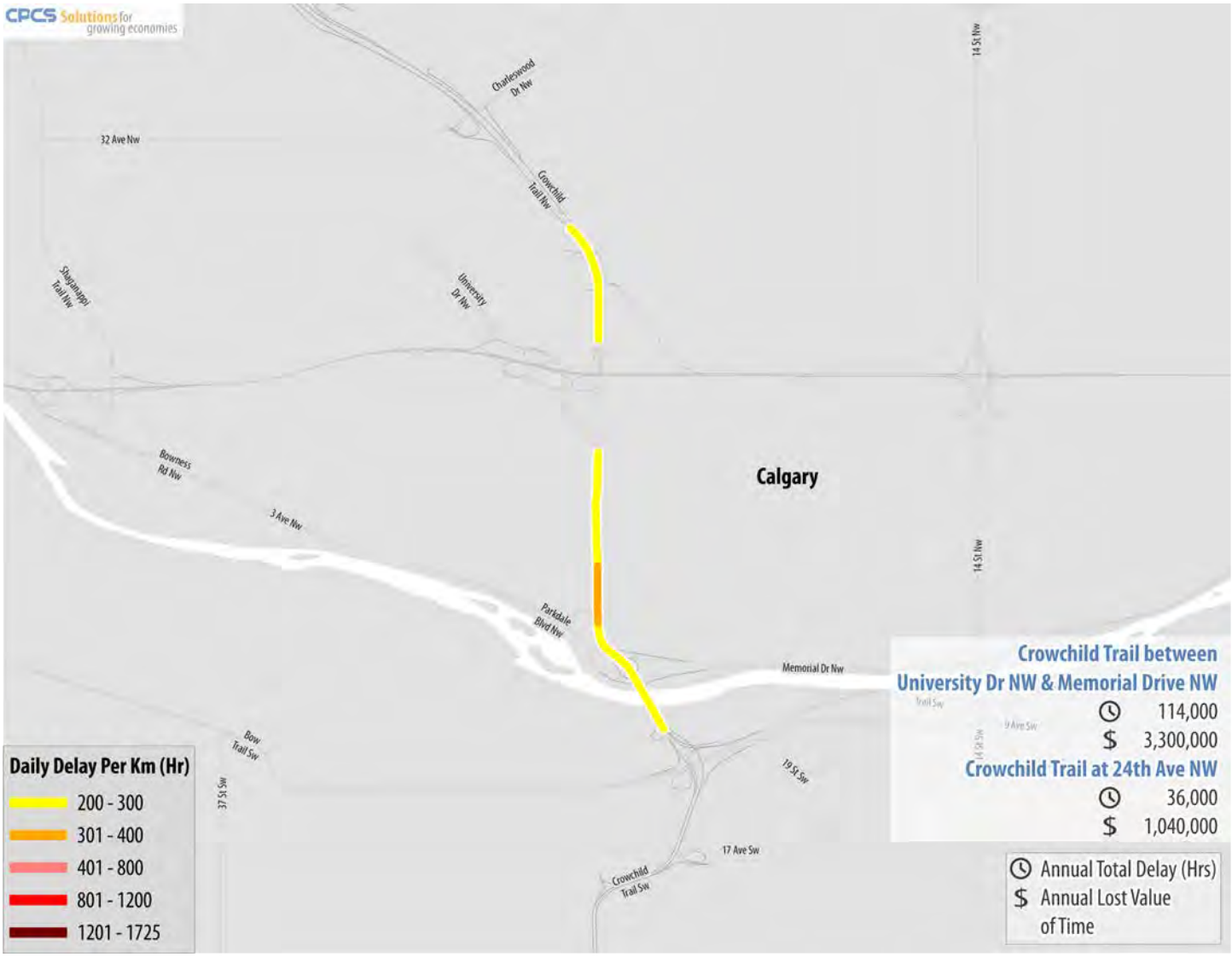
Source: CPCS analysis of data provided by HERE and provincial/local departments of transportation.

Figure 17. Edmonton's Worst Bottleneck



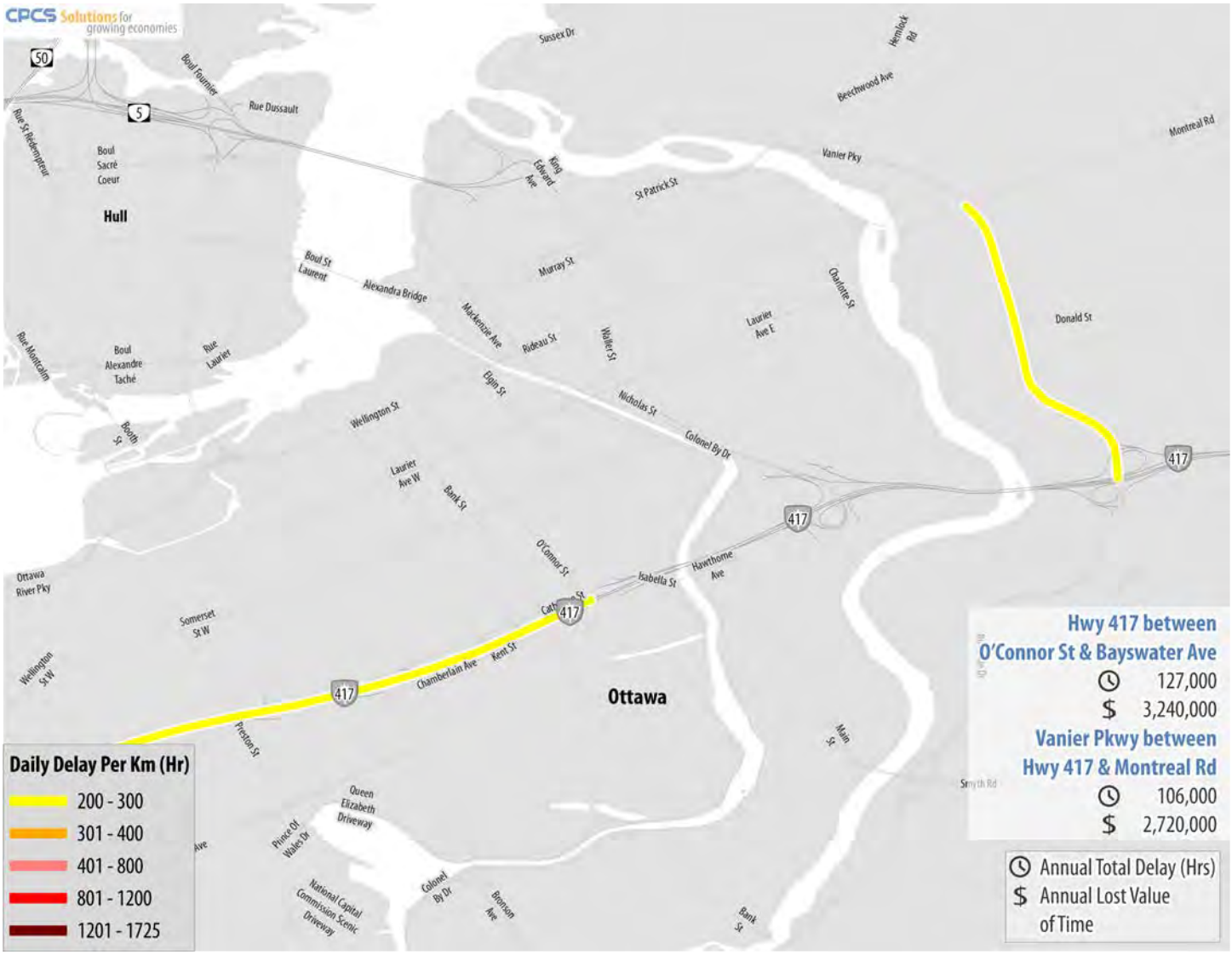
Source: CPCS analysis of data provided by HERE and provincial/local departments of transportation.

Figure 18. Calgary's Worst Bottlenecks



Source: CPCS analysis of data provided by HERE and provincial/local departments of transportation.

Figure 19. Ottawa's Worst Bottlenecks



Source: CPCS analysis of data provided by HERE and provincial/local departments of transportation.

Region-wide Measures of Congestion

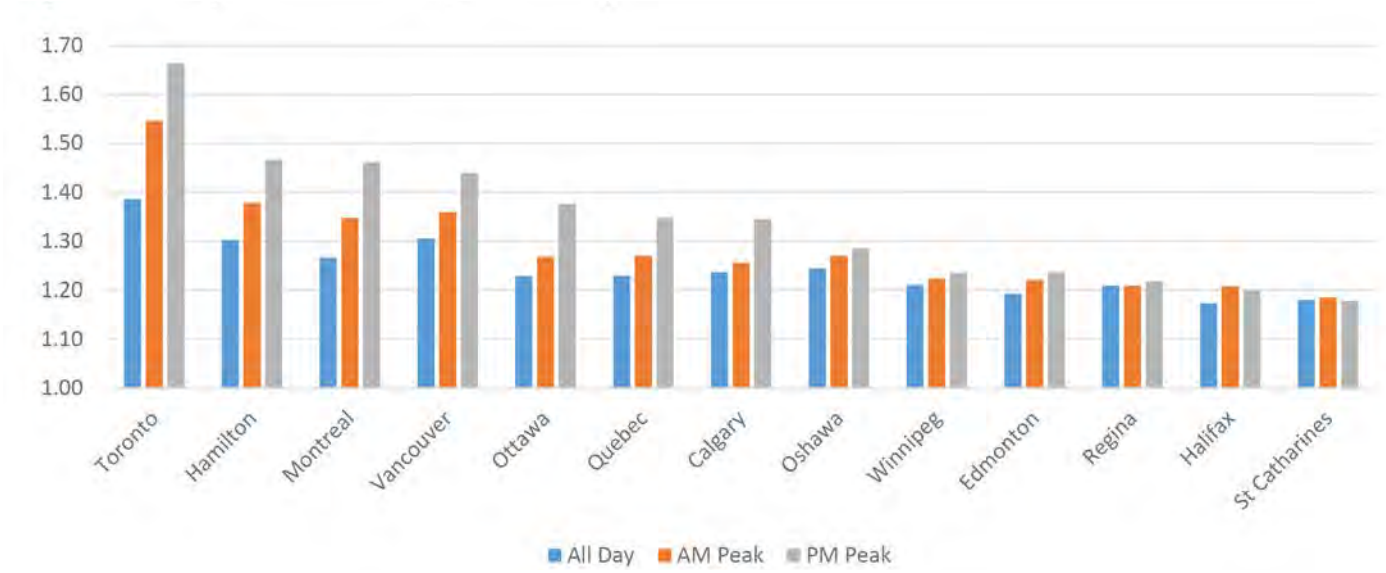
Our analysis has focused primarily on identifying the worst bottlenecks, which are specific stretches of highway as opposed to region-wide measures of congestion. As noted in the introduction, other studies have estimated region-wide measures of congestion. Although doing so is not the primary focus of this Study, our data also allows for developing region-wide congestion measures.

In order to do so, we have calculated Travel Time Indices (TTI) for each of the urban areas that were included in our dataset. The TTI is the travel rate during a specified period of time relative to the travel rate in free-flow conditions. For example, if it takes 45 minutes to travel between points A and B during the morning peak and it takes 30 minutes to travel between the same points during free-flow conditions, the TTI is 45 / 30 = 1.50. The TTI can be calculated as an all-day average or as an average during a more specific period of time (morning or afternoon peak, for example).

The TTI differs from our method of estimating bottlenecks in a few key ways:

- The bottleneck analysis measures the level of congestion for specific stretches of highway, whereas the TTI measures average congestion levels region-wide.
- The bottleneck analysis uses MTS as the baseline speed, whereas the TTI uses FFS as the baseline speed (with the FFS being higher than the MTS). Further, the TTI as we calculate it here uses a slightly more liberal estimate of FFS.
- The bottleneck analysis takes the total volume of traffic into account to determine the rankings, with higher volume highways showing up as more severe bottlenecks. The TTI is not affected by volume, except to weigh different speed observations in each hours in order to arrive at a single TTI for each city.

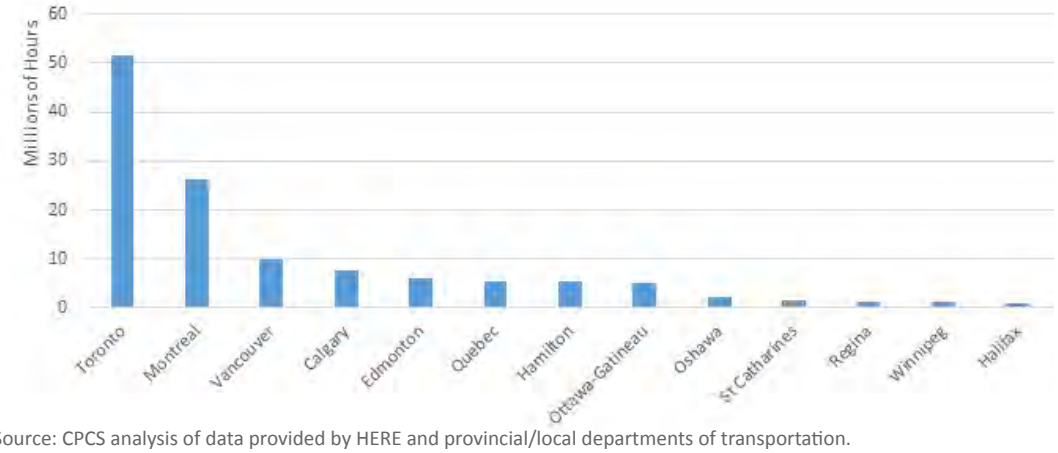
Figure 20. Weekday Travel Time Indices by Census Metropolitan Area



Source: CPCS analysis of data provided by HERE and provincial/local departments of transportation.

The TTI for each CMA included in our analysis is shown in Figure 20 (shown in order of highest to lowest All Day TTI). For each CMA, the average TTI throughout the day is shown, as well as the AM Peak (7 – 9am) and PM Peak (4 – 6pm) TTIs. For example, the All Day TTI for Toronto is 1.39. This means that on average during a weekday a trip in the Toronto Area highways takes 39% longer than it would under free-flow conditions. During the morning peak that trip would take 55% longer than it would under free-flow conditions, increasing to 66% longer during the afternoon peak. Because the All Day average is calculated using a weighted-average of volumes throughout the day, it places greater weight upon the peak periods than it does to the off-peak periods (which is why the All Day average is usually close at least to the morning peak, if not both).

Figure 21. Additional Minutes of Travel Time per Year Relative to Free-Flow (60 Minute Baseline, AM and PM Peak)



Source: CPCS analysis of data provided by HERE and provincial/local departments of transportation.

For the purpose of measuring congestion costs, the FFS is not a suitable measure for the baseline speed. In the example above, the presence of a TTI of 1.50 does not suggest that the actual travel time "should" be 30 minutes instead of 45 minutes. As noted in our opening discussion regarding the purpose of this Study, the optimal level of congestion varies by time and place, and depends on the cost of reducing congestion in those specific areas. However, FFS and by extension the TTI can be useful for making general comparisons of the total traffic level across urban areas, which is why it is commonly used.

Using the same data, we can also estimate the cumulative amount of time spent in traffic by motorists, relative to the amount of time that would have been spent in traffic if free-flow conditions prevailed. To do this, we multiplied our hourly estimates of net travel times (actual travel times minus free-flow travel times) for each day on each highway segment by 250, the approximate number of non-holiday weekdays in the year. The results are shown in Figure 22. In total, motorists across all CMAs spent an additional 125 million hours in traffic, relative to the time that they would have spent in free-flow conditions.

Figure 22. Additional Annual Hours of Travel Time Relative to Free-Flow

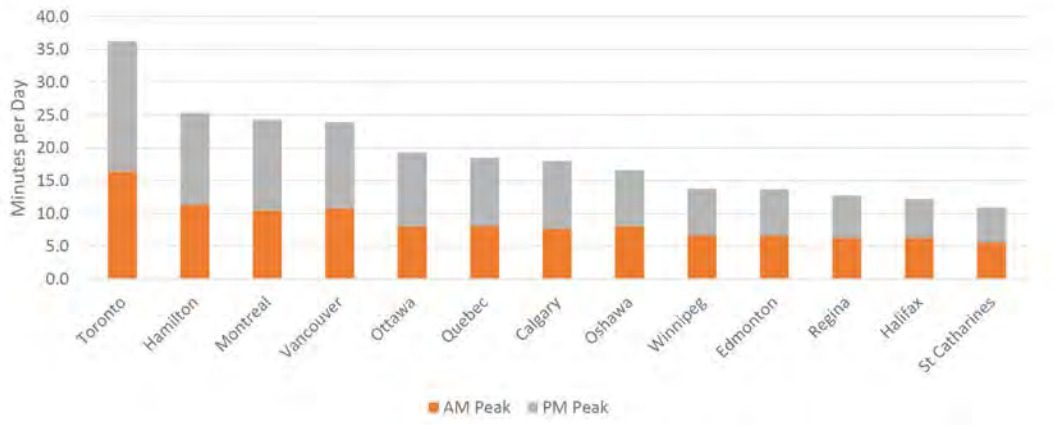
CMA	Millions of Hours
Toronto	51.6
Montreal	26.3
Vancouver	10.0
Calgary	7.8
Edmonton	6.2
Quebec	5.3
Hamilton	5.2
Ottawa-Gatineau	5.2
Oshawa	2.3
St Catharines	1.5
Regina	1.1
Winnipeg	1.1
Halifax	0.9
Total	124.4

Source: CPCS analysis of data provided by HERE and provincial/local departments of transportation.

Interpreting the TTI

The TTI can be used to estimate how much the typical motorist's commute time would be reduced in each city if free-flow conditions prevailed (again noting the free-flow conditions at all hours is not a reasonable expectation). For example, if the typical motorist spends 75 minutes per day commuting to and from work, and the TTI was 1.25, that time would be reduced to 75 / 1.25 = 60 minutes (a difference of 15 minutes) if free-flow conditions prevailed. In the chart below, we refer that difference as additional minutes of travel time relative to free-flow.

Figure 23. Additional Minutes of Travel Time per Day Relative to Free-Flow (60 Minute Baseline, AM and PM Peak)



Source: CPCS analysis of data provided by HERE and provincial/local departments of transportation.

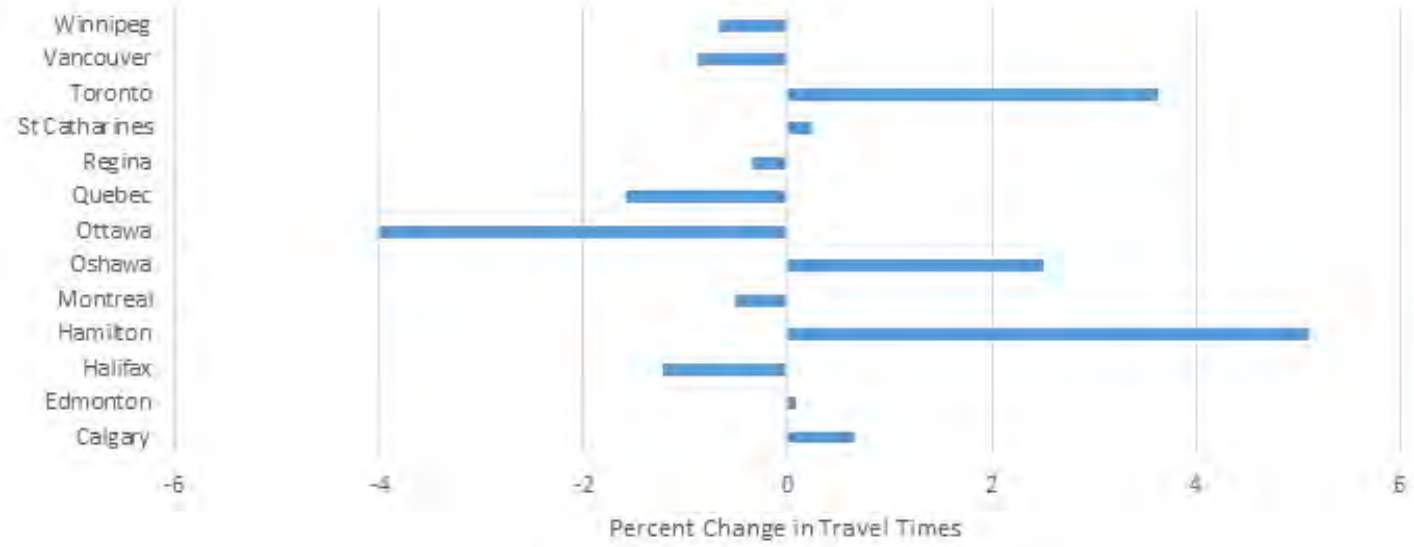
Unsurprisingly, the typical Toronto area motorist spends the most additional time per day relative to a two-way 60 minute free-flow commute. In typical peak period traffic conditions, what would be a 60 minute two-way commute becomes a 96 minute commute (for 36 additional minutes in total). Hamilton (which is part of the GTHA) appears next, followed by Montreal and Vancouver.

No top bottlenecks were found in the medium sized cities due in part to the smaller volumes of traffic found on their highways (recall that the bottleneck analysis takes both speed and volume into account). As indicated by Figure 23, however, motorists in those cities also face considerable delays, relative to free-flow speeds. For a typical Ottawa area motorist, for example, what would be a 60 minute two-way commute in free-flow conditions becomes a 79 minute commute during peak periods.

Although there are some exceptions, PM peak period traffic is more severe than AM peak period traffic on average. This is due in part to the fact that commuters usually leave home at more variable times in the morning (spreading the traffic to some extent) than they leave work in the afternoon (which tends to be more clustered closer to 5pm).

As noted, the AM and PM peak periods in the figures above are defined as 7 – 9am and 4 – 6pm, respectively. By fixing the length of the peak periods across all urban areas, we do not see how the length of the peak periods vary. While there are many ways of showing this, one way of showing the difference between the urban areas in this regard is to show the TTI values for a one specific hour relative to another.

Figure 24. Change in Average Travel Times Between 5 – 6pm and 6 – 7pm



Source: CPCS analysis of data provided by HERE and provincial/local departments of transportation.

For example, Figure 24 shows the change in the TTI from 5 – 6pm to 6 – 7pm in each urban area. If the TTI does not change from 5 – 6pm to 6 – 7pm, this suggests that travel speeds and overall traffic levels are consistent between the two hours. However, if the TTI for 6 – 7pm is lower than the TTI for 5 – 6pm, this suggests that traffic is dissipating. Urban areas with TTIs that are considerably lower for 6 – 7pm relative to 5 – 6pm then have shorter peak periods overall relative to those urban areas that do not.

As shown in Figure 24, average travel times in some urban areas (notably Toronto, Oshawa and Hamilton – all part of the GTHA, and Calgary) are actually longer (speeds are slower) during the 6 – 7pm period than they are during the 5 – 7pm period. In these urban areas, the afternoon "rush hour" clearly extends into the early evening. In other urban areas, particularly Ottawa and to a lesser extent Quebec City and Halifax, there is a significant drop in travel times (speeds are faster) during the 6 – 7pm period. This suggests that peak hour congestion does not last as long in these urban areas.

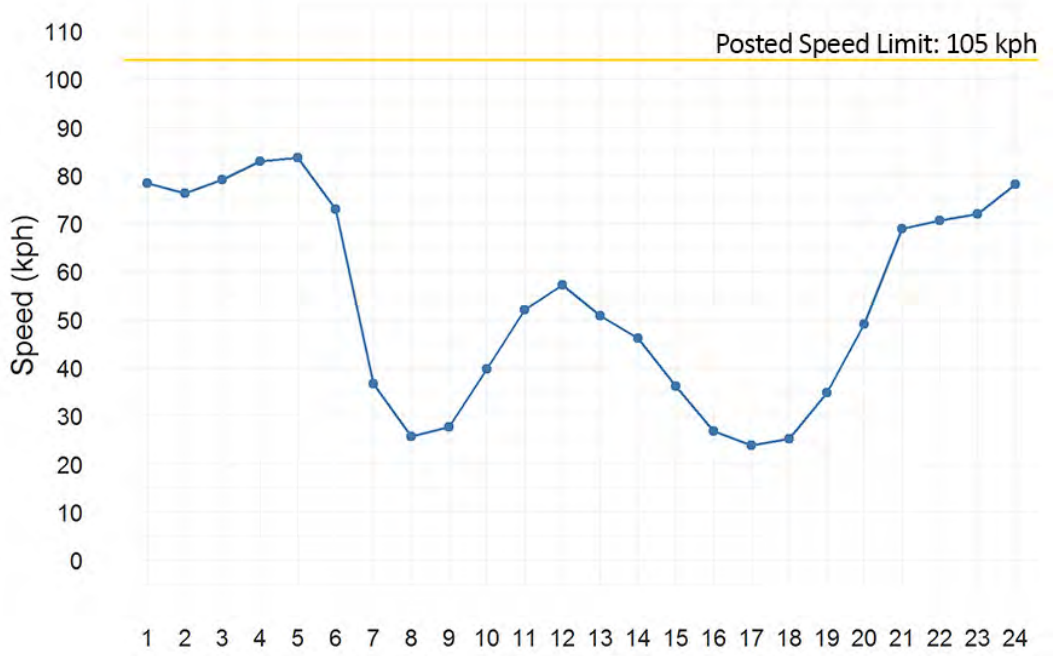
Comparison With Top US Bottlenecks

Comparisons With Top US Bottlenecks

In 2015, CPCS completed an analysis of top highway bottlenecks in the US, using broadly similar methodologies and data sources. The new Canadian analysis allows for a comparison of the worst bottlenecks across both countries.

Through this comparison we find that Canada's worst bottleneck (the stretch of Highway 401 through Toronto) ranks among the ten worst across Canada and the US. In terms of total hours of delay, it compares with the worst bottlenecks in the New York metro area. Only New York, LA and Chicago have bottlenecks that are worse than Toronto's.

Figure 25. Additional Minutes of Travel Time per Day Relative to Free-Flow (60 Minute Baseline, AM and PM Peak)



Source: CPCS analysis of data provided by HERE and provincial/local departments of transportation.

Meanwhile, Montreal's worst bottlenecks falls within the 20 worst across both countries. Specifically, this stretch of Highway 40 is comparable to the worst bottleneck in Boston, and is among the worst bottlenecks on the Eastern seaboard.

Despite the severe levels of congestion in Toronto and Montreal, the I90 between Roosevelt Rd. and N Nagle Ave. in Chicago is found to be the most severe bottleneck due to the extremely low travel speeds in the AM, midday and PM peak hours (see Figure 18). In both the AM and PM peaks, average travel speeds fall well below 30 kph, while during the midday average travel speeds remain between 40 and 60 kph at best. These low speeds combined with the length of the highway segment that sees such consistently low speeds make it the worst ranking bottleneck.

Figure 26. Canadian bottlenecks compared with worst US bottlenecks in 2015

Rank	CMA	Location	Length (km)	Annual Total Delay ('000 hours)	Annual Delay Cost (CAD millions)	Potential Annual Fuel Savings ('000 litres)	Potential Emissions Savings ('000 kg CO2)
1	Chicago	I90 between Roosevelt Rd and N Nagle Ave	19.3	16,900	543	24,113	60,320
2	Los Angeles	I405 between SR22 and I605	6.6	7,100	248	6,887	16,640
3	Los Angeles	I10 between Santa Fe Ave and Crenshaw Blvd	11.1	6,900	243	8,448	21,320
4	Los Angeles	I405 between Venice Blvd and Wilshire Blvd	8.4	6,300	220	7,427	18,200
5	Los Angeles	US101 between Franklin Ave and Glendale Blvd	7.1	5,400	189	6,668	16,640
6	Los Angeles	I110 between Exposition Blvd and Stadium Way	6.9	5,400	188	7,025	17,160
7	Los Angeles	US101 between Sepulveda Blvd and Laurel Canyon Blvd	6.1	3,600	124	3,966	10,140
8	New York and Union City	Lincoln Tunnel between 10th Ave and John F Kennedy Blvd	4.2	3,400	113	6,550	15,860
9	Toronto	Hwy 401 between Hwy 427 & Yonge St	15.3	3,218	82	5,721	15,250
10	New York	I95 between I895 and Broadway	5.0	3,000	106	5,851	14,300
11	Austin	I35 between East Riverside Dr and E Dean Keeton St	4.8	3,000	95	6,724	17,420
12	Los Angeles	I5/I10 between N Mission Rd and US101	3.2	2,300	81	3,659	9,360

Source: CPCS analysis of data provided by HERE and US state / CA provincial / local departments of transportation.

Continued on next page.

Figure 26. Canadian bottlenecks compared with worst US bottlenecks in 2015 (continued)

Rank	CMA	Location	Length (km)	Annual Total Delay ('000 hours)	Annual Delay Cost (CAD millions)	Potential Annual Fuel Savings ('000 litres)	Potential Emissions Savings ('000 kg CO2)
13	San Francisco	I80 between US101 and Bay Bridge	3.1	2,200	76	3,020	7,280
14	Toronto	DVP/404 between Don Mills Rd & Finch Ave	10.5	2,171	56	3,478	9,209
15	Los Angeles	I10 between La Brea Ave and National Blvd	3.5	2,100	74	2,088	5,200
16	Los Angeles	I5 between S Eastern Ave and Euclid Ave	3.2	2,100	73	3,756	9,620
17	Boston	I93 between I90 and US1	3.1	2,100	75	7,498	18,200
18	Montreal	Hwy 40 between Blvd Pie-IX and Hwy 520	10.6	1,956	46	4,197	10,901
19	Oakland	I80 between I580 and Ashby Ave	3.2	1,900	65	2,619	6,500
20	Seattle	I5 between Madison St and Exit 168A	2.6	1,600	59	2,346	5,980
21	Fort Lee	I95 between SR4 and Palisades Interstate Pkwy	1.4	1,500	49	3,069	7,540
22	Newark and Kearny	Pulaski Skyway between I95 and Central Ave	1.8	1,400	47	3,244	7,800
23	Miami	Palmetto Expy between 41st St and Dolphin Expy	2.7	1,400	39	2,451	6,240
24	New York	I678 between Queens Blvd and Liberty Ave	2.3	1,400	48	1,942	4,680

Source: CPCS analysis of data provided by HERE and US state / CA provincial / local departments of transportation.

Continued on next page.

Figure 26. Canadian bottlenecks compared with worst US bottlenecks in 2015 (continued)

Rank	CMA	Location	Length (km)	Annual Total Delay ('000 hours)	Annual Delay Cost (CAD millions)	Potential Annual Fuel Savings ('000 litres)	Potential Emissions Savings ('000 kg CO2)
25	Houston	I610 between Richmond Ave and Post Oak Blvd	2.1	1,300	41	1,928	4,940
26	Chicago	I90 Between I55 and W Pershing Rd	1.9	1,300	41	2,569	6,760
27	Atlanta	I75/I85 between Freedom Pkwy NE and North Ave NE	2.1	1,200	35	1,486	3,900
28	Houston	I69 between Hazard St and Buffalo Speedway	2.1	1,100	36	2,321	5,980
29	DC	I395 between Washington Blvd and George Washington Memorial Pkwy	1.8	1,100	35	1,221	2,860
30	Dallas	Woodall Rodgers Freeway	1.8	1,100	34	1,782	4,420
31	Toronto	Gardiner Expy between S Kingsway & Bay St	7.4	1,076	28	1,671	4,447
32	Boston	I93 between Edge Hill Rd and West St	19	1,000	36	1,373	3,380
33	Los Angeles	I405 between Burbank Blvd and Ventura Blvd	1.6	1,000	34	1,286	3,120
34	Los Angeles	US101 between SR110 and Alameda St	1.6	1,000	34	1,644	4,160
35	Montreal	Hwy 15 between Hwy 40 & Chemin de la Côte-Saint-Luc	3.9	812	19	1,653	4,273

Source: CPCS analysis of data provided by HERE and US state / CA provincial / local departments of transportation.

Appendix A: Mathematical Formulations

Calculating normalized hour-indexed delays
We calculated length-normalized hour-indexed delays (hours per mile) for every urban freeway segment i using this relationship:

$$Delay\ (d_{ji}) = Vehicles\ per\ hour_{ji} * \left(\frac{1}{Observed\ Speed_{ji}} - \frac{1}{Baseline\ Speed_{i}}\right)$$

Where,
Observed Speed is the weekday profile speed for every hour j in the day in every freeway segment i;

Baseline Speed is the Maximum Throughput Speed (MTS) for that freeway segment i, a counterfactual speed based on ideal travel conditions. We develop this for each segment using relationships published in the Transportation Research Board's Highway Capacity Manual (HCM);

Vehicles per hour is the hourly volume estimated as above.
The relationship above holds ONLY in weekday hours when the observed speed is lower than the Maximum Throughput Speed (ideal conditions). In other words, the conditions for calculating congestion are met when drivers experience slowdowns. When observed speed exceeds MTS, there is no congestion – delay in those hours and segments in 0.

Calculating Maximum Throughput Speed (MTS)

The Maximum Throughput Speed is the speed corresponding to optimal vehicle volume flow, i.e. the speed at which a maximum number of vehicles can pass through a road segment. Imagine an empty stretch of highway with a few vehicles passing through at the Free Flow Speed (FFS). As more vehicles enter the stretch, the volume (number of vehicles passing through a road segment at a given time) increases and the speed decreases due to lane changes, fluctuating separation distance, and other behavioral and design factors. As more and more vehicles enter the freeway, the volume reaches a theoretical maximum throughput – the speed at this stage in the traffic flow process is the MTS. Additional vehicles beyond this level of throughput start to reduce the speed leading to slow downs and congestion. Even though drivers experience slowdowns, this may still be far from "sitting in traffic" or jam conditions.

Although the MTS baseline is lower than the FFS, it represents a better use of available freeway capacity and is therefore an improved reference point for estimating delays due to congestion. Assuming a constant volume of vehicles in this range of speeds, using the MTS as a baseline also gives us a more conservative estimate of congestion. In other words, we most likely underestimate hourly delays.

To calculate the MTS (in mph):

$$MTS_i = 39 + 0.2 * FFS_i$$

Where,

FFS is the free flow speed as estimated by the 95th percentile of calculated weekday average hourly speeds. Because the hourly speeds themselves are average speeds, the calculated FFS is lower than the true 95th percentile speed. Our method of calculating FFS can be roughly interpreted as the average vehicle speed in the best or second-best hour of the day (which is usually an overnight or early morning hour when traffic volumes are low).

Ranking bottlenecks

We ranked bottlenecks by the metric Daily Total Delay (hours), defined as the sum of the estimated delays in all hours experienced by all vehicles entering and leaving a congestion queue on a representative non-holiday weekday.

To go from the length-normalized hour-indexed delay (hours per mile, as above) to the Daily Total Delay (hours), we followed a four-step process:

1. Adjustment to Daily Delay: We first calculated the length-normalized daily delay (hours/km) for all urban freeway segments i

$$Daily\ Delay\ (D_i) = \sum_{j=1}^{24} Delay\ (d_{ji})$$

2. Adjacency Analysis: We then defined a bottleneck as a group of contiguous highway segments i that are each above a certain Daily Delay threshold. For major bottlenecks, a cut-off of 400 hours/km of Daily Delay was chosen based on the Di distribution across all freeway segments with non-zero delays. In iterative analysis we found that a cut off of 300 hours/km did not change the list of bottlenecks, rather added some new adjacent segments to the existing list, thus 400 hours/km appeared to be a natural break in the distribution. The chosen cut-off represents the 90th percentile, meaning the top 10% of congested freeway segments qualified for national bottlenecks. If two bottlenecks were located within 0.5 km of each other, they, along with the segments in between were considered as being part of one corridor. NOTE: We did not apply this 0.5 km for the bottlenecks located in two different freeways near an interchange.

3. Length-weighting: The Daily Total Delay for each bottleneck was calculated as the sum-product of Daily Delay (Di) and length of individual segments i in a bottleneck.

$$Daily\ Total\ Delay_A = \sum_{i=1}^{n} Daily\ Delay\ (D_i) * Length_i$$

Where,

i represents a freeway segment that is part of bottleneck A, and n is the number of segments in that bottleneck. This resulting metric accounts for both length of the bottleneck and the expected volume of vehicles through that bottleneck over a 24-hour period. The corresponding queue length (in kilometers) for bottleneck A is LA, given by

$$Queue\ Length\ (L_A) = \sum^{n} Length_i$$

4. National Ranking: In the final step, we rank ordered all the bottlenecks identified in the adjacency analysis in Step 2, using the Daily Total Delay (hours) calculated in Step 3. We identified 240 hours of Daily Total Delay (or about 60,000 hours annually) as a natural break in the distribution of top-ranked bottlenecks. The final output of this analysis is the curated list of top 20 bottlenecks shown in the results.

Calculating the lost value of time due to delays

We valued each hour of delay using the province-specific estimate of the average hourly wage (CA $/hour). This value is a weighted average of employment wage rates across many labor and skill sectors, and based on data collected by Statistics Canada. This approach most likely underestimates the lost value of time, because it doesn't full include the value of an hour's work to the economy and its multiplying effects.

Calculating the benefits of alleviating congestion

We estimated the excess fuel spent due to congestion and potential fuel savings (liters) using relationships between vehicle speed (kilometers per hour, kph) and fuel economy (kilometers per liter, mpg) published by the Oak Ridge National Laboratory [6]. These relationships are based on lab tests as well as observed data from a large fleet of vehicles. Only the excess fuel used when vehicles are traveling at slow speeds during congested conditions are counted.

We then calculated the potential emissions avoided (kg CO2) using standard parameter values published by the Environment Canada [7]:

CO2 Emissions from a gallon of gasoline (for cars): 2.289 kg CO2/ litre

CO2 Emissions from a gallon of diesel (for trucks): 2.663 kg CO2/ litre

Appendix B: Comparison with Previous Estimate of Congestion Costs in the GTHA

Introduction

The purpose of this Study is to identify and rank the top highway congestion bottlenecks in urban areas in Canada. Although the purpose is not to explicitly calculate total congestion costs in each urban area, as a result of the process of identifying the top highway bottlenecks we are able to sum the total delay and associated delay costs across all highways in order to arrive at an estimate of total delay costs on those highways. This total can be compared to past estimates of congestion costs after adjusting for differences in scope in methodology.

The most notable past research conducted to identify congestion costs in Canada is a study completed by HDR for Metrolinx in 2008. [8] This HDR study is the source for the estimate of $6 billion in annual congestion costs in the Greater Toronto and Hamilton Area (GTHA) that is often cited by analysts and media. This appendix compares the HDR methodology to our methodology, identified key differences in data sources and reconciles the differences in the two estimates of total delay costs in the GTHA.

Comparison of Methodology

The HDR report estimated the following components of congestion costs in the GTHA for 2006:

- Time (delay) costs (auto and transit users)
- Vehicle operating costs
- Accidents
- Vehicle emissions

In addition, the HDR report estimated the cost in terms of a reduction in regional GDP (due to lost employment, etc.). These costs are not explicitly added to the above congestion costs but it is implied by the report that they are additive (the $6 billion total cost figure that is frequently cited is the sum of both the congestion costs above and the reduction in regional GDP).

In terms of coverage, the HDR report includes the following municipalities:

- Hamilton
- Halton Region
- Peel Region
- City of Toronto
- Region of York
- Durham Region

The analysis covers expressways, arterials, collectors and "important" local roads.

The key data source for VKT was Metrolinx modelling that was conducted in support of the Draft Regional Transportation Plan. The modelling covered the AM peak period (the values were then extrapolated to cover the PM peak period as well by HDR). Travel speeds were estimated from VKT from speed-flow functions (based on US Bureau of Public Road functions).

Relative to our methodology, the HDR methodology:

- Covered a broader range of congestion costs, by including estimates of transit user time costs, accident costs, vehicle operating costs (beyond fuel costs) and reductions in regional GDP. For a rough comparison, these costs can be scaled relative to auto user time costs to make the estimates more comparable, as excess travel times are at the core of all costs estimated by HDR.
- Covered a larger portion of the road network (arterials, collectors and important local roads). This difference can roughly be addressed by estimating the portion of VKT that occurs on expressways relative to other roads. The HDR report notes that the majority of VKT occurs on expressways.
- Used modelled rather than observations of actual travel speeds. The HDR report estimated travel speeds based on observed traffic volumes using the standard BPR function. Our analysis used observations of actual travel speeds by road segment. This is an important distinction as actual travel speeds can deviate substantially from modelled travel speeds.

Reconciling the Data

At the core of HDR's estimates of congestion costs is the estimate of auto user travel delay. Their estimates of auto user travel delay and other congestion cost components are shown below.

Figure A1. Summary of Components of Congestion Costs from HDR Report

Component	Annual Cost ($million)
Time cost- auto users	2,245
Time cost- transit riders	337
Vehicle operating costs	479
Accidents	256
Vehicle emissions	29
Cost of Congestion (all of the above)	3,346
Reduction in Regional GDP	2,733
Total of Congestion and Reduction in Regional GDP*	6,079*

Source: HDR, Page 3, Table 1.

*The Cost of Congestion and Reduction in Regional GDP are not explicitly added together in the HDR report.

The auto user time costs are a function of actual travel speeds, "optimal" travels speeds, total traffic volumes and the value of time. Their optimal speeds in the morning peak period are estimated to average 74.6 kph for the region compared to their estimated average actual speeds of 50.6 kph. Excess hours of travel are estimated to total over 93 million annually, broken down by region/city as shown below. Also shown are estimates of AM Peak VKT.

Figure A2. Summary of Auto User Travel Delay Estimate from HDR Report

Municipality	Hours per Year (thousands)	AM Peak VKT
Hamilton	2,340,523	1,791,463
Halton Region	6,321,584	3,606,596
Peel Region	23,099,566	6,421,952
City of Toronto	42,463,052	9,296,614
Region of York	16,794,912	6,134,044
Durham Region	7,909,060	3,874,073
GTHA Total*	98,928,697*	31,124,742

Source: HDR, Page 12 (Table 1), Page A1-1 (Table 12).
*The sum of all municipality shown in the report does not equal the GTHA Total shown in the report. The GTHA Total shown in this table is the sum of the hours from each of the municipalities.

In order to contrast HDR's estimates of total congestion costs with our own, the key component is the total hours of travel delay for the GTHA, which is approximately 93 million hours annually (as noted, the GTHA total in the table above is calculated as the sum of hours across all municipalities, we refer to the 93 million figure to be consistent with the main text provided in the HDR report). After adjusting for the fact that the 93 million hours are based on travel on most of the road network in the GTHA, as opposed to travel primarily on expressways, we have an estimate that is roughly comparable to that of our own.

Total and Expressway VKT in the GTHA

As noted, HDR estimated that the majority of VKT in the GTHA occurs on expressways. Our own analysis conducted by estimating VKT on the highway network (AADT per road segment multiplied by segment length) and comparing this total to estimates of total VKT for the whole city or region (from the Transportation Tomorrow Survey) confirm this to be the case. For example, our estimate of VKT on the expressways in the GTHA (including the Hamilton, Toronto and Oshawa CMAs) is 19.4 billion annually. Meanwhile VKT by households (which excludes business VKT) for the TTS area (which is larger than the GTHA) is estimated to be 22.6 billion annually.

The estimate from the TTS is likely an underestimate as it was calculated by multiplying total trips by median trip length (whereas the mean trip length is likely longer than the median trip length). Furthermore, there is a significant amount of commercial vehicle activity that is not captured by the TTS. Despite these differences in survey

coverage, these results confirm that at least the majority of VKT in the GTHA occurs on expressways.

Although the majority of VKT occurs on expressways, it is not necessarily the case that the majority of time is spent on expressways. This is due to the fact that despite the presence of road congestion, average travel speeds on expressways remain higher than on other road types, even during peak hours. Although our raw speed data set is primarily constrained to expressways, we were able to conduct a rough analysis of travel speeds for a sample of expressways and arterial roads in the GTHA using HERE's and other sources' online travel planners available in the public domain, combined with assumptions of the number of lanes by road type and vehicles per lane hour. According to this rough analysis, we estimated that approximately 68% of the travel delay in the GTHA occurs on expressways. If this analysis included a sample of collector or local roads, the portion of travel delay that occurs on expressways would be smaller. However, the high number confirms at the very least that a large portion and perhaps the majority of travel delay does indeed occur on expressways.

Our Estimates of VKT and Total Hours of Delay

Given the above analysis, if we were to assume that half of the travel delay occurs on expressways, we would be able to sum the travel delay across all expressways in our analysis and multiply that sum by two to arrive at an estimate of auto user travel delay that is comparable to the total auto user travel delay estimated by HDR. Our estimate of total auto user travel delay on expressways is 13.4 million hours annually. Multiplying by two gives us an estimate of 26.8 million hours annually, a number that is far lower than the 93 million hours estimated by HDR (despite the fact that HDR's base year was 2006 and our base year was 2012 for the volume data and 2015 for the speed data). Assuming that the hourly Value of Travel Time savings have remained similar, this implies a much lower total cost of congestion from our analysis.

There are likely two key areas which contribute to the difference in the estimates of total delay costs. One is that HDR's travel speeds were modelled from volumes, whereas our travel speeds were based on observations of actual speeds. As noted, modelled speeds could diverge significantly from actual speeds.

The other key difference is the assumption in the baseline travel speed to which estimates of actual speeds are compared in order to arrive at the estimate of total delay. HDR used an average baseline speed of 74.6 kph, which they considered to represent the "optimal" travel speed. Our average baselines speed was based on an estimate of Maximum Throughput Speed, in this case typically ranged between 70 – 83 kph for the GTHA. Note that these baseline speeds are not directly comparable because the HDR estimate is based on an average of travel speeds on expressways, arterials, collectors and important local roads. The fact that other road types are included in HDR's analysis seems to indicate that an optimal average travel speed

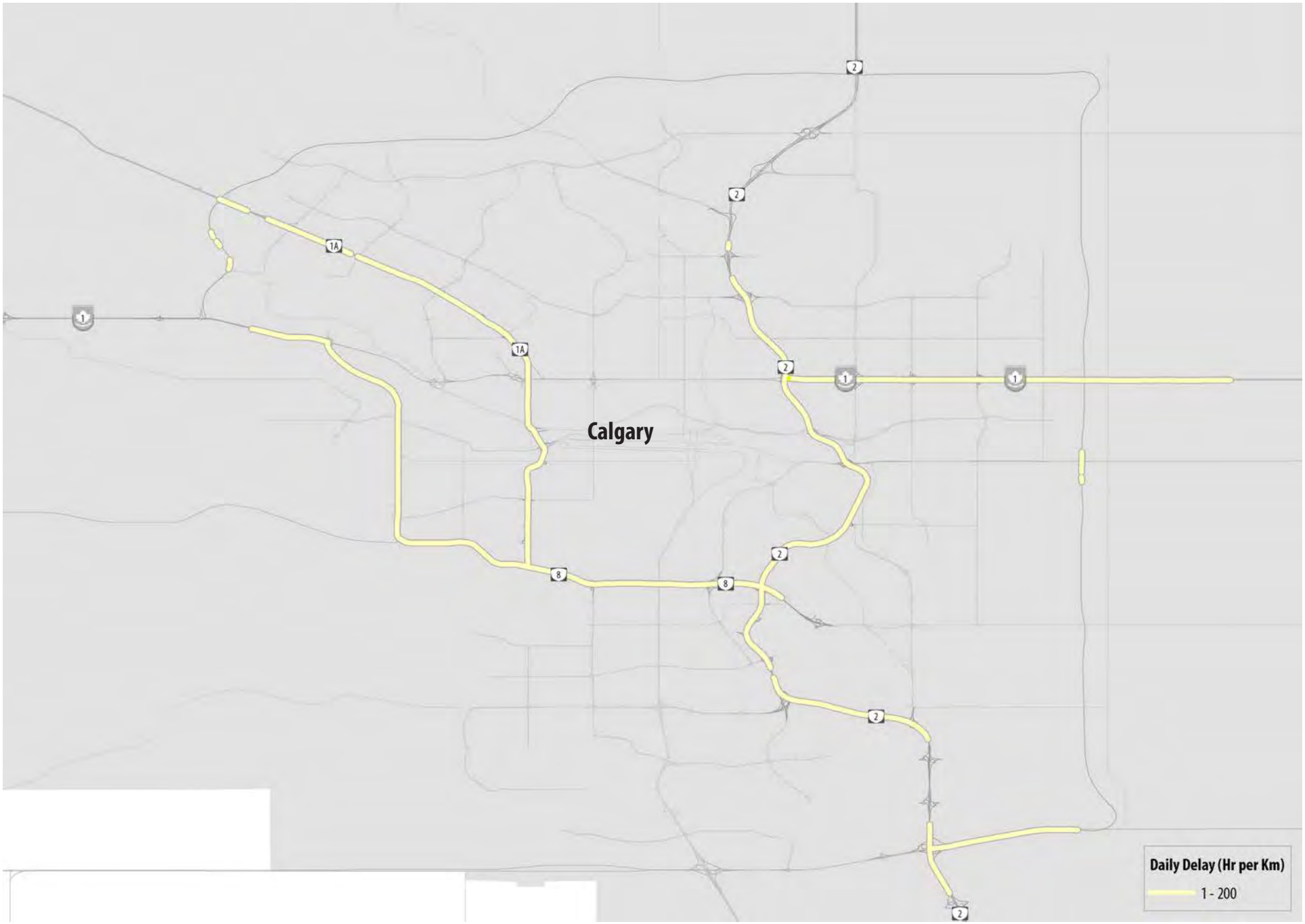
of 74.6 kph in peak hours may be unreasonably high. In other words, if our analysis suggests that the MTS ranges between 70 – 83 kph on expressways, the optimal travel speed averaged across all road types is likely to be much lower than this range. This difference in the two approaches is likely the primary cause of the difference in the two estimate of auto user congestion costs.

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Appendix C: Delay Maps for All CMAs

The following delay maps for each CMA show our estimates of the total daily delay (in hours) per kilometer on the highway networks that were included in our analysis. As indicated in the discussion of our methodology, the total delay takes into account both speed and traffic volumes. This means that the maps differ from maps that solely depict speed in that they indicate the stretches of highway where travel speeds are low and a large number of motorists are experiencing those low travel speeds.

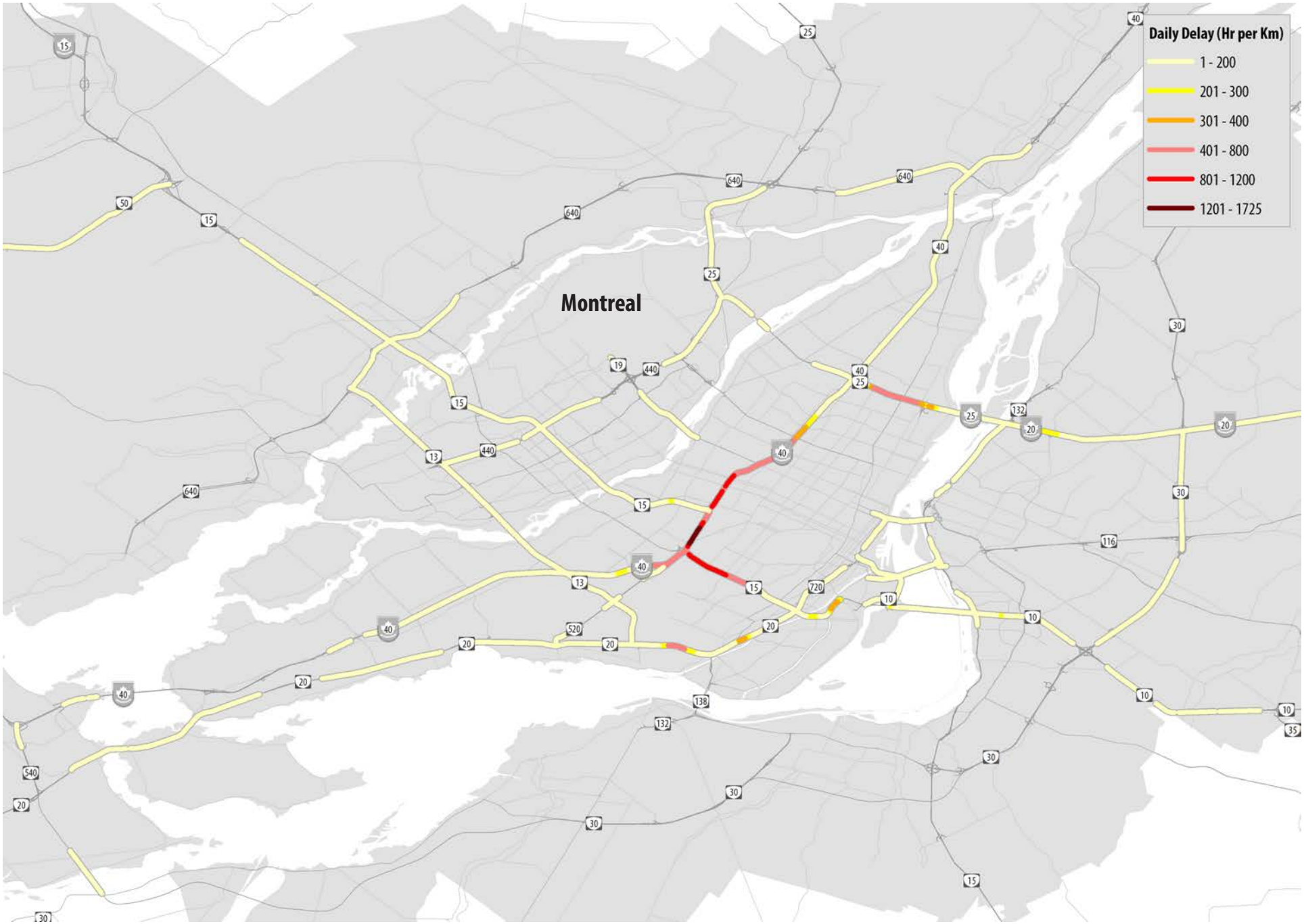
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Calgary
Daily Delay (Hr per Km)
1 - 200

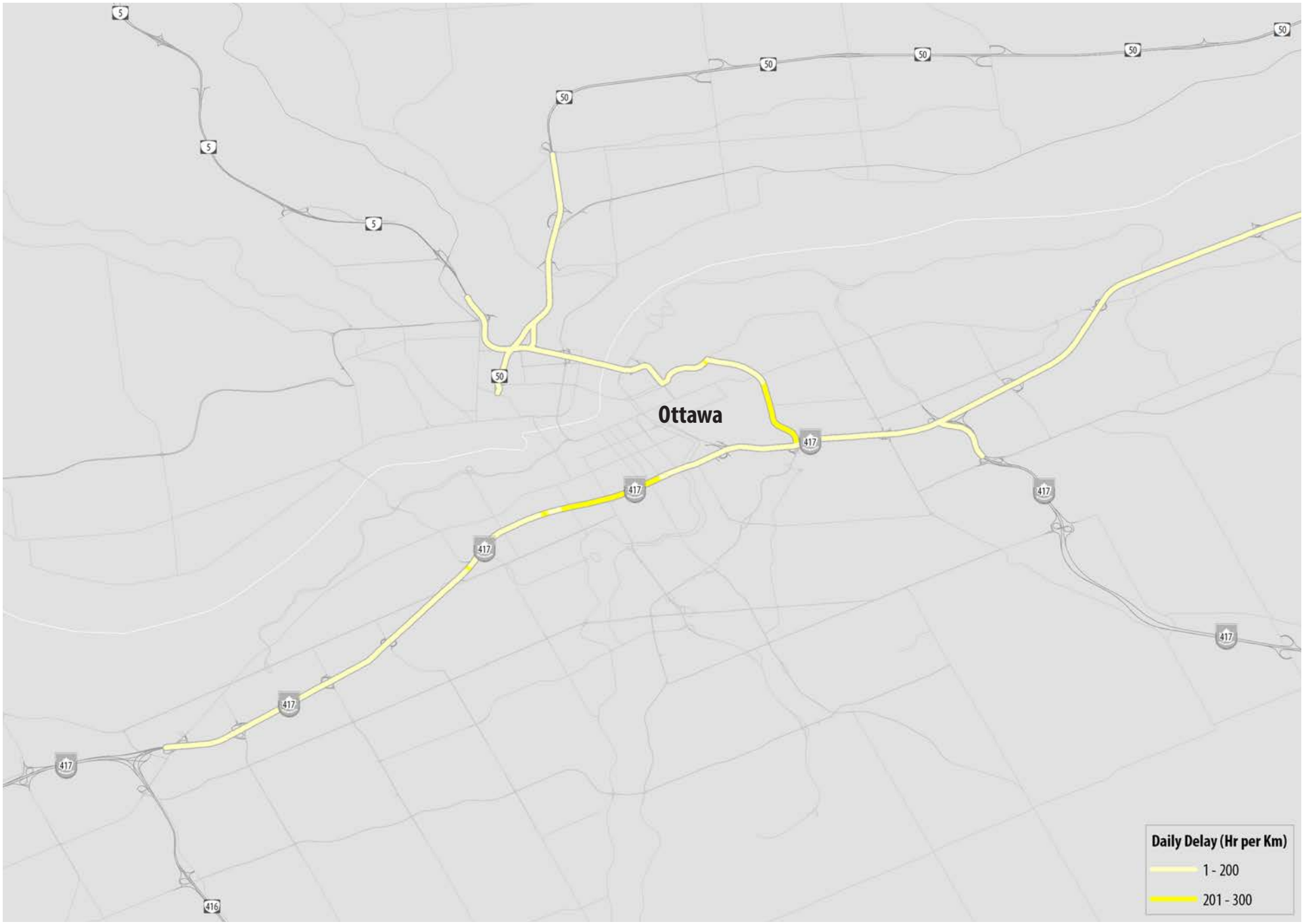

Edmonton
16
16A
216
2
630
14
Daily Delay (Hr per Km)
1 - 200
201 - 300
301 - 400


Halifax
Daily Delay (Hr per Km)
1 - 200


407
403
403
403
Hamilton
6
6
403
Daily Delay (Hr per Km)
1 - 200


Daily Delay (Hr per Km)
1 - 200
201 - 300
301 - 400
401 - 800
801 - 1200
1201 - 1725
Montreal

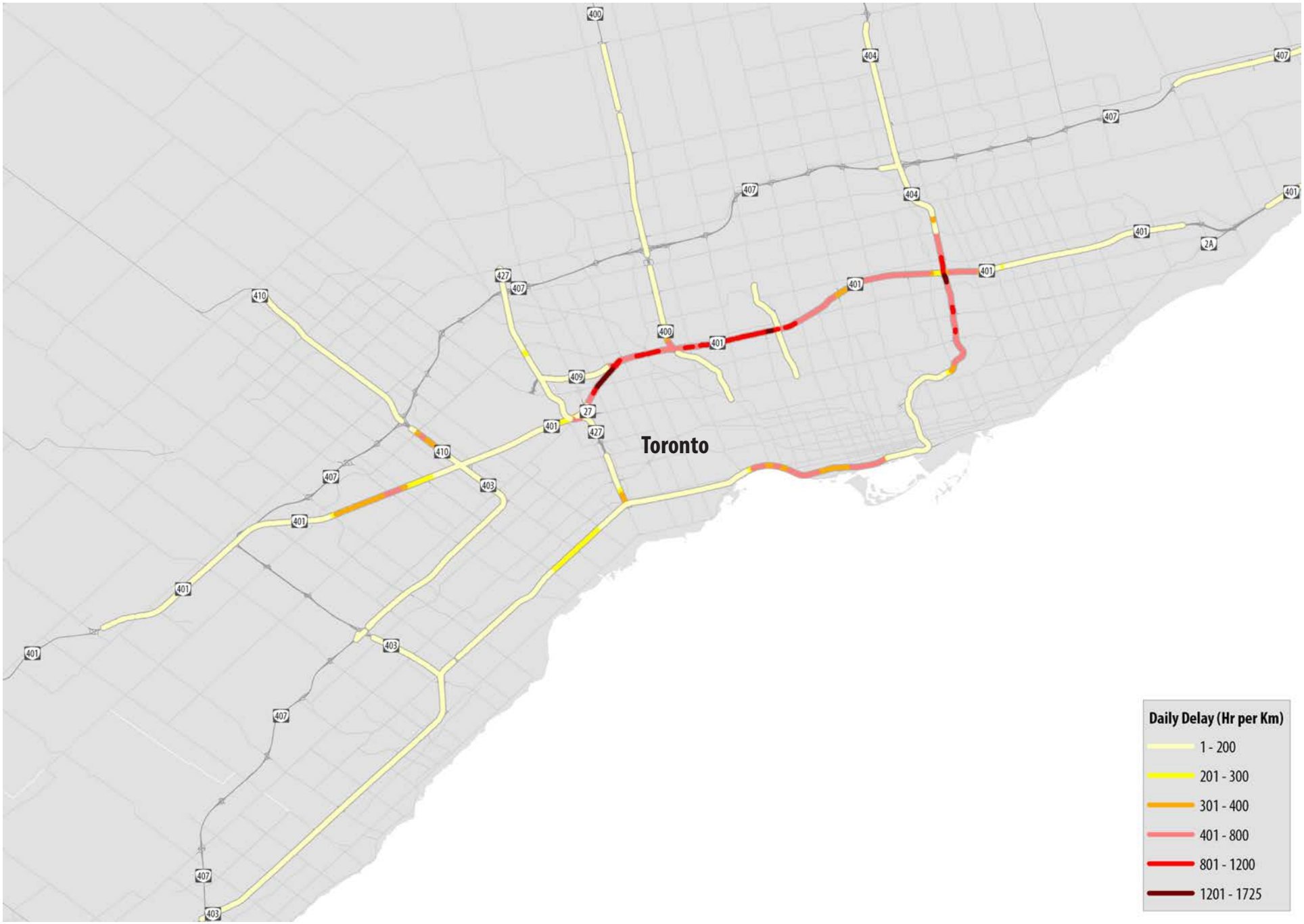

Oshawa
407
401
2A
115
Daily Delay (Hr per Km)
1 - 200
201 - 300
301 - 400


Ottawa
Daily Delay (Hr per Km)
1 - 200
201 - 300

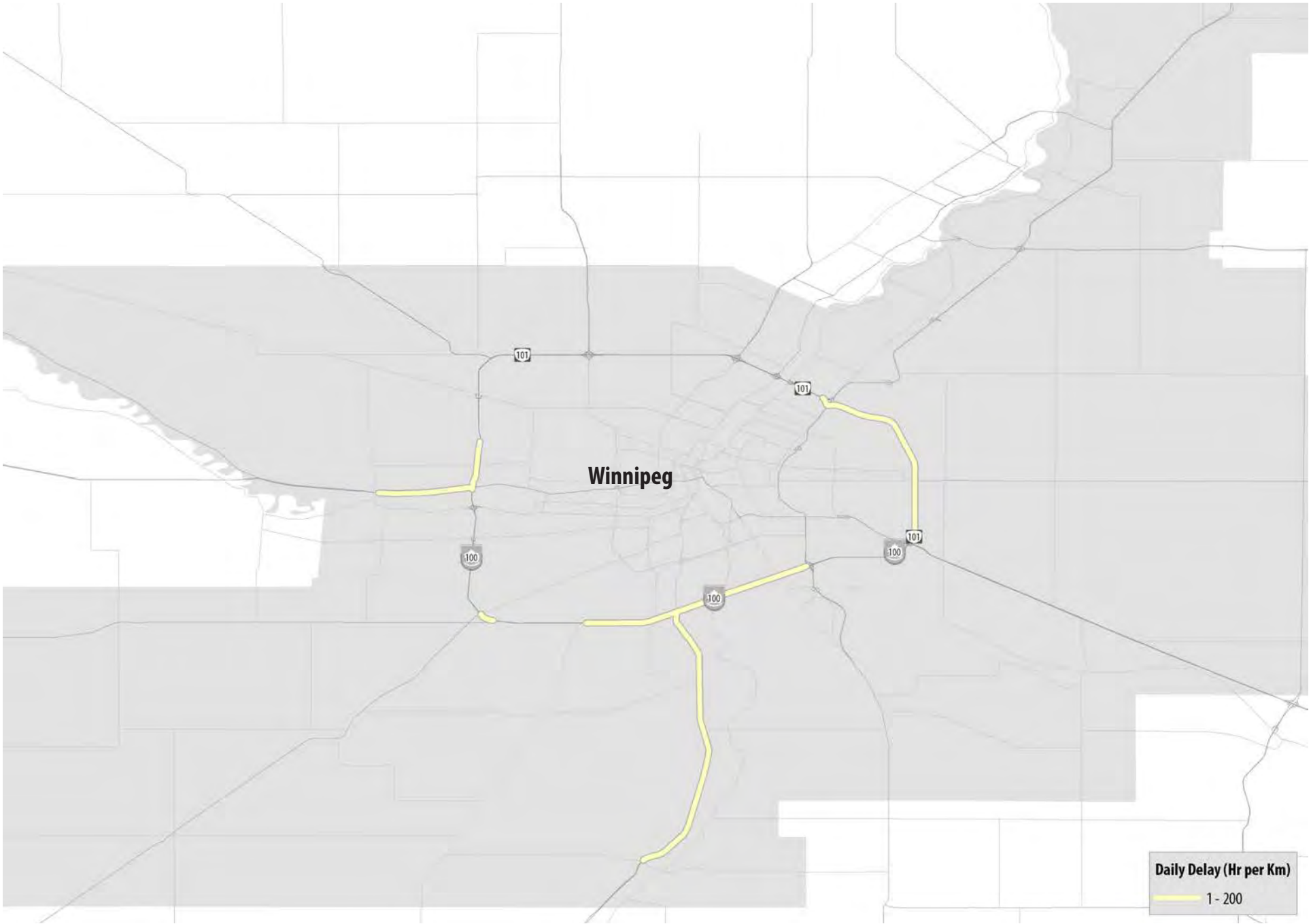

Quebec City
Daily Delay (Hr per Km)
1 - 200
201 - 300
301 - 400


11
6
Regina
1
Daily Delay (Hr per Km)
1 - 200


St. Catharine's
406
406
406
405
405
58
420
Daily Delay (Hr per Km)
1 - 200


Toronto
Daily Delay (Hr per Km)
1 - 200
201 - 300
301 - 400
401 - 800
801 - 1200
1201 - 1725

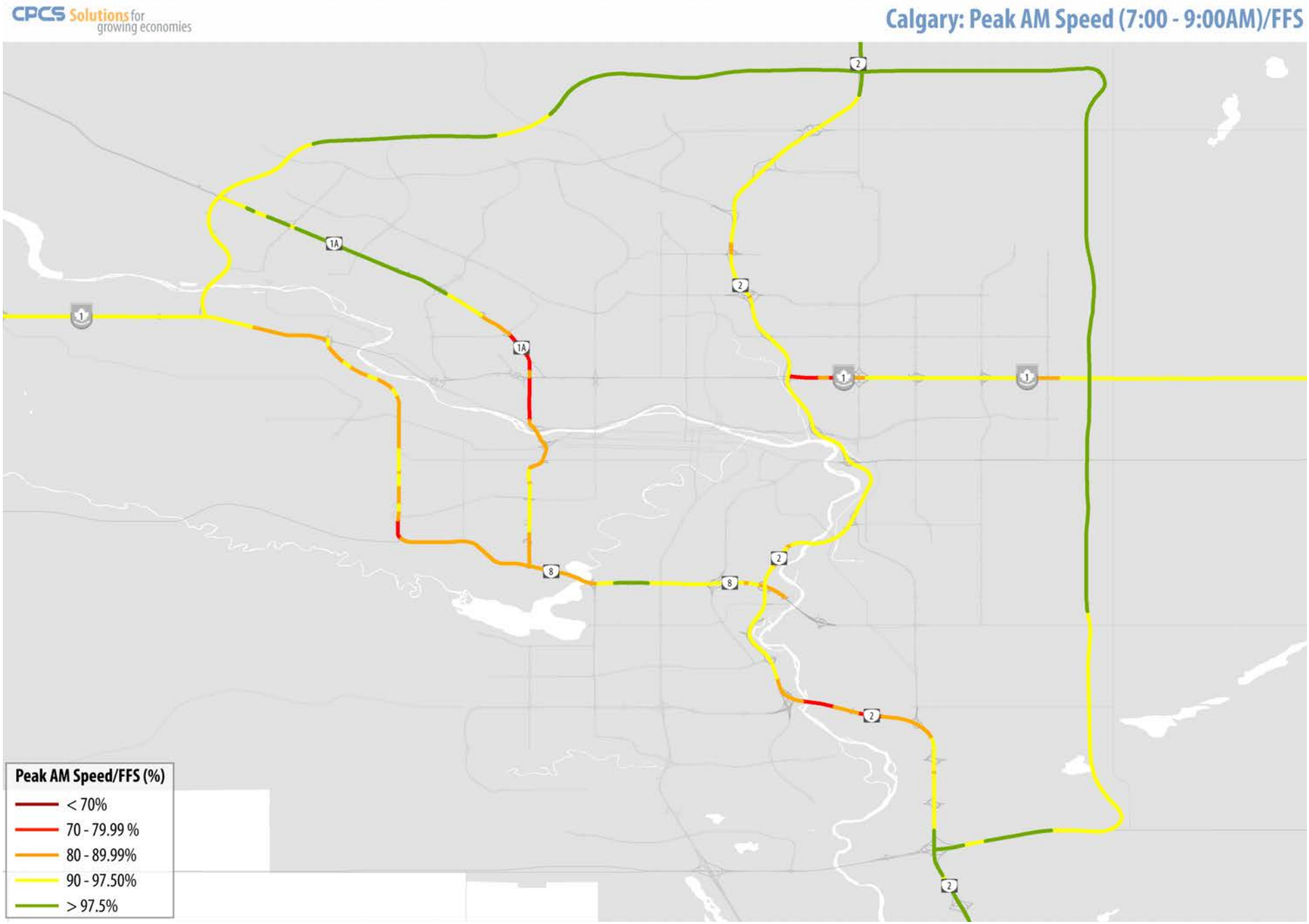

Vancouver
1
91
91A
99
Daily Delay (Hr per Km)
1 - 200
201 - 300
301 - 400
401 - 800
801 - 1200

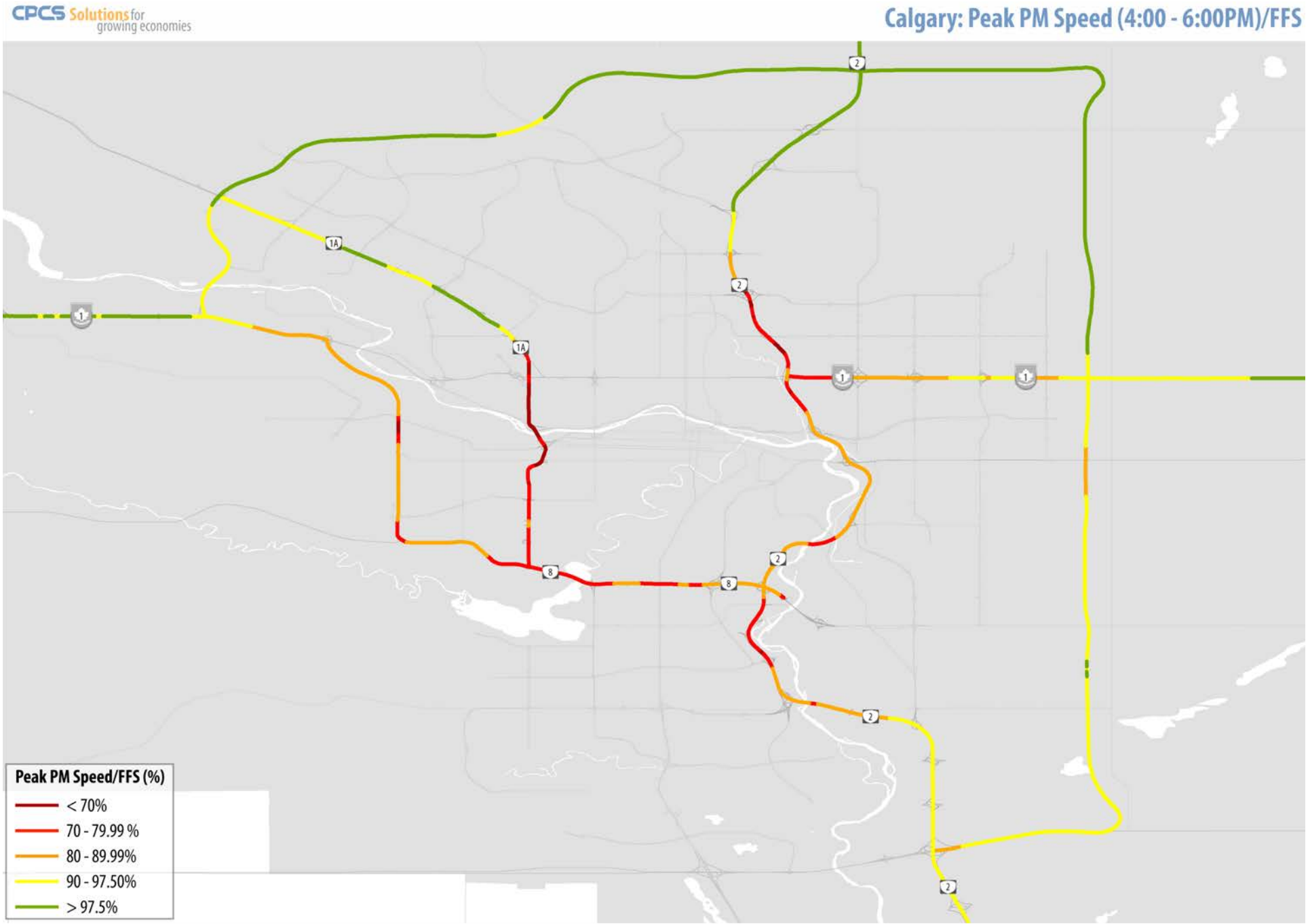

Winnipeg
101
101
101
100
100
100
Daily Delay (Hr per Km)
1 - 200

Appendix D: Speed Relative to Free Flow Maps

The following maps show the average AM or PM travel speeds relative to free flow speeds in each CMA.

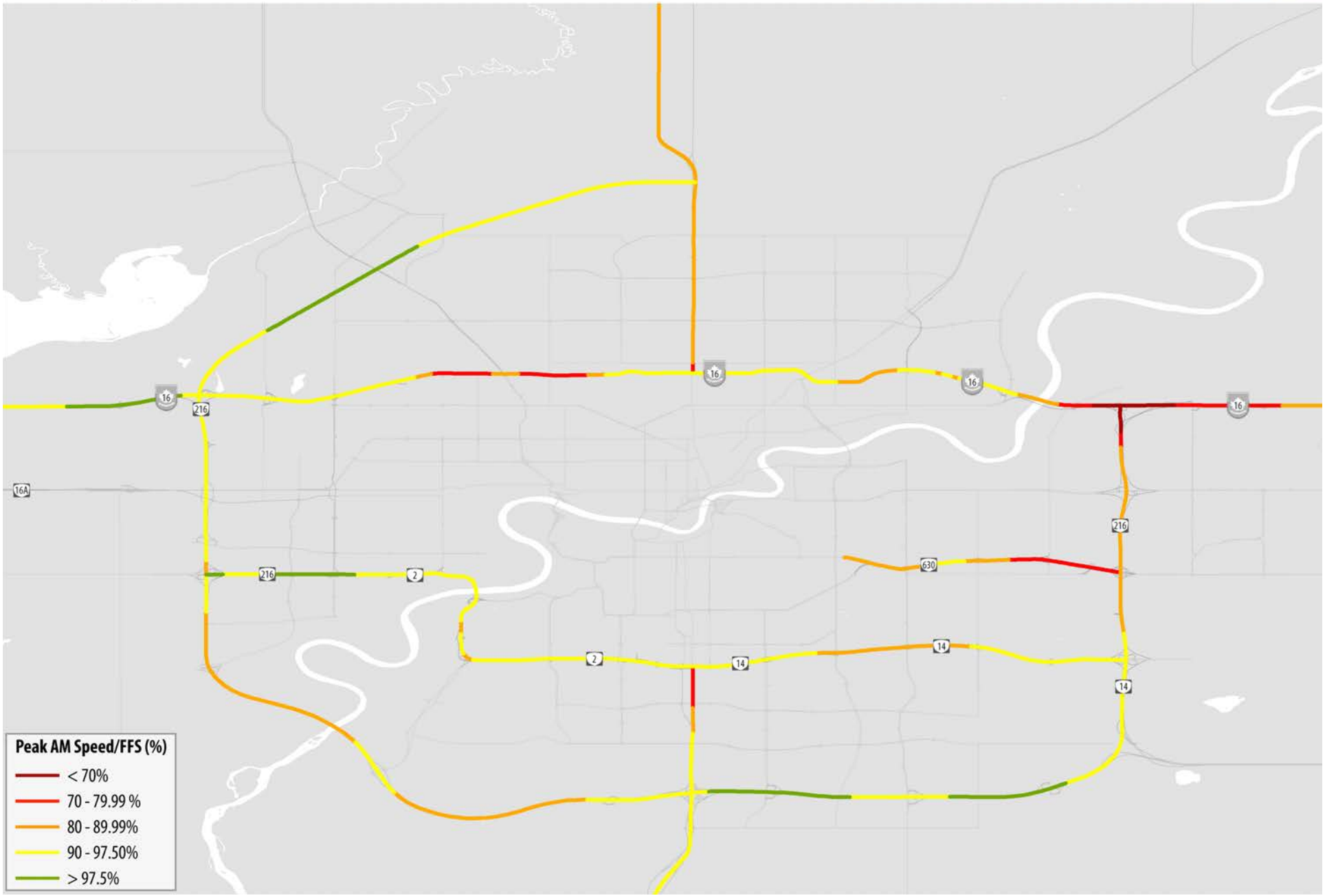
CMD 26-H7.39-Ref3 - Page 1157


CPCS Solutions for growing economies
Calgary: Peak AM Speed (7:00 - 9:00AM)/FFS
Peak AM Speed/FFS (%)
< 70%
70 - 79.99 %
80 - 89.99%
90 - 97.50%
> 97.5%


CPCS Solutions for growing economies
Calgary: Peak PM Speed (4:00 - 6:00PM)/FFS
Peak PM Speed/FFS (%)
< 70%
70 - 79.99 %
80 - 89.99%
90 - 97.50%
> 97.5%

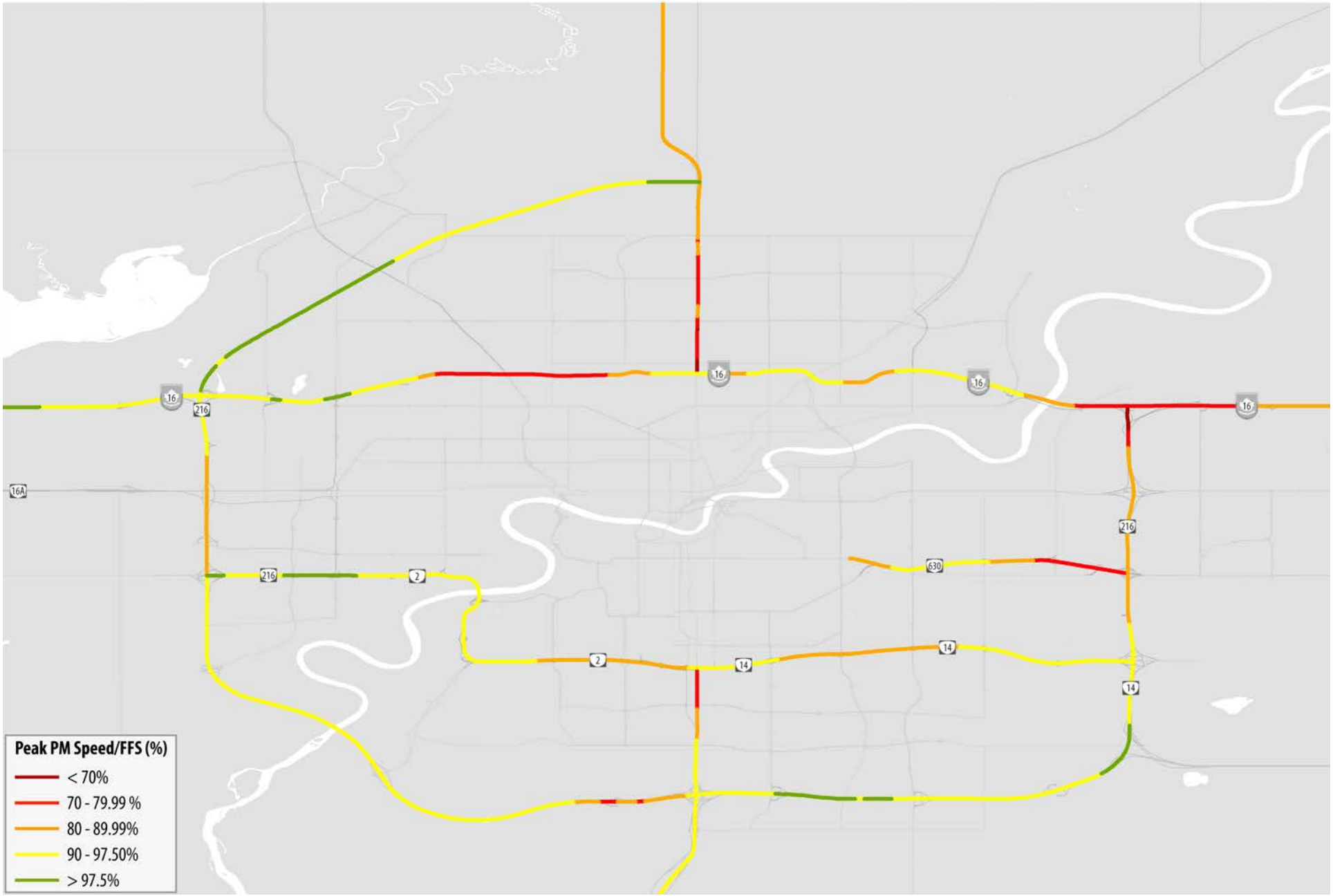
CPCS Solutions for growing economies

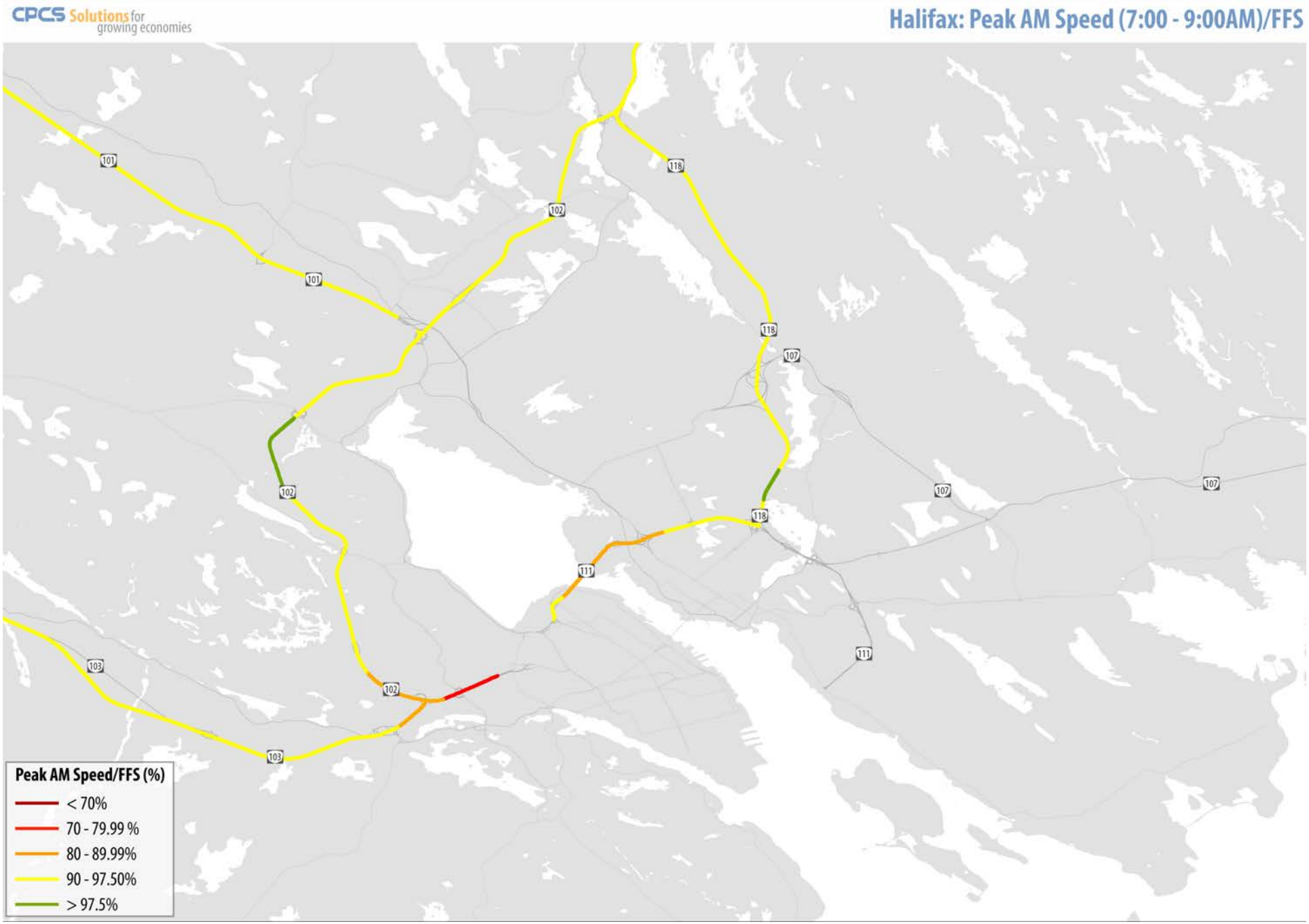
Edmonton: Peak AM Speed (7:00 - 9:00AM)/FFS

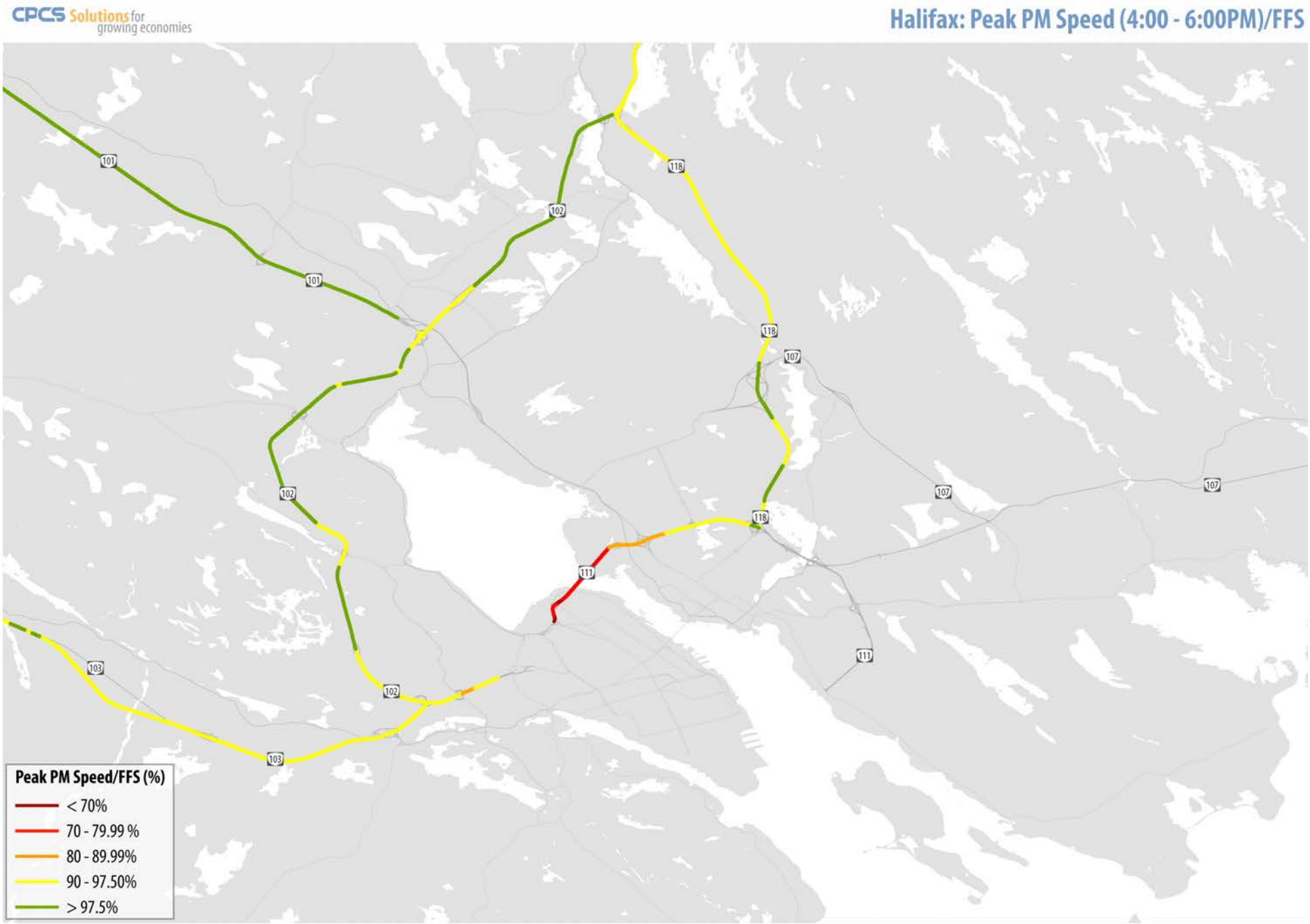


CPCS Solutions for growing economies

Edmonton: Peak PM Speed (4:00 - 6:00PM)/FFS




CPCS Solutions for growing economies
Halifax: Peak AM Speed (7:00 - 9:00AM)/FFS
101
101
102
102
102
118
118
118
107
107
107
111
111
103
103
Peak AM Speed/FFS (%)
< 70%
70 - 79.99 %
80 - 89.99%
90 - 97.50%
> 97.5%

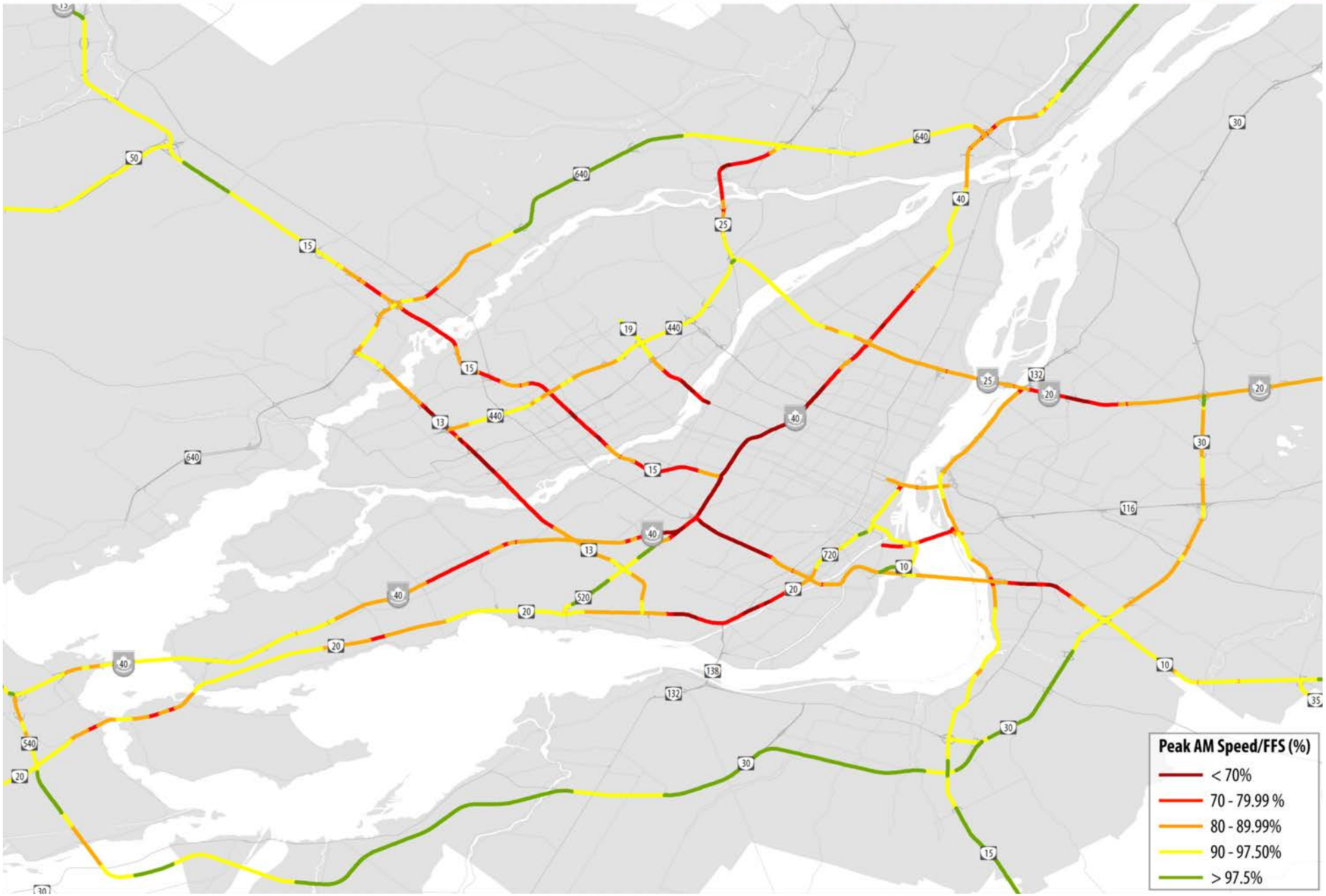

CPCS Solutions for growing economies
Halifax: Peak PM Speed (4:00 - 6:00PM)/FFS
101
101
102
102
102
103
103
118
118
118
107
107
107
111
111
Peak PM Speed/FFS (%)
< 70%
70 - 79.99 %
80 - 89.99%
90 - 97.50%
> 97.5%


CPCS Solutions for growing economies
Hamilton: Peak AM Speed (7:00 - 9:00AM)/FFS
407
407
403
403
403
6
6
Peak AM Speed/FFS (%)
< 70%
70 - 79.99 %
80 - 89.99%
90 - 97.50%
> 97.5%


CPCS Solutions for growing economies
Hamilton: Peak PM Speed (4:00 - 6:00PM)/FFS
407
407
403
403
6
6
403
Peak PM Speed/FFS (%)
< 70%
70 - 79.99 %
80 - 89.99%
90 - 97.50%
> 97.5%

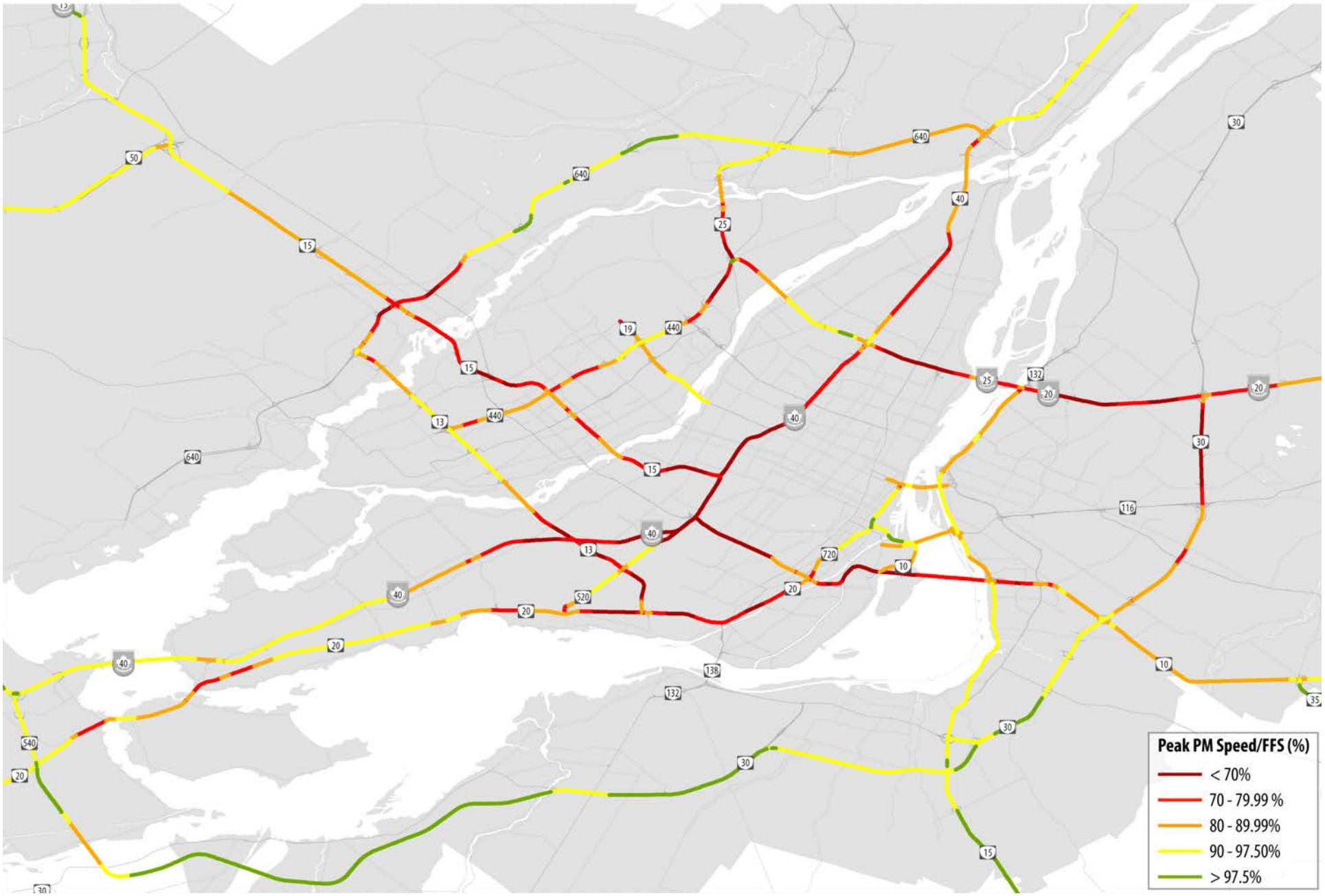
CPCS Solutions for growing economies

Montréal: Peak AM Speed (7:00 - 9:00AM)/FFS



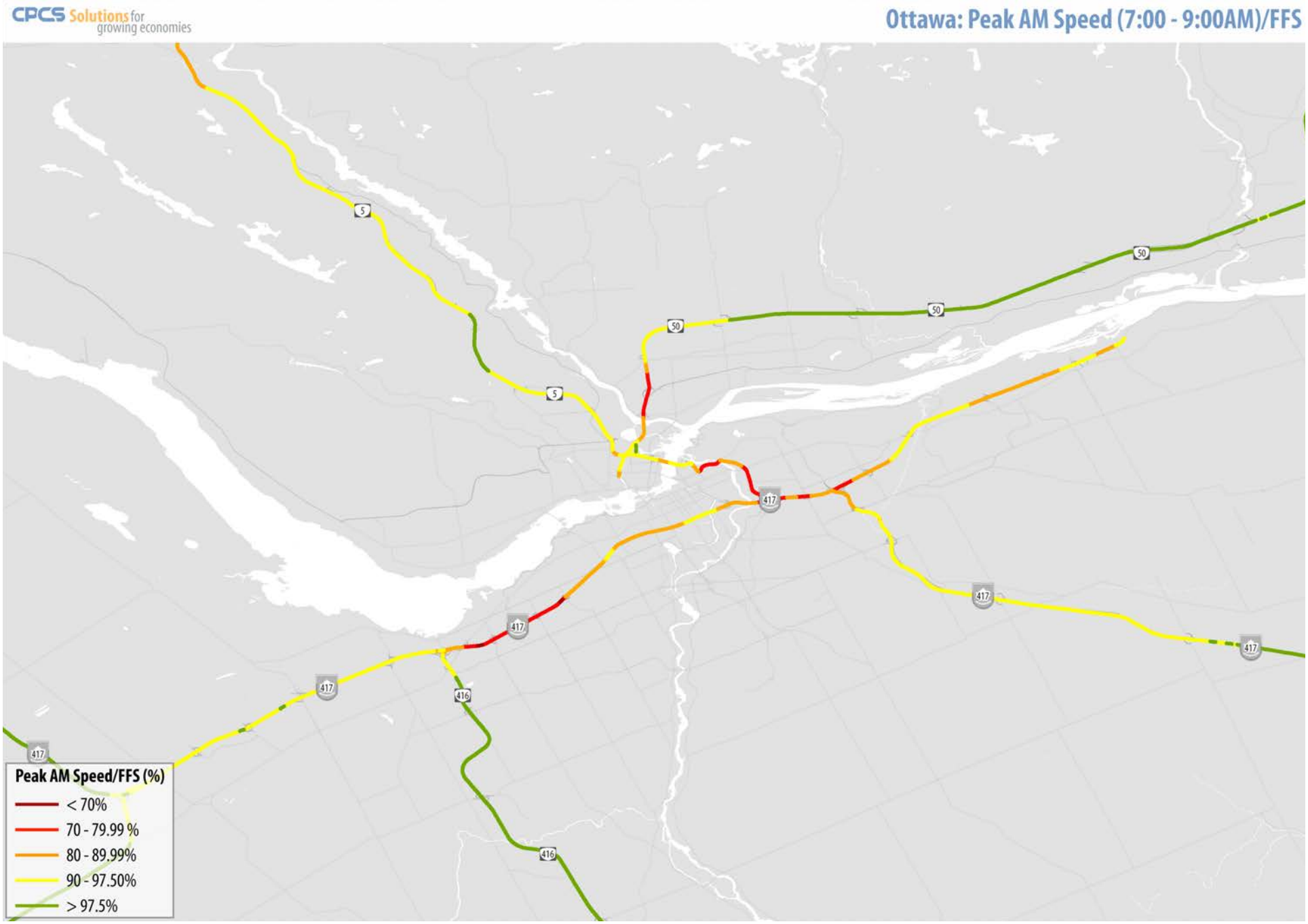
CPCS Solutions for growing economies

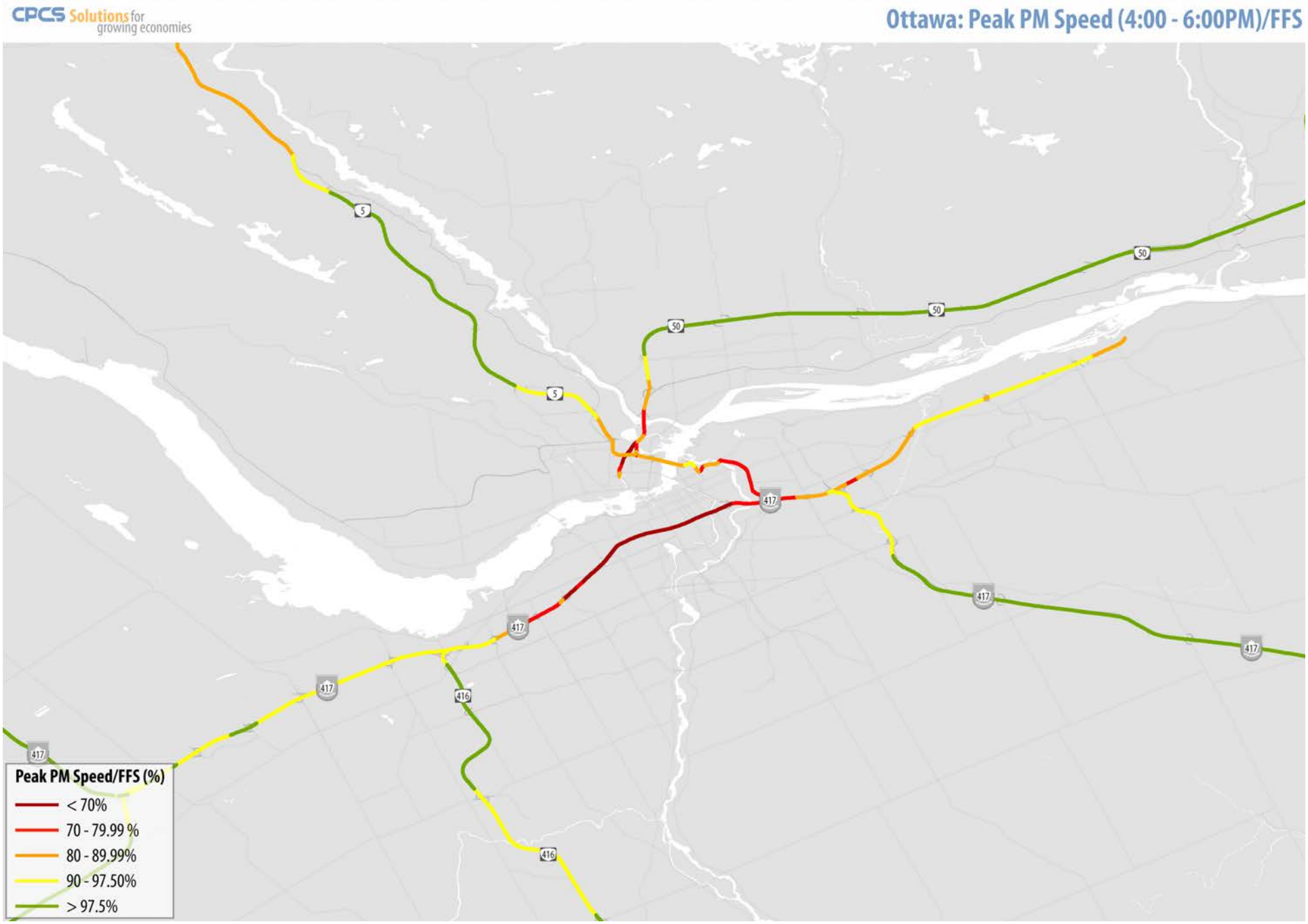
Montréal: Peak PM Speed (4:00 - 6:00PM)/FFS

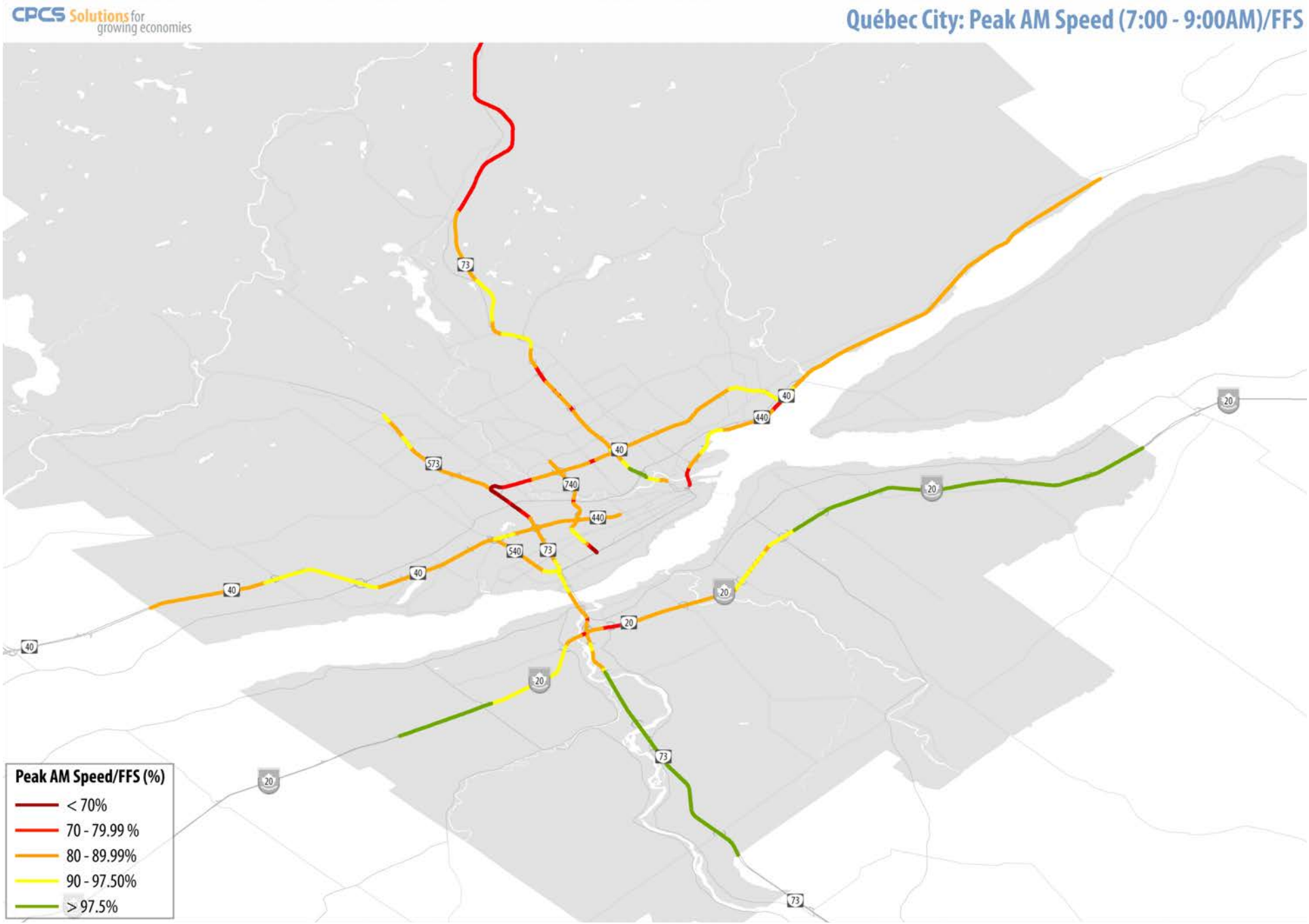


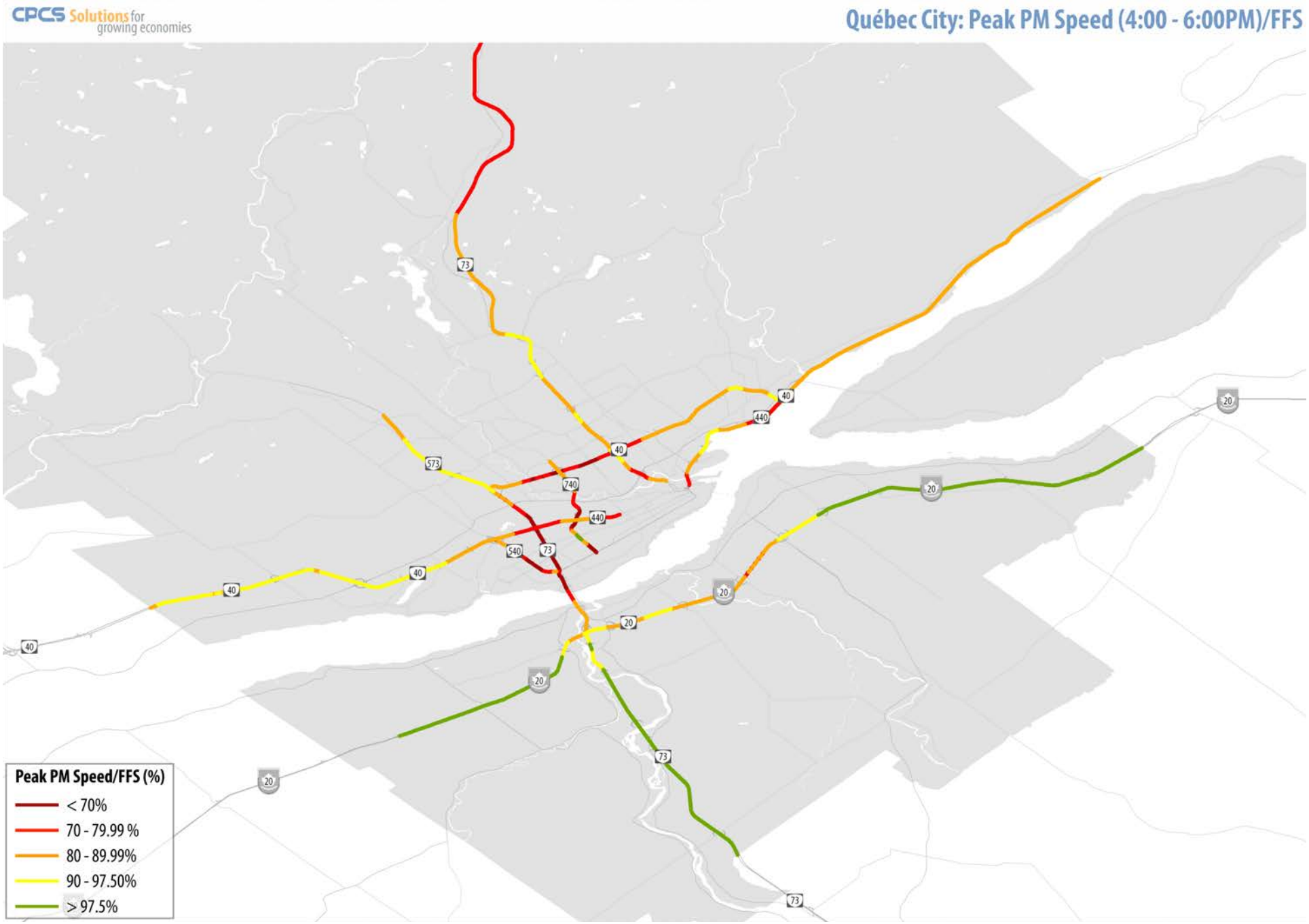

CPCS Solutions for growing economies
Oshawa: Peak AM Speed (7:00 - 9:00AM)/FFS
115
115
407
407
401
401
401
401
401
2A
Peak AM Speed/FFS (%)
< 70%
70 - 79.99 %
80 - 89.99%
90 - 97.50%
> 97.5%


CPCS Solutions for growing economies
Oshawa: Peak PM Speed (4:00 - 6:00PM)/FFS
115
115
407
407
401
401
401
401
401
401
2A
Peak PM Speed/FFS (%)
< 70%
70 - 79.99 %
80 - 89.99%
90 - 97.50%
> 97.5%


CPCS Solutions for growing economies
Ottawa: Peak AM Speed (7:00 - 9:00AM)/FFS
Peak AM Speed/FFS (%)
< 70%
70 - 79.99 %
80 - 89.99%
90 - 97.50%
> 97.5%


CPCS Solutions for growing economies
Ottawa: Peak PM Speed (4:00 - 6:00PM)/FFS
Peak PM Speed/FFS (%)
< 70%
70 - 79.99 %
80 - 89.99%
90 - 97.50%
> 97.5%


CPCS Solutions for growing economies
Québec City: Peak AM Speed (7:00 - 9:00AM)/FFS
Peak AM Speed/FFS (%)
< 70%
70 - 79.99 %
80 - 89.99%
90 - 97.50%
> 97.5%

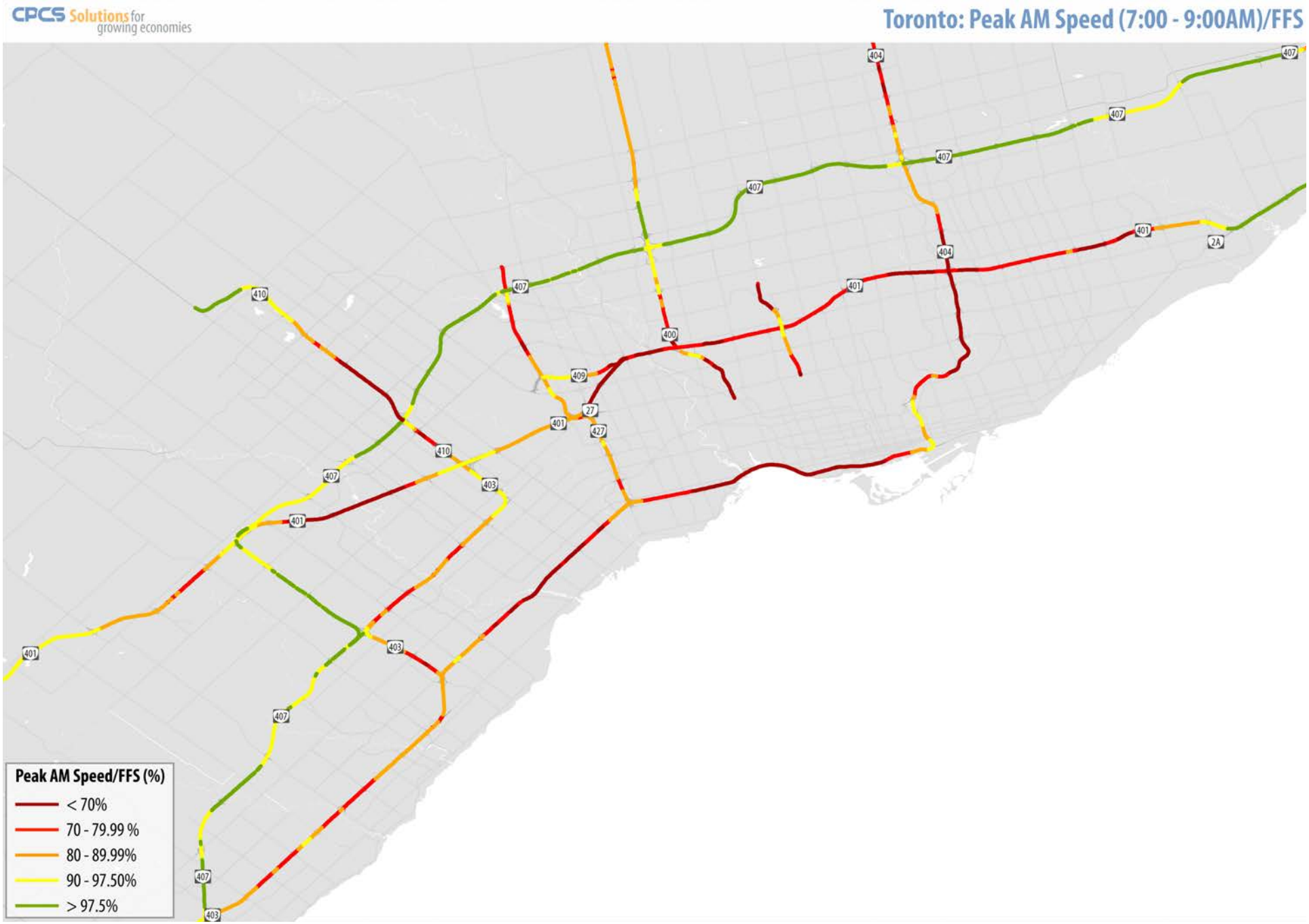

CPCS Solutions for growing economies
Québec City: Peak PM Speed (4:00 - 6:00PM)/FFS
Peak PM Speed/FFS (%)
< 70%
70 - 79.99 %
80 - 89.99%
90 - 97.50%
> 97.5%
73
40
440
573
740
540
20

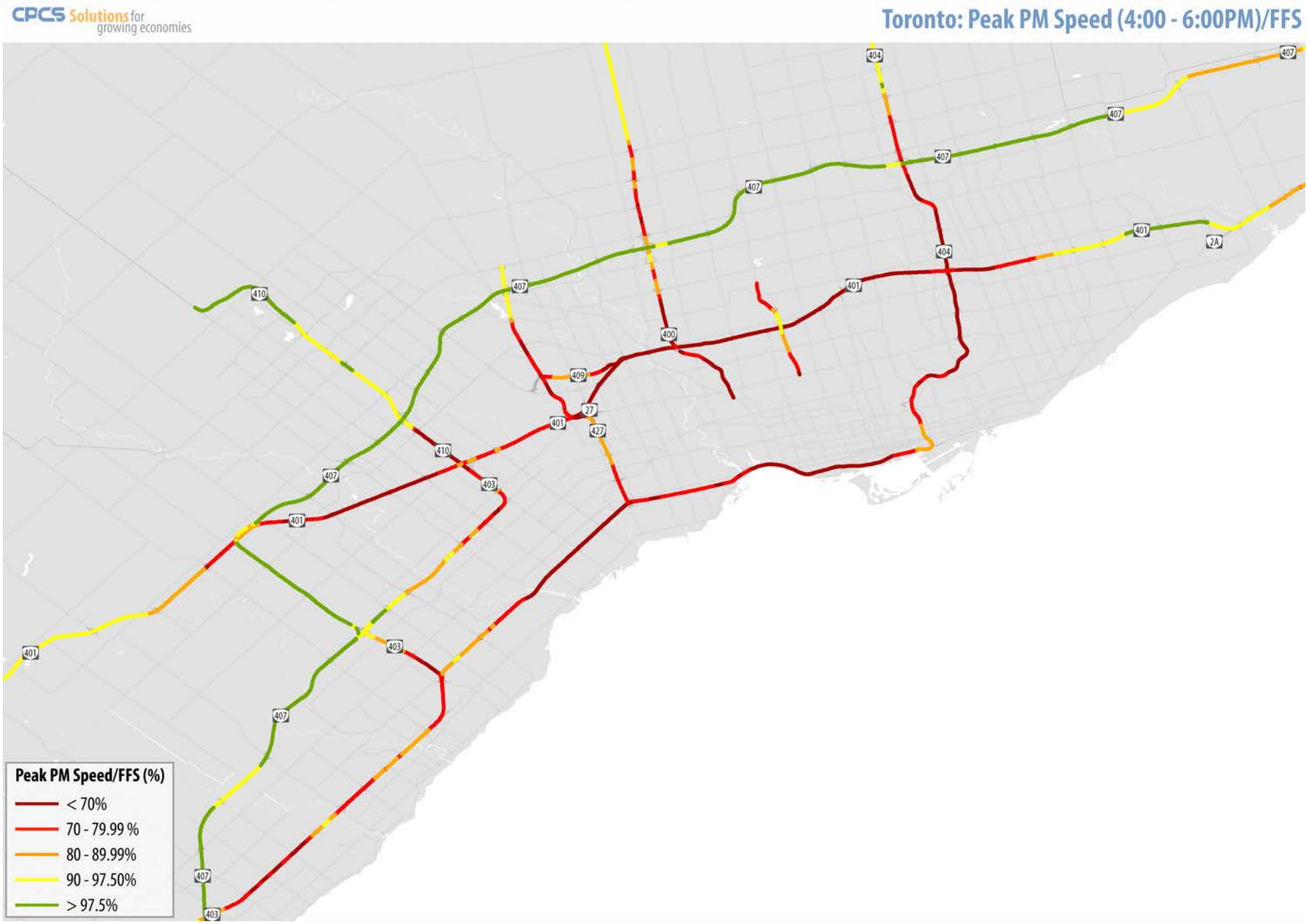

CPCS Solutions for growing economies
Regina: Peak AM Speed (7:00 - 9:00AM)/FFS
11
6
1
Peak AM Speed/FFS (%)
< 70%
70 - 79.99 %
80 - 89.99%
90 - 97.50%
> 97.5%


CPCS Solutions for growing economies
Regina: Peak PM Speed (4:00 - 6:00PM)/FFS
11
6
1
Peak PM Speed/FFS (%)
< 70%
70 - 79.99 %
80 - 89.99%
90 - 97.50%
> 97.5%


CPCS Solutions for growing economies
St. Catharine's: Peak AM Speed (7:00 - 9:00AM)/FFS
406
405
405
58
420
Peak AM Speed/FFS (%)
< 70%
70 - 79.99 %
80 - 89.99%
90 - 97.50%
> 97.5%

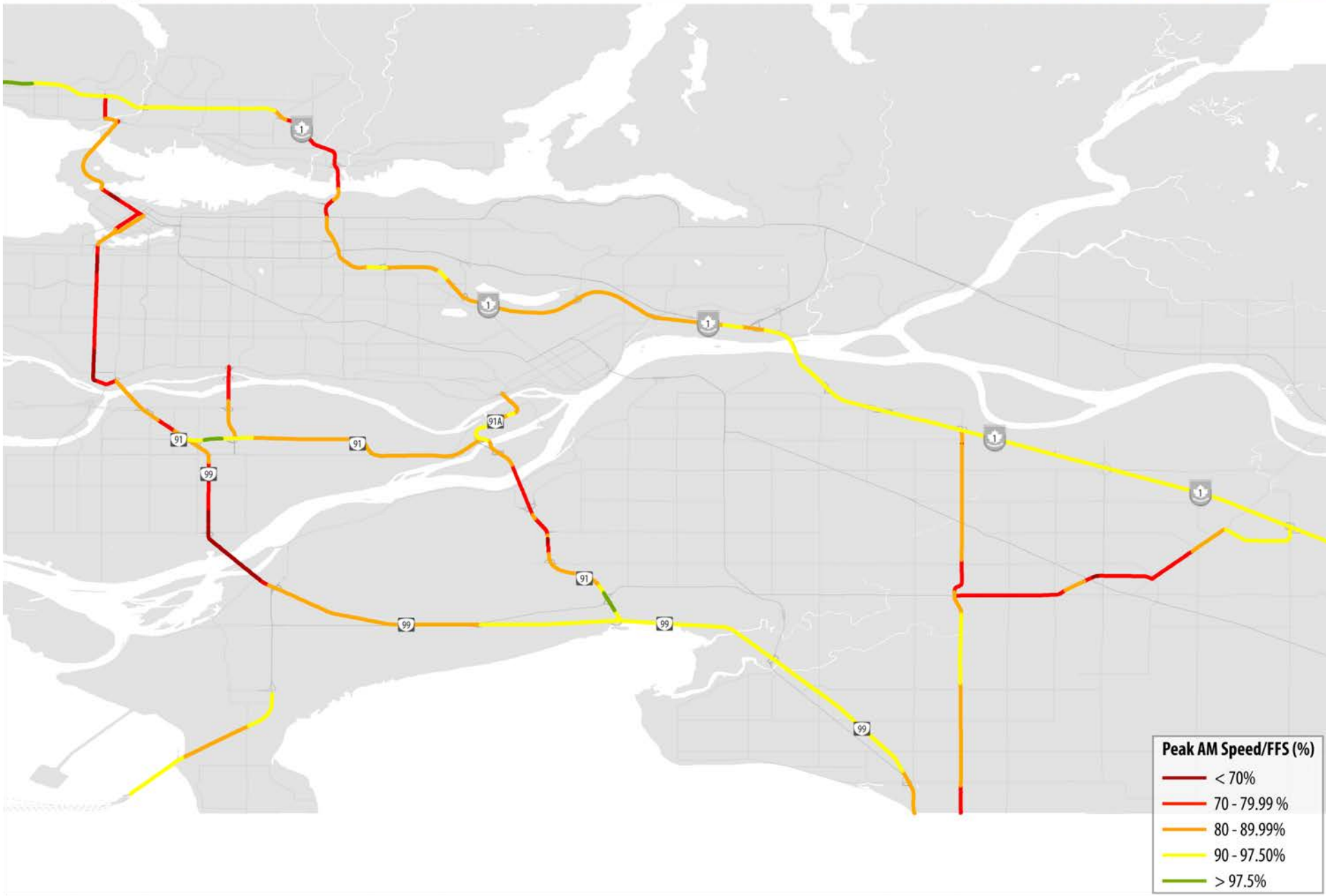

CPCS Solutions for growing economies
St. Catharine's: Peak PM Speed (4:00 - 6:00PM)/FFS
406
405
405
58
420
Peak PM Speed/FFS (%)
< 70%
70 - 79.99 %
80 - 89.99%
90 - 97.50%
> 97.5%

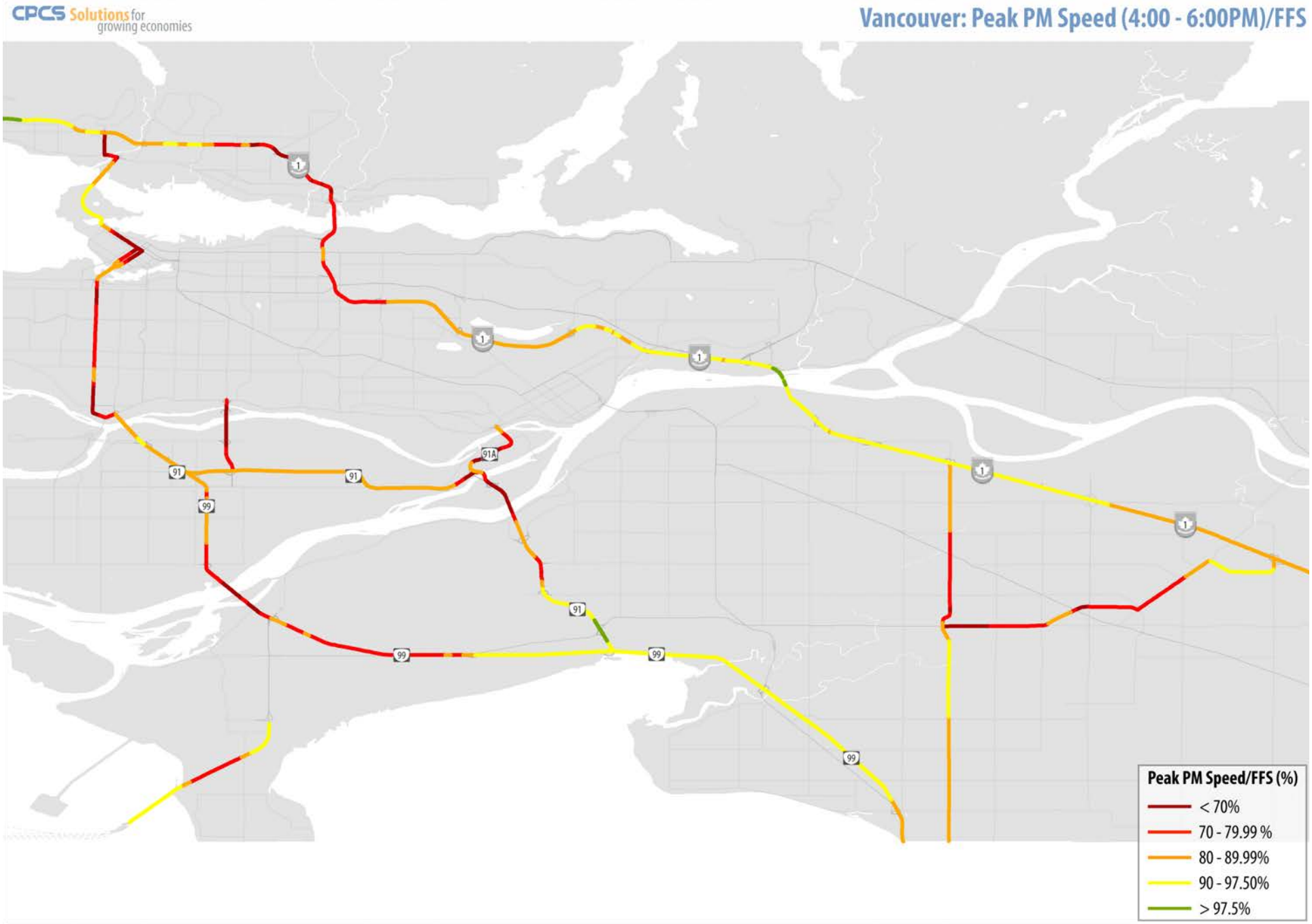

CPCS Solutions for growing economies
Toronto: Peak AM Speed (7:00 - 9:00AM)/FFS
Peak AM Speed/FFS (%)
< 70%
70 - 79.99 %
80 - 89.99%
90 - 97.50%
> 97.5%

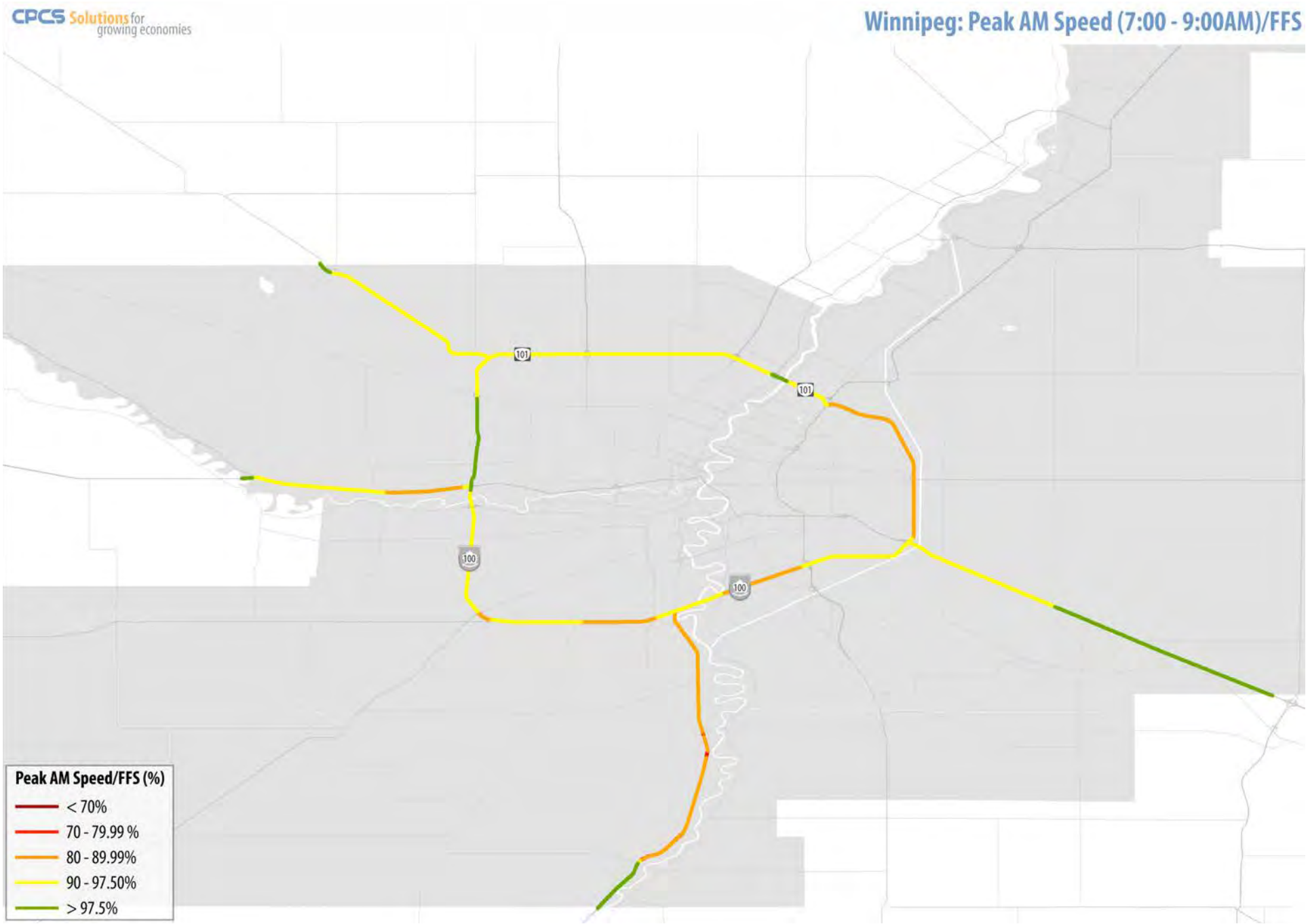

CPCS Solutions for growing economies
Toronto: Peak PM Speed (4:00 - 6:00PM)/FFS
Peak PM Speed/FFS (%)
< 70%
70 - 79.99 %
80 - 89.99%
90 - 97.50%
> 97.5%

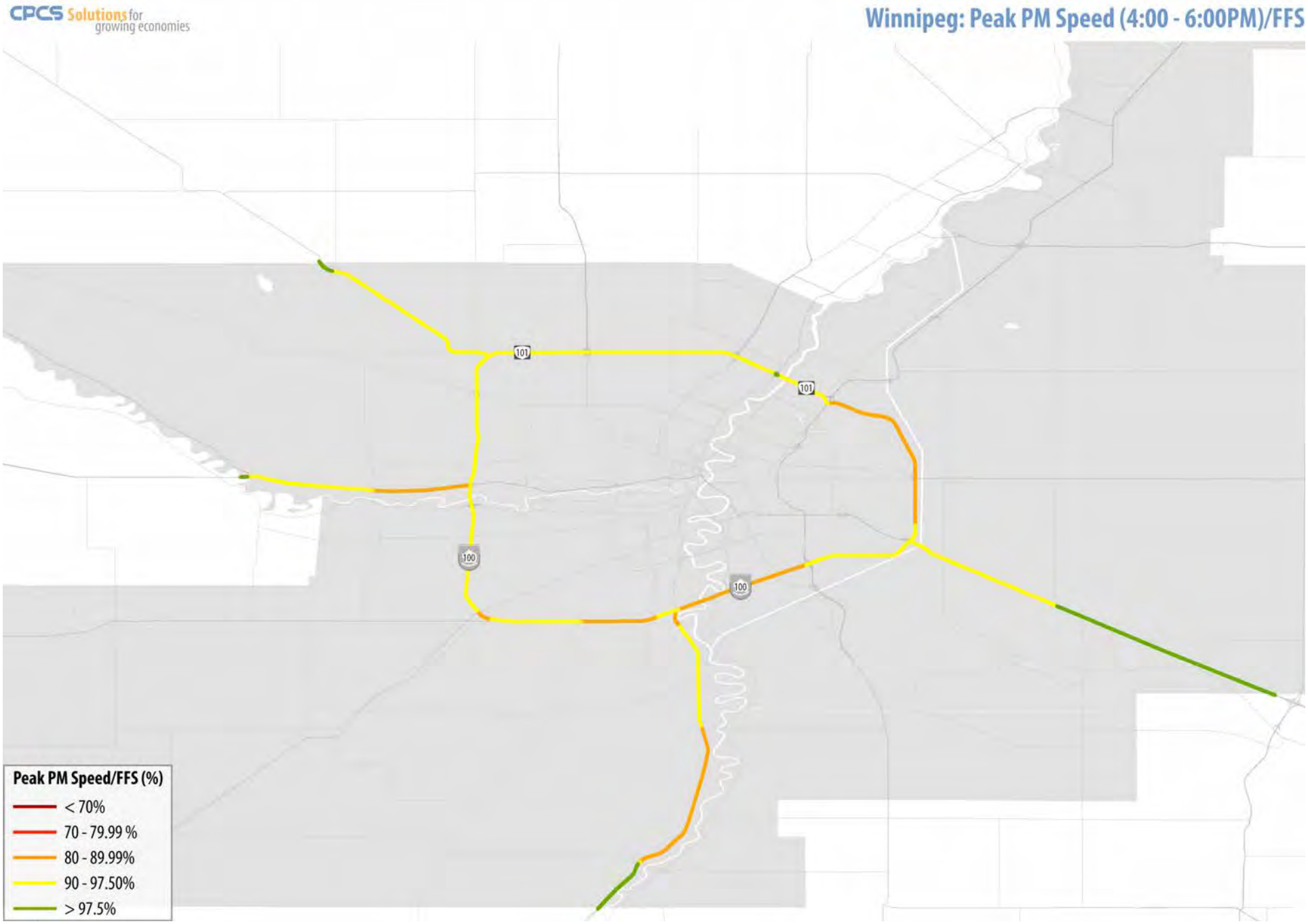
CPCS Solutions for growing economies

Vancouver: Peak AM Speed (7:00 - 9:00AM)/FFS




CPCS Solutions for growing economies
Vancouver: Peak PM Speed (4:00 - 6:00PM)/FFS
Peak PM Speed/FFS (%)
< 70%
70 - 79.99 %
80 - 89.99%
90 - 97.50%
> 97.5%


CPCS Solutions for growing economies
Winnipeg: Peak AM Speed (7:00 - 9:00AM)/FFS
101
101
100
100
Peak AM Speed/FFS (%)
< 70%
70 - 79.99 %
80 - 89.99%
90 - 97.50%
> 97.5%


CPCS Solutions for growing economies
Winnipeg: Peak PM Speed (4:00 - 6:00PM)/FFS
101
101
100
100
Peak PM Speed/FFS (%)
< 70%
70 - 79.99 %
80 - 89.99%
90 - 97.50%
> 97.5%

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[4] Federal Highway Administration (FHWA), "Urban Congestion Trends," US Department of Transportation, Washington DC, 2012.

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[6] Oak Ridge National Laboratory, "Transportation Energy Data Book: Chapters 4 and 5," 2015.

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TORONTO

Backgrounder

August 19, 2022

2021 Census: Language

The 2021 Census Day was May 11, 2021. On August 17, 2022, Statistics Canada released its fourth set of data from this Census, on language.

Knowledge of Official Languages

- 4.5% of Torontonians had no knowledge of either official language (English and French), down slightly from 4.9% in 2016 and 5.3% in 2011. Within the city, there is a high concentration of people with no knowledge of either official languages in north-west Scarborough (north of the 401 expressway, west of Markham Rd, east of the Don Valley and south of Steeles). This area is one of the City's traditional immigrant reception areas. Other smaller pockets can be found in the downtown such as Kensington-Chinatown area; and north Etobicoke (see Map 1).
- In 2021, a greater proportion of women+ than men+ had no knowledge of either official language, English and French (5.2% vs 3.7%, respectively), and as well had greater knowledge of both English and French (9.3% vs 7.8%, respectively).

Mother Tongue

- Toronto continues to be a mosaic of languages. According to the 2021 Census, 42.5% of Toronto residents had a mother tongue other than English or French. This represents a slight decrease from the 2016 figure of 43.9%.
- Just over one half of all Toronto residents (50.2%) reported English as their sole mother tongue. An additional 5.4 of Toronto residents identified English and a non-official language as their multiple mother tongues, an increase from the 2016 figure of 3.4%.

Language spoken at home (Home Language)

- 25.9% of people in Toronto regularly spoke a language other than English or French at home, a similar rate to 2016.
- 1,244,555 people, or 44.9% of Toronto residents, reported speaking at least one non-official language at home, including 35,750 residents who reported speaking multiple non-official languages at home.
- Mandarin, Cantonese, Tagalog, Spanish and Tamil were the top non-English languages spoken at home.
- There are notable shifts among the number of speakers of Toronto’s most spoken home languages. The number of Cantonese speakers, the second most prevalent home language category, decreased by 10%, while the number of Tagalog speakers (third most prevalent) increased 21% and the number of Spanish speakers (fourth most prevalent) increased 12%.

GLOSSARY

Statistics Canada maintains a Census Dictionary for the Census of Population, 2021. Many more terms associated with the Census can be found there. Statistics Canada also publishes 2021 Census of Population reference products with further information.

Age: The age of a person on the day of the Census, May 11, 2021.

Census Division (CD): a group of neighbouring municipalities joined together for the purposes of regional planning and managing common services (such as police or ambulance services). Census Division is the general term for provincially legislated areas (such as county, *municipalité régionale de comté* (MRC) and regional district) or their equivalents.

Census Metropolitan Area (CMA): one or more adjacent municipalities centred on a population centre (known as the core). A CMA must have a total population of at least 100,000, based on data from the current Census of Population Program, of which 50,000 or more must live in the core based on adjusted data from the previous Census of Population Program. To be included in the CMA, other adjacent municipalities must have a high degree of integration with the core, as measured by commuting flows derived from data on place of work from the previous Census Program.

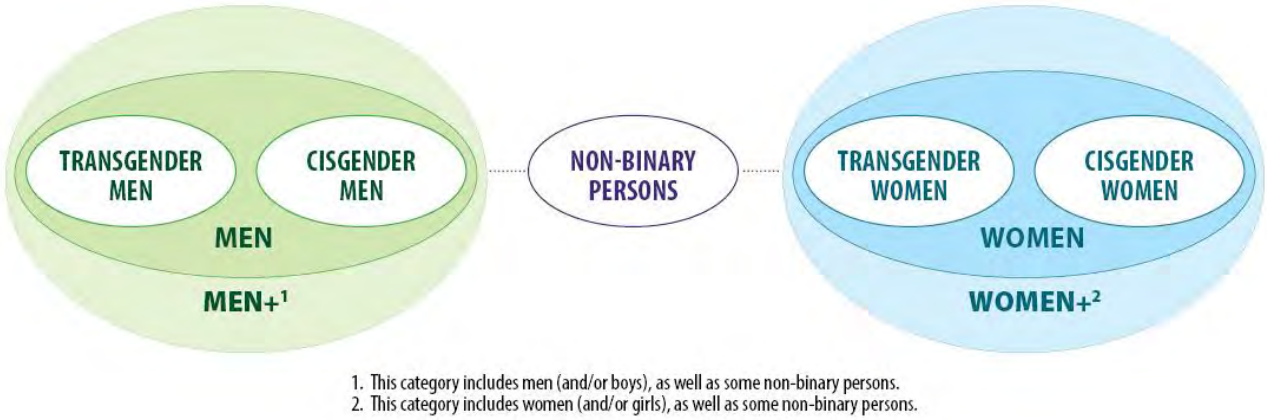
Census Tract (CT): a small, geographic area, typically with a population smaller than 10,000 persons. Their geography is relatively stable over time to allow for comparison of changes from Census to Census.

Centre: as seen in several Maps, Centres are defined in the City of Toronto Official Plan. They play an important role in how the City manages growth. The Scarborough, North York, Etobicoke and Yonge-Eglinton Centres are places with excellent transit accessibility where jobs, housing and services will be concentrated in dynamic mixed-use settings with different levels of activity and intensity. More information can be found in the Toronto Official Plan.

Downtown: The City of Toronto's definition of Downtown is consistent with the definition of Downtown used by Statistics Canada in their reporting on growth in urban centres based on the 2021 Census results. Downtown is bounded by Lake Ontario to the south, Bathurst Street to the west, the mid-town rail corridor and Rosedale Valley Road to the north and the Don River to the east, as defined in Map 41-1 of the Downtown Plan of the City of Toronto Official Plan. Downtown is the largest economic node in the city and the region. Parts of Downtown are expected to see growth, and the Downtown Plan directs how and where within Downtown that growth should occur. More information can be found in the Toronto Official Plan.

Gender refers to an individual's personal and social identity as a man, woman or non-binary person (a person who is not exclusively a man or a woman). For city of Toronto, gender data was disseminated using the two-category gender variables 'Men+' and 'Women+' as illustrated in the following graphic prepared by Statistics Canada. See Figure 1.

Figure 1: Gender Variables



Source: Statistics Canada

GTHA refers to the Greater Toronto and Hamilton Area. This area is comprised of the single-tier municipalities of Toronto and Hamilton, the regional municipalities of York, Durham, Peel, and Halton, and the cities and towns within the GTHA regional municipalities. This is not the same geography as the Toronto Census Metropolitan Area as defined by Statistics Canada.

Language spoken most often at home (Home Language) refers to the language the person speaks most often at home at the time of data collection. A person can report more than one language as "spoken most often at home" if the languages are spoken equally often.

For a person who lives alone, the language spoken most often at home is the language in which they feel most comfortable. For a child who has not yet learned to speak, this is the language spoken most often to the child at home. Where two languages are spoken to the child, the language spoken most often at home is the language spoken most often. If both languages are used equally often, then both languages are included here.

Mother tongue refers to the first language learned at home in childhood and still understood by the person at the time the data was collected. If the person no longer understands the first language learned, the mother tongue is the second language learned. For a person who learned two languages at the same time in early childhood, the mother tongue is the language this person spoke most often at home before starting school. The person has two mother tongues only if the two languages were learned at the same time and are still understood by the person. For a child who has not yet learned to speak, the mother tongue is the language spoken most often to this child at home. The child has two mother tongues only if both languages are spoken equally often so that the child learns both languages at the same time.

Undercoverage is the number of persons excluded by the Census who should have been counted, as determined by Statistics Canada. Although Statistics Canada makes a great effort to count every person, in each Census a notable number of people are left out for a variety of reasons. For example, people may be traveling, some dwellings are hard to find,

and some people simply refuse to participate. Overcoverage can also occur, when people are counted more than once or should not have been counted in a given population. Undercoverage is generally more common than overcoverage. The total impact of the coverage errors is the net undercoverage.

NOTES

The numbers in this Backgrounder are not adjusted for undercoverage, See the Glossary for an explanation of undercoverage.

All figures in this backgrounder are randomly rounded to multiples of 5 by Statistics Canada as a privacy measure.

All data in this backgrounder are based on geographic boundaries available at time of writing. In the event of any future boundary revisions, some data totals may change. This is especially the case for small area units such as Census Tracts.

The information previously collected by the long-form Census questionnaire was collected in 2011 as part of the voluntary National Household Survey. In 2016, Statistics Canada restored the mandatory long-form Census questionnaire in an effort to improve data collection. The families, households, and marital status numbers reported in this backgrounder are based on the mandatory short-form component of the Census for 2011, 2016 and 2021, and therefore can be compared.

FUTURE CENSUS RELEASES

The City of Toronto will be releasing more backgrounders coinciding with each Census release, except for the Census of Agriculture. The 2021 Census release schedule is available from Statistics Canada online. The City of Toronto will be preparing backgrounders for the following releases:

- September 21, 2022
  - Indigenous peoples
  - Housing
- October 26, 2022
  - Immigration, place of birth, and citizenship
  - Ethnocultural and religious diversity
  - Mobility and migration
- November 30, 2022
  - Education
  - Labour
  - Language of work
  - Commuting
  - Instruction in the official minority language

PAST CENSUS RELEASES

The City of Toronto has released the following backgrounder to date, to coincide with the 2021 Census release schedule. Older backgrounders relating to 2016 Census and 2011 Census and National Household Survey topics can also be accessed on the City's website, under item City of Toronto Census Reports.

- Population and Dwelling Counts, February 9, 2022
- Age, Sex at Birth and Gender, and Type of Dwelling, April 27, 2022
- Families, Households, Marital Status and Income, July 13, 2022

REFERENCES

Prepared by staff from:

- Social Development, Finance and Administration,
  Social Policy Analysis and Research
- City Planning, Planning, Research and Analytics

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TABLES, CHARTS AND MAPS

Table 1: Top 15 Mother Tongue Languages in the City of Toronto
(Excluding Official Languages)

Rank	Mother Tongue	Persons	% of Toronto (single responses)	Change since 2016
1	Mandarin	112,620	4.1%	1.1%
2	Yue (Cantonese)	103,530	3.7%	-9.7%
3	Tagalog (Pilipino, Filipino)	82,185	3.0%	-1.3%
4	Spanish	78,575	2.8%	7.9%
5	Portuguese	60,360	2.2%	1.7%
6	Tamil	52,905	1.9%	-8.0%
7	Italian	50,995	1.8%	-18.6%
8	Iranian Persian	34,575	1.2%	*
9	Urdu	34,460	1.2%	-7.9%
10	Russian	33,770	1.2%	-6.6%
11	Arabic	32,985	1.2%	10.6%
12	Korean	32,805	1.2%	-2.6%
13	Bengali	31,335	1.1%	10.1%
14	Vietnamese	27,445	1.0%	10.8%
15	Gujarati	27,090	1.0%	2.6%

Table 2: Top 15 Home Languages in the City of Toronto
(Excluding Official Languages)

Rank	Language Most Often Spoken at Home	Persons	% of Toronto (single responses)	Change since 2016
1	Mandarin	86150	3.1%	-1.8%
2	Yue (Cantonese)	74845	2.7%	-10.3%
3	Tagalog (Pilipino, Filipino)	51355	1.9%	20.8%
4	Spanish	46355	1.7%	11.6%
5	Tamil	40825	1.5%	-2.8%
6	Portuguese	35625	1.3%	6.6%
7	Iranian Persian	23600	0.9%	*
8	Korean	23115	0.8%	-2.2%
9	Urdu	22650	0.8%	-4.1%
10	Russian	21060	0.8%	-8.7%
11	Italian	21040	0.8%	-22.4%
12	Bengali	20505	0.7%	8.3%
13	Vietnamese	19130	0.7%	12.4%
14	Arabic	18060	0.7%	9.6%
15	Gujarati	18045	0.7%	9.2%

* Note: The language, “Iranian Persian” was included as part of a larger category "Persian (Farsi)" in the 2016 Census.

Figure 1: Top 76 Mother Tongue Languages, Toronto, 2021 (Excluding English)

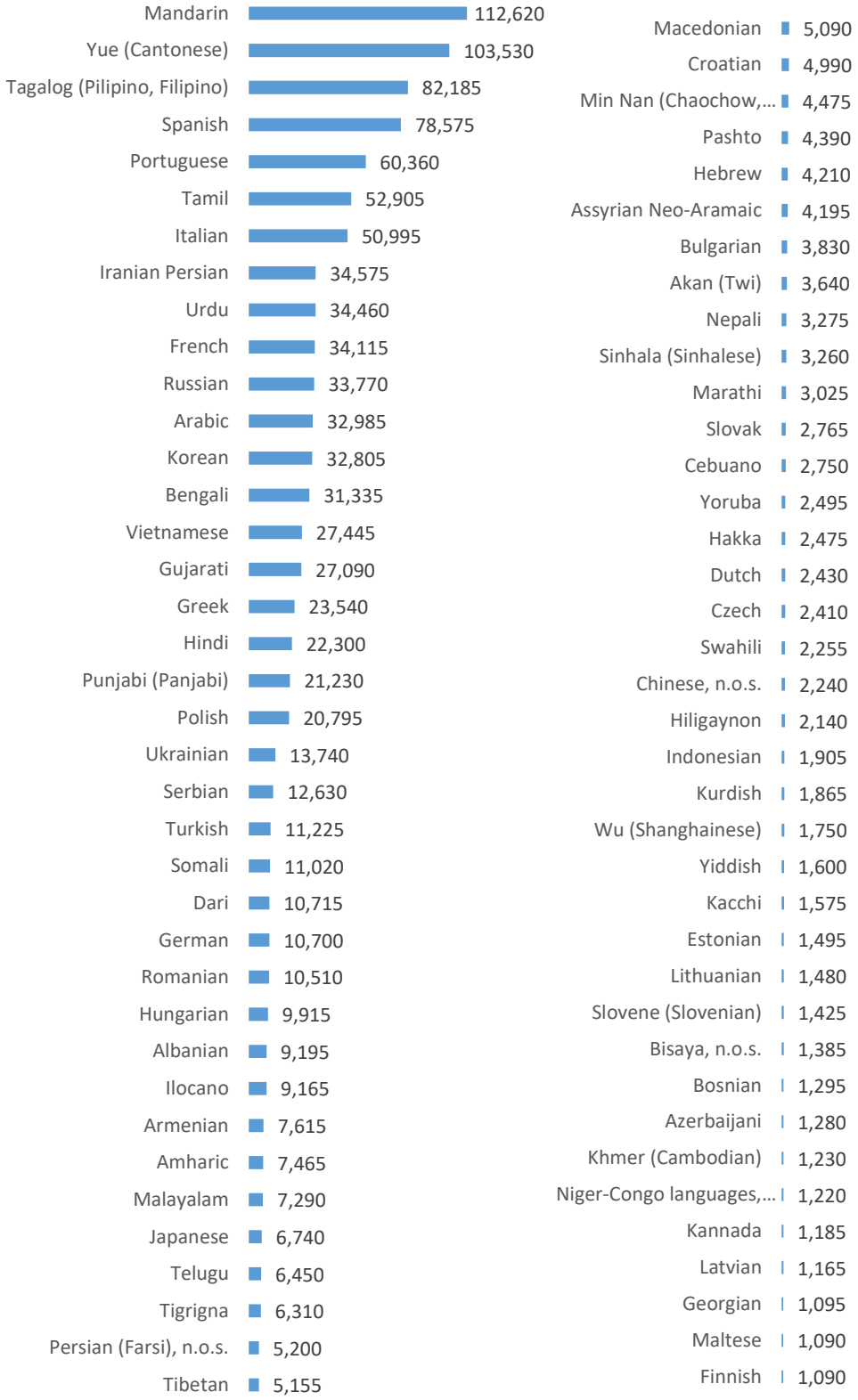
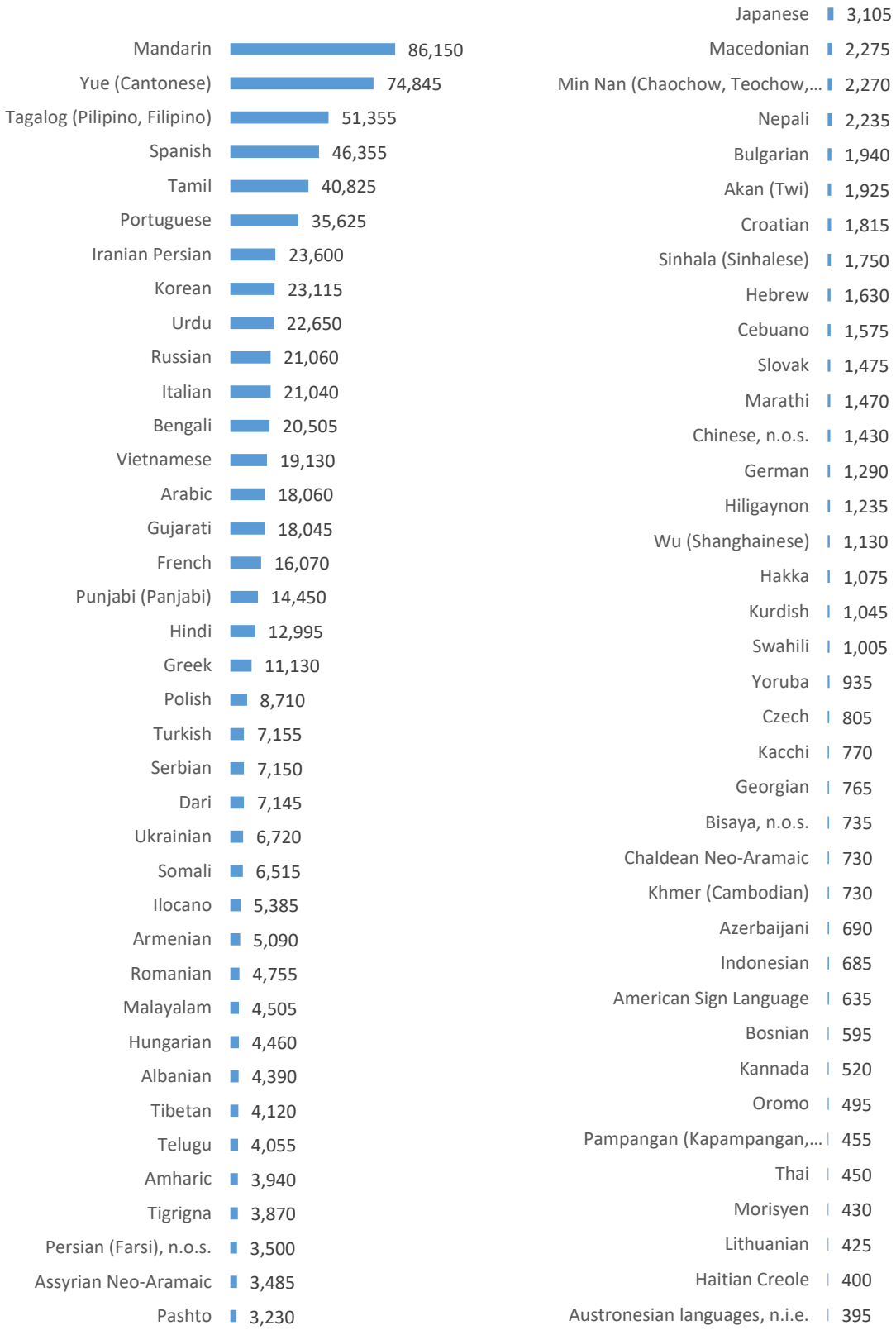


Figure 2: Top 76 Home languages, Toronto, 2021 (Excluding English)



IAEA Safety Standards

for protecting people and the environment

Site Evaluation for Nuclear Installations

Specific Safety Requirements

No. SSR-1



IAEA

International Atomic Energy Agency

IAEA SAFETY STANDARDS AND RELATED PUBLICATIONS

IAEA SAFETY STANDARDS

Under the terms of Article III of its Statute, the IAEA is authorized to establish or adopt standards of safety for protection of health and minimization of danger to life and property, and to provide for the application of these standards.

The publications by means of which the IAEA establishes standards are issued in the **IAEA Safety Standards Series**. This series covers nuclear safety, radiation safety, transport safety and waste safety. The publication categories in the series are **Safety Fundamentals**, **Safety Requirements** and **Safety Guides**.

Information on the IAEA's safety standards programme is available on the IAEA Internet site

http://www-ns.iaea.org/standards/

The site provides the texts in English of published and draft safety standards. The texts of safety standards issued in Arabic, Chinese, French, Russian and Spanish, the IAEA Safety Glossary and a status report for safety standards under development are also available. For further information, please contact the IAEA at: Vienna International Centre, PO Box 100, 1400 Vienna, Austria.

All users of IAEA safety standards are invited to inform the IAEA of experience in their use (e.g. as a basis for national regulations, for safety reviews and for training courses) for the purpose of ensuring that they continue to meet users' needs. Information may be provided via the IAEA Internet site or by post, as above, or by email to Official.Mail@iaea.org.

RELATED PUBLICATIONS

The IAEA provides for the application of the standards and, under the terms of Articles III and VIII.C of its Statute, makes available and fosters the exchange of information relating to peaceful nuclear activities and serves as an intermediary among its Member States for this purpose.

Reports on safety in nuclear activities are issued as **Safety Reports**, which provide practical examples and detailed methods that can be used in support of the safety standards.

Other safety related IAEA publications are issued as **Emergency Preparedness and Response** publications, **Radiological Assessment Reports**, the International Nuclear Safety Group's **INSAG Reports**, **Technical Reports** and **TECDOCs**. The IAEA also issues reports on radiological accidents, training manuals and practical manuals, and other special safety related publications.

Security related publications are issued in the **IAEA Nuclear Security Series**.

The **IAEA Nuclear Energy Series** comprises informational publications to encourage and assist research on, and the development and practical application of, nuclear energy for peaceful purposes. It includes reports and guides on the status of and advances in technology, and on experience, good practices and practical examples in the areas of nuclear power, the nuclear fuel cycle, radioactive waste management and decommissioning.

SITE EVALUATION FOR NUCLEAR INSTALLATIONS

The following States are Members of the International Atomic Energy Agency:

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ALGERIA
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ANTIGUA AND BARBUDA
ARGENTINA
ARMENIA
AUSTRALIA
AUSTRIA
AZERBAIJAN
BAHAMAS
BAHRAIN
BANGLADESH
BARBADOS
BELARUS
BELGIUM
BELIZE
BENIN
BOLIVIA, PLURINATIONAL STATE OF
BOSNIA AND HERZEGOVINA
BOTSWANA
BRAZIL
BRUNEI DARUSSALAM
BULGARIA
BURKINA FASO
BURUNDI
CAMBODIA
CAMEROON
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GUYANA
HAITI
HOLY SEE
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IRAQ
IRELAND
ISRAEL
ITALY
JAMAICA
JAPAN
JORDAN
KAZAKHSTAN
KENYA
KOREA, REPUBLIC OF
KUWAIT
KYRGYZSTAN
LAO PEOPLE'S DEMOCRATIC REPUBLIC
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LESOTHO
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LIBYA
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LITHUANIA
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TURKEY
TURKMENISTAN
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VIET NAM
YEMEN
ZAMBIA
ZIMBABWE

The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world".

IAEA SAFETY STANDARDS SERIES No. SSR-1

SITE EVALUATION FOR NUCLEAR INSTALLATIONS

SPECIFIC SAFETY REQUIREMENTS

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2019

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FOREWORD

by Yukiya Amano
Director General

The IAEA's Statute authorizes the Agency to "establish or adopt… standards of safety for protection of health and minimization of danger to life and property" — standards that the IAEA must use in its own operations, and which States can apply by means of their regulatory provisions for nuclear and radiation safety. The IAEA does this in consultation with the competent organs of the United Nations and with the specialized agencies concerned. A comprehensive set of high quality standards under regular review is a key element of a stable and sustainable global safety regime, as is the IAEA's assistance in their application.

The IAEA commenced its safety standards programme in 1958. The emphasis placed on quality, fitness for purpose and continuous improvement has led to the widespread use of the IAEA standards throughout the world. The Safety Standards Series now includes unified Fundamental Safety Principles, which represent an international consensus on what must constitute a high level of protection and safety. With the strong support of the Commission on Safety Standards, the IAEA is working to promote the global acceptance and use of its standards.

Standards are only effective if they are properly applied in practice. The IAEA's safety services encompass design, siting and engineering safety, operational safety, radiation safety, safe transport of radioactive material and safe management of radioactive waste, as well as governmental organization, regulatory matters and safety culture in organizations. These safety services assist Member States in the application of the standards and enable valuable experience and insights to be shared.

Regulating safety is a national responsibility, and many States have decided to adopt the IAEA's standards for use in their national regulations. For parties to the various international safety conventions, IAEA standards provide a consistent, reliable means of ensuring the effective fulfilment of obligations under the conventions. The standards are also applied by regulatory bodies and operators around the world to enhance safety in nuclear power generation and in nuclear applications in medicine, industry, agriculture and research.

Safety is not an end in itself but a prerequisite for the purpose of the protection of people in all States and of the environment — now and in the future. The risks associated with ionizing radiation must be assessed and controlled without unduly limiting the contribution of nuclear energy to equitable and sustainable development. Governments, regulatory bodies and operators everywhere must ensure that nuclear material and radiation sources are used beneficially, safely and ethically. The IAEA safety standards are designed to facilitate this, and I encourage all Member States to make use of them.

THE IAEA SAFETY STANDARDS

BACKGROUND

Radioactivity is a natural phenomenon and natural sources of radiation are features of the environment. Radiation and radioactive substances have many beneficial applications, ranging from power generation to uses in medicine, industry and agriculture. The radiation risks to workers and the public and to the environment that may arise from these applications have to be assessed and, if necessary, controlled.

Activities such as the medical uses of radiation, the operation of nuclear installations, the production, transport and use of radioactive material, and the management of radioactive waste must therefore be subject to standards of safety.

Regulating safety is a national responsibility. However, radiation risks may transcend national borders, and international cooperation serves to promote and enhance safety globally by exchanging experience and by improving capabilities to control hazards, to prevent accidents, to respond to emergencies and to mitigate any harmful consequences.

States have an obligation of diligence and duty of care, and are expected to fulfil their national and international undertakings and obligations.

International safety standards provide support for States in meeting their obligations under general principles of international law, such as those relating to environmental protection. International safety standards also promote and assure confidence in safety and facilitate international commerce and trade.

A global nuclear safety regime is in place and is being continuously improved. IAEA safety standards, which support the implementation of binding international instruments and national safety infrastructures, are a cornerstone of this global regime. The IAEA safety standards constitute a useful tool for contracting parties to assess their performance under these international conventions.

THE IAEA SAFETY STANDARDS

The status of the IAEA safety standards derives from the IAEA's Statute, which authorizes the IAEA to establish or adopt, in consultation and, where appropriate, in collaboration with the competent organs of the United Nations and with the specialized agencies concerned, standards of safety for protection of health and minimization of danger to life and property, and to provide for their application.

With a view to ensuring the protection of people and the environment from harmful effects of ionizing radiation, the IAEA safety standards establish fundamental safety principles, requirements and measures to control the radiation exposure of people and the release of radioactive material to the environment, to restrict the likelihood of events that might lead to a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation, and to mitigate the consequences of such events if they were to occur. The standards apply to facilities and activities that give rise to radiation risks, including nuclear installations, the use of radiation and radioactive sources, the transport of radioactive material and the management of radioactive waste.

Safety measures and security measures[1] have in common the aim of protecting human life and health and the environment. Safety measures and security measures must be designed and implemented in an integrated manner so that security measures do not compromise safety and safety measures do not compromise security.

The IAEA safety standards reflect an international consensus on what constitutes a high level of safety for protecting people and the environment from harmful effects of ionizing radiation. They are issued in the IAEA Safety Standards Series, which has three categories (see Fig. 1).

Safety Fundamentals

Safety Fundamentals present the fundamental safety objective and principles of protection and safety, and provide the basis for the safety requirements.

Safety Requirements

An integrated and consistent set of Safety Requirements establishes the requirements that must be met to ensure the protection of people and the environment, both now and in the future. The requirements are governed by the objective and principles of the Safety Fundamentals. If the requirements are not met, measures must be taken to reach or restore the required level of safety. The format and style of the requirements facilitate their use for the establishment, in a harmonized manner, of a national regulatory framework. Requirements, including numbered 'overarching' requirements, are expressed as 'shall' statements. Many requirements are not addressed to a specific party, the implication being that the appropriate parties are responsible for fulfilling them.

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[1] See also publications issued in the IAEA Nuclear Security Series.

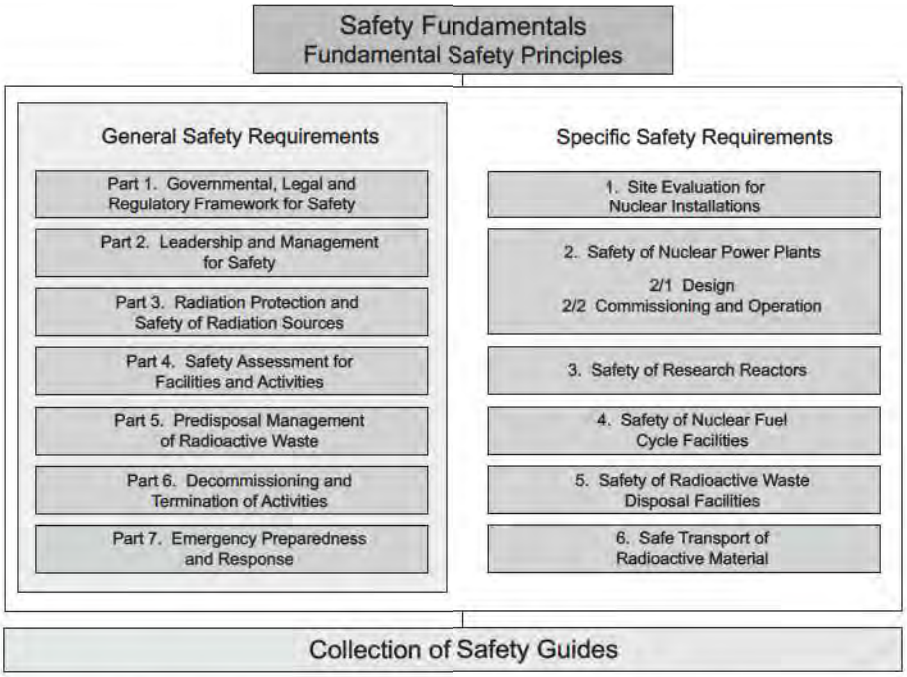


FIG. 1. The long term structure of the IAEA Safety Standards Series.

Safety Guides

Safety Guides provide recommendations and guidance on how to comply with the safety requirements, indicating an international consensus that it is necessary to take the measures recommended (or equivalent alternative measures). The Safety Guides present international good practices, and increasingly they reflect best practices, to help users striving to achieve high levels of safety. The recommendations provided in Safety Guides are expressed as 'should' statements.

APPLICATION OF THE IAEA SAFETY STANDARDS

The principal users of safety standards in IAEA Member States are regulatory bodies and other relevant national authorities. The IAEA safety standards are also used by co-sponsoring organizations and by many organizations that design, construct and operate nuclear facilities, as well as organizations involved in the use of radiation and radioactive sources.

The IAEA safety standards are applicable, as relevant, throughout the entire lifetime of all facilities and activities — existing and new — utilized for peaceful purposes and to protective actions to reduce existing radiation risks. They can be used by States as a reference for their national regulations in respect of facilities and activities.

The IAEA's Statute makes the safety standards binding on the IAEA in relation to its own operations and also on States in relation to IAEA assisted operations.

The IAEA safety standards also form the basis for the IAEA's safety review services, and they are used by the IAEA in support of competence building, including the development of educational curricula and training courses.

International conventions contain requirements similar to those in the IAEA safety standards and make them binding on contracting parties. The IAEA safety standards, supplemented by international conventions, industry standards and detailed national requirements, establish a consistent basis for protecting people and the environment. There will also be some special aspects of safety that need to be assessed at the national level. For example, many of the IAEA safety standards, in particular those addressing aspects of safety in planning or design, are intended to apply primarily to new facilities and activities. The requirements established in the IAEA safety standards might not be fully met at some existing facilities that were built to earlier standards. The way in which IAEA safety standards are to be applied to such facilities is a decision for individual States.

The scientific considerations underlying the IAEA safety standards provide an objective basis for decisions concerning safety; however, decision makers must also make informed judgements and must determine how best to balance the benefits of an action or an activity against the associated radiation risks and any other detrimental impacts to which it gives rise.

DEVELOPMENT PROCESS FOR THE IAEA SAFETY STANDARDS

The preparation and review of the safety standards involves the IAEA Secretariat and five safety standards committees, for emergency preparedness and response (EPReSC) (as of 2016), nuclear safety (NUSSC), radiation safety (RASSC), the safety of radioactive waste (WASSC) and the safe transport of radioactive material (TRANSSC), and a Commission on Safety Standards (CSS) which oversees the IAEA safety standards programme (see Fig. 2).

All IAEA Member States may nominate experts for the safety standards committees and may provide comments on draft standards. The membership of

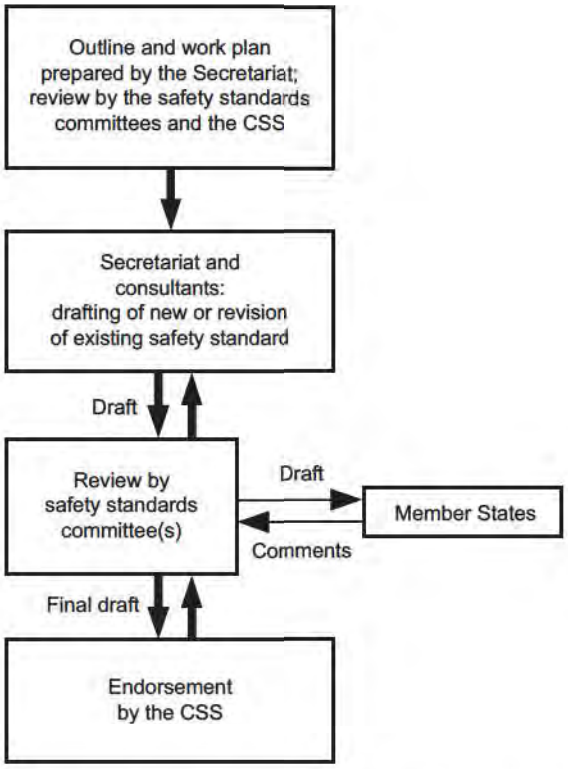


FIG. 2. The process for developing a new safety standard or revising an existing standard.

the Commission on Safety Standards is appointed by the Director General and includes senior governmental officials having responsibility for establishing national standards.

A management system has been established for the processes of planning, developing, reviewing, revising and establishing the IAEA safety standards. It articulates the mandate of the IAEA, the vision for the future application of the safety standards, policies and strategies, and corresponding functions and responsibilities.

INTERACTION WITH OTHER INTERNATIONAL ORGANIZATIONS

The findings of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and the recommendations of international

expert bodies, notably the International Commission on Radiological Protection (ICRP), are taken into account in developing the IAEA safety standards. Some safety standards are developed in cooperation with other bodies in the United Nations system or other specialized agencies, including the Food and Agriculture Organization of the United Nations, the United Nations Environment Programme, the International Labour Organization, the OECD Nuclear Energy Agency, the Pan American Health Organization and the World Health Organization.

INTERPRETATION OF THE TEXT

Safety related terms are to be understood as defined in the IAEA Safety Glossary (see http://www-ns.iaea.org/standards/safety-glossary.htm). Otherwise, words are used with the spellings and meanings assigned to them in the latest edition of The Concise Oxford Dictionary. For Safety Guides, the English version of the text is the authoritative version.

The background and context of each standard in the IAEA Safety Standards Series and its objective, scope and structure are explained in Section 1, Introduction, of each publication.

Material for which there is no appropriate place in the body text (e.g. material that is subsidiary to or separate from the body text, is included in support of statements in the body text, or describes methods of calculation, procedures or limits and conditions) may be presented in appendices or annexes.

An appendix, if included, is considered to form an integral part of the safety standard. Material in an appendix has the same status as the body text, and the IAEA assumes authorship of it. Annexes and footnotes to the main text, if included, are used to provide practical examples or additional information or explanation. Annexes and footnotes are not integral parts of the main text. Annex material published by the IAEA is not necessarily issued under its authorship; material under other authorship may be presented in annexes to the safety standards. Extraneous material presented in annexes is excerpted and adapted as necessary to be generally useful.

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1. INTRODUCTION

BACKGROUND

1.1. This Safety Requirements publication supersedes the edition of Site Evaluation for Nuclear Installations that was issued in 2016 as IAEA Safety Standards Series No. NS-R-3 (Rev. 1)[1]. NS-R-3 (Rev. 1) was a partial revision of IAEA Safety Standards Series No. NS-R-3[2] issued in 2003 and it took into account issues highlighted after the Fukushima Daiichi accident. This publication takes into account developments that have occurred since 2003 in relation to site evaluation for nuclear installations.

1.2. The requirements for site evaluation for nuclear installations established in this publication are intended to contribute to the protection of workers and the public, and to the protection of the environment, from harmful effects of ionizing radiation, in order to meet the fundamental safety objective established in IAEA Safety Standards Series No. SF-1, Fundamental Safety Principles [1]. It is recognized that there are steady advances in technology and scientific knowledge in nuclear safety and corresponding advances in what is considered adequate protection. Safety requirements evolve with these advances, and this publication reflects the present consensus among States.

1.3. This Safety Requirements publication establishes requirements for site evaluation for nuclear installations, in order to meet the fundamental safety objective [1]. Several related Safety Guides (see Refs [2–8]) provide recommendations on how to meet the requirements for site evaluation for nuclear installations as contained in this publication.

OBJECTIVE

1.4. The objective of this publication is to establish requirements for:

(a) Defining the information to be used in the site evaluation process;

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[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. NS-R-3 (Rev. 1), IAEA, Vienna (2016).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. NS-R-3, IAEA, Vienna (2003).

(b) Evaluating a site such that the site specific hazards and the safety related site characteristics are adequately taken into account, in order to derive appropriate site specific design parameters[3];
(c) Analysing the characteristics of the population and the region surrounding the site to determine whether there would be significant difficulties in implementing emergency response actions effectively [9].

1.5. The requirements in this publication are to be applied:

(a) To identify the natural and human induced external hazards that could affect the safety of the nuclear installation;
(b) To assess the interactions between the site and nuclear installation for operational states and accident conditions, over the lifetime of the nuclear installation, including accidents that could warrant the implementation of emergency response actions.

1.6. This publication is intended for use by regulatory bodies in establishing regulatory requirements, and by operating organizations or their contractors in conducting site evaluation for nuclear installations.

SCOPE

1.7. The requirements in this publication apply to all nuclear installations [10], as follows:

— Nuclear power plants;
— Research reactors (including subcritical and critical assemblies) and any adjoining radioisotope production facilities;
— Storage facilities for spent fuel;
— Facilities for the enrichment of uranium;
— Nuclear fuel fabrication facilities;
— Conversion facilities;
— Facilities for the reprocessing of spent fuel;
— Facilities for the predisposal management of radioactive waste arising from nuclear fuel cycle facilities;
— Nuclear fuel cycle related research and development facilities.

[3] Site specific design parameters are needed for the design of a nuclear installation. The design of a nuclear installation is adequate for a specific site if the actual parameters used in the design envelop the corresponding site specific design parameters.

1.8. This Safety Requirements publication covers site evaluation for both new and existing nuclear installations. For existing nuclear installations, decisions concerning the implementation of new or enhanced safety features will need to consider, as practicable, the safety significance of such features, as well as economic, social and environmental factors.

1.9. The 'site area' is the geographical area that contains an authorized facility, authorized activity or source, and within which the management of the authorized facility or authorized activity or first responders may directly initiate an emergency response [9]. The site area is typically the area within the security perimeter fence or other designated property marker.

1.10. The 'external zone' is the area immediately surrounding a proposed site area in which the population distribution and density, and land and water uses, are considered with respect to their impact on planning effective emergency response actions [9].[4]

1.11. The word 'region' is used generally in this publication to refer to the area surrounding the site and is normally intended to include more than the external zone. The size of this region will be defined for each specific external hazard (see para. 4.14). This region is also sometimes known as the 'geographical area of interest'.

1.12. The 'site vicinity' is smaller than the region and larger than the site area (typically covering a geographical area not less than 5 km in radius).

1.13. The human induced external events considered in this Safety Requirements publication are all of accidental origin. Considerations relating to the physical protection of the nuclear installation against sabotage, and to physical protection against unauthorized removal or sabotage of the nuclear material, are outside the scope of this publication, although such considerations are likely to have significant implications for site evaluation. This publication does not address the threat assessment of malicious acts. Recommendations for the establishment of the design basis threat are provided in IAEA Nuclear Security Series No. 13 [11] and in supporting publications in the IAEA Nuclear Security Series.

1.14. The interfaces between nuclear safety and nuclear security have to be considered and synergies have to be developed so that safety and nuclear

[4] The external zone is the area that would be the emergency planning zones if the installation were in place.

security complement and enhance one another. For example, site specific design parameters for the qualification of structures, systems and components important to safety against natural and human induced external hazards, as required in this publication, can also be used for the qualification of structures, systems and components important for nuclear security against relevant external hazards.

1.15. The siting process for a nuclear installation is divided into two stages:

(a) Site survey, in which candidate sites are identified after the investigation of a large region and the rejection of unsuitable sites;
(b) Site selection, in which the candidate sites are assessed by screening, evaluation, comparison and ranking on the basis of safety and other considerations to select one or more preferred candidate sites.

1.16. The suitability of the site is then confirmed in the site evaluation process. The site evaluation process starts with the second stage of the siting process (i.e. site selection), and continues throughout the entire lifetime of the nuclear installation. The detailed site evaluation (for the selected site) provides input to the preliminary safety analysis report and the final safety analysis report. Site evaluation continues throughout the operational stage of the nuclear installation, and includes monitoring, periodic safety review and other activities to confirm the site specific design parameters as well as safety re-evaluations based on the outcome of periodic safety reviews.

1.17. This publication addresses the evaluation of those site related factors that have to be taken into account to ensure that the site–installation combination does not constitute an unacceptable risk to people or the environment over the lifetime of the nuclear installation. It is recognized that there are other important factors in site evaluation, such as technology, economics, non-radiological environmental impacts and socioeconomic impacts, as well as the opinion of interested parties, including the public. Such aspects of site evaluation are not covered in this publication.

STRUCTURE

1.18. Section 2 of this publication sets out the fundamental safety objective and the safety principles applicable to site evaluation. Section 3 establishes requirements for the application of the management system for site evaluation. Section 4 establishes the general requirements that are applicable to all types of external hazard. Section 5 establishes requirements for specific technical aspects

related to the evaluation of natural and human induced external hazards. Section 6 establishes requirements for specific technical aspects related to the evaluation of the effects of the nuclear installation on the surrounding environment (including the atmosphere, the hydrosphere and the biosphere) and on the population. Section 7 establishes requirements for monitoring and periodic review of natural and human induced external hazards and site conditions throughout the lifetime of the nuclear installation.

2. SAFETY PRINCIPLES AND CONCEPTS

2.1. As stated in SF-1 [1]: "**The fundamental safety objective is to protect people and the environment from harmful effects of ionizing radiation.**" Paragraph 2.1 of SF-1 [1] states:

> "This fundamental safety objective of protecting people — individually and collectively — and the environment has to be achieved without unduly limiting the operation of facilities or the conduct of activities that give rise to radiation risks. To ensure that facilities are operated and activities conducted so as to achieve the highest standards of safety that can reasonably be achieved, measures have to be taken:
>
> (a) To control the radiation exposure of people and the release of radioactive material to the environment;
> (b) To restrict the likelihood of events that might lead to a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation;
> (c) To mitigate the consequences of such events if they were to occur."

2.2. Paragraph 2.2 of SF-1 [1] states:

> "The fundamental safety objective applies for all facilities and activities, and for all stages over the lifetime of a facility or radiation source, including planning, siting, design, manufacturing, construction, commissioning and operation, as well as decommissioning and closure. This includes the associated transport of radioactive material and management of radioactive waste."

2.3. This Safety Requirements publication establishes requirements for application of the principles of SF-1 [1], in particular Principles 8 and 9:

— "**All practical efforts must be made to prevent and mitigate nuclear or radiation accidents**" (Principle 8 of SF-1 [1]).
— "The primary means of preventing and mitigating the consequences of accidents is 'defence in depth'. Defence in depth is implemented primarily through the combination of a number of consecutive and independent levels of protection that would have to fail before harmful effects could be caused to people or to the environment" (para. 3.31 of SF-1 [1]).
— "Defence in depth is provided by an appropriate combination of [inter alia] … [a]dequate site selection and the incorporation of good design and engineering features providing safety margins, diversity and redundancy" (para. 3.32 of SF-1 [1]).
— "**Arrangements must be made for emergency preparedness and response for nuclear or radiation incidents**" (Principle 9 of SF-1 [1]).

2.4. To address Principle 8 of SF-1 [1], site evaluation for a nuclear installation shall characterize the natural and human induced external hazards that could affect the safety of the nuclear installation (see Requirement 1). The site evaluation shall provide adequate input to the design and safety assessment for demonstration of protection of people and the environment from harmful effects of ionizing radiation.

2.5. To address Principle 9 of SF-1 [1], site evaluation for a nuclear installation shall provide adequate input for demonstration of protection of people and the environment from the consequences of radioactive releases. The site evaluation shall identify the site characteristics that could affect the feasibility of planning effective emergency response actions in the external zone.

Requirement 1: Safety objective in site evaluation for nuclear installations

The safety objective in site evaluation for nuclear installations shall be to characterize the natural and human induced external hazards that might affect the safety of the nuclear installation, in order to provide adequate input for demonstration of protection of people and the environment from harmful effects of ionizing radiation.

2.6. The safety objective in site evaluation is derived from the fundamental safety objective established in SF-1 [1]. Demonstration of compliance with the safety requirements established in this publication provides the basis for demonstration of achievement of the safety objective for site evaluation.

3. APPLICATION OF THE MANAGEMENT SYSTEM FOR SITE EVALUATION

Requirement 2: Application of the management system for site evaluation

Site evaluation shall be conducted in a comprehensive, systematic, planned and documented manner in accordance with a management system.

3.1. An integrated management system that meets the requirements of IAEA Safety Standards Series No. GSR Part 2, Leadership and Management for Safety [12] shall be established. The management system shall cover the organization, planning, work control, verification and documentation of activities and qualification and training of personnel to ensure that the required quality of the work is achieved at each stage of site evaluation. The management system shall be implemented at the earliest possible time in the conduct of site evaluation for the nuclear installation.

3.2. Site evaluation shall include, as part of the management system, proper quality assurance arrangements covering each activity that could influence safety or affect the derivation of site specific design parameters and other safety related site characteristics. The quality assurance arrangements shall be consistent with regulatory requirements and their application shall be commensurate with the importance of the activity under consideration to safety.

3.3. For each site evaluation activity, including inspection, testing, verification and validation, the acceptance criteria and the responsibilities for performing the activity shall be specified.

3.4. The results of studies and investigations conducted as part of the site evaluation shall be documented in sufficient detail to permit an independent review.

3.5. An independent review shall be made of the evaluation of the natural and human induced external hazards and the site specific design parameters, and of the evaluation of the potential radiological impact of the nuclear installation on people and the environment.

4. GENERAL REQUIREMENTS FOR SITE EVALUATION

Requirement 3: Scope of the site evaluation for nuclear installations

The scope of the site evaluation shall encompass factors relating to the site and factors relating to the interaction between the site and the installation, for all operational states and accident conditions, including accidents that could warrant emergency response actions.

4.1. The scope of the site evaluation shall cover all external hazards, monitoring activities and site specific parameters relevant for the safety of the nuclear installation. In determining the scope of the site evaluation, a graded approach shall be applied commensurate with the radiation risk posed to people and the environment.

4.2. The application of the safety requirements for site evaluation for nuclear installations shall be commensurate with the potential hazards associated with the nuclear installation.

4.3. The level of detail needed in the evaluation of a site for a nuclear installation shall be commensurate with the risk associated with the nuclear installation and the site and will differ depending on the type of nuclear installation.

4.4. The scope and level of detail of the site evaluation process necessary to support the safety demonstration for the nuclear installation shall be determined in accordance with a graded approach.

4.5. For site evaluation for nuclear installations other than nuclear power plants, the following shall be taken into consideration in the application of a graded approach:

(a) The amount, type and status of the radioactive inventory at the site (e.g. whether the radioactive material on the site is in solid, liquid and/or gaseous form, and whether the radioactive material is being processed in the nuclear installation or is being stored on the site);
(b) The intrinsic hazards associated with the physical and chemical processes that take place at the nuclear installation;
(c) For research reactors, the thermal power;
(d) The distribution and location of radioactive sources in the nuclear installation;

(e) The configuration and layout of installations designed for experiments, and how these might change in future;
(f) The need for active systems and/or operator actions for the prevention of accidents and for the mitigation of the consequences of accidents;
(g) The potential for on-site and off-site consequences in the event of an accident.

Requirement 4: Site suitability

The suitability of the site shall be assessed at an early stage of the site evaluation and shall be confirmed for the lifetime of the planned nuclear installation.

4.6. In the assessment of the suitability of a site for a nuclear installation, the following aspects shall be addressed at an early stage of the site evaluation:

(a) The effects of natural and human induced external events occurring in the region that might affect the site;
(b) The characteristics of the site and its environment that could influence the transfer of radioactive material released from the nuclear installation to people and to the environment;
(c) The population density, population distribution and other characteristics of the external zone, in so far as these could affect the feasibility of planning effective emergency response actions [9], and the need to evaluate the risk to individuals and to the population.

4.7. The site shall be deemed unsuitable for a nuclear installation if one or more of the three aspects listed in para. 4.6 indicates that the site is unacceptable and the deficiencies cannot be compensated for by means of a combination of measures for site protection, design features of the nuclear installation and administrative procedures.

4.8. Site suitability shall be assessed on the basis of relevant current data and methodologies. If relevant, conservative criteria shall be developed in relation to site specific accident scenarios, and the consistency of such criteria with the overall site suitability shall be demonstrated.

4.9. A decision regarding the suitability of the site shall be based on the characteristics of the nuclear installation, including planned operations at the site, the amount and nature of potential radioactive releases and their impact on people and the environment.

4.10. For nuclear power plants, the total nuclear capacity to be installed at the site shall be determined at the first stages of the siting process. If it is later determined or anticipated that the installed nuclear capacity (or, for other nuclear installations, the inventory of nuclear material) or its impact has increased to a level significantly greater than that previously determined to be acceptable, the site shall be re-evaluated considering the higher capacity, inventory or impact.

4.11. In the overall evaluation of site suitability, site specific attributes, such as cooling water availability or extreme environmental conditions, and their potential role in affecting the safe and continuous operation of the nuclear installation, shall also be addressed.

Requirement 5: Site and regional characteristics

The site and the region shall be investigated with regard to the characteristics that could affect the safety of the nuclear installation and the potential radiological impact of the nuclear installation on people and the environment.

4.12. Natural phenomena as well as human activities in the region with the potential to induce hazards at the site that might affect the safety of the nuclear installation shall be identified and evaluated. The extent of this evaluation shall be commensurate with the safety significance of the potential hazards at the site.

4.13. The characteristics of the natural environment in the region that could be affected by the potential radiological impact of the nuclear installation shall be investigated and assessed, for all operational states and accident conditions and for all stages of the lifetime of the nuclear installation (see Section 6).

4.14. The size of the region to be investigated shall be defined for each of the natural and human induced external hazards. Both the magnitude of the hazard and the distance from the source of the hazard to the site shall be considered in determining the size of the region to be investigated. For certain natural external events, such as tsunamis and volcanic phenomena, it shall be ensured that the size of the region that is investigated is sufficiently large to address the potential effects at the site.

4.15. The site and the region shall be studied to evaluate the present and foreseeable future characteristics that could have an impact on the safety of the nuclear installation. This includes potential changes in the severity and/or the frequency of natural external events, as well as changes in the population distribution in the region, the present and future use of land and water, the further

development of existing nuclear installations or the construction of other facilities that could affect the safety of the nuclear installation or the feasibility of planning effective emergency response actions.

Requirement 6: Identification of site specific hazards

Potential external hazards associated with natural phenomena, human induced events and human activities that could affect the region shall be identified through a screening process.

4.16. The process and associated criteria used in the screening of site specific hazards shall comply with the safety objective for site evaluation and shall be properly justified and documented.

4.17. The scope of evaluation of external events in the screening process shall cover the full ranges of severity and frequency of occurrence relevant for the design and the safety assessment of the nuclear installation, including events of high severity but low probability that could contribute to the overall risk.

4.18. An event might be screened out because it is enveloped by a set of events. However, it shall be ensured that all potential effects of the screened-out event are bounded by this set of events.

4.19. External hazards that are not excluded by the screening process shall be evaluated and then used in establishing the site specific design parameters and in the re-evaluation of the site, in accordance with the significance of these hazards to the safety of the nuclear installation.

Requirement 7: Evaluation of natural and human induced external hazards

The impact of natural and human induced external hazards on the safety of the nuclear installation shall be evaluated over the lifetime of the nuclear installation.

4.20. The site evaluation for a nuclear installation shall consider the frequency and severity of natural and human induced external events, and potential combinations of such events, that could affect the safety of the nuclear installation.

4.21. Information on the frequency and severity of external events derived from the characterization of the hazards shall be used in establishing the site specific

design parameters. Adequate account shall be taken of both aleatory uncertainties and epistemic uncertainties in the establishment of site specific design parameters.

4.22. Appropriate methods, supported by numerical models when necessary, shall be used to characterize the hazards relevant for site evaluation and the design of the nuclear installation. A thorough uncertainty analysis of the method and input data shall be performed as part of the hazard evaluation.

4.23. The decision to use deterministic and/or probabilistic methodologies in hazard evaluation shall be based on the nature of the hazard, the availability of data and the applicable requirements for safety assessment.

4.24. Special consideration shall be given to the use of applicable probabilistic methodologies and the use of probabilistic hazard curves representing external events as an input to the probabilistic safety assessment for external hazards. Such probabilistic hazard curves shall be developed with reference to the specific site conditions.

4.25. The evaluation of hazards shall address the possibility that external events can occur in combination, simultaneously or within short time frames. Interrelationships and causality between external events shall be evaluated.

4.26. The results of the evaluation of hazards shall be expressed in terms that can be used as an input for deriving the site specific design parameters; that is, appropriate parameters for describing the severity of the effects of the hazards shall be selected or developed.

4.27. The potential for explosion, chemical releases and/or thermal releases that might affect the safety of the nuclear installation or the dispersion of radioactive material shall be considered in the site evaluation process.

4.28. The potential for interactions between radioactive and non-radioactive substances, such as interactions due to heat or chemicals in radioactive liquid effluents, shall be considered.

Requirement 8: Measures for site protection

If the projected design of the nuclear installation is not able to safely withstand the impact of natural and human induced external hazards, the need for site protection measures shall be evaluated.

4.29. The need for protection of the site against the effects of specific phenomena associated with natural and human induced external hazards shall be evaluated considering adequate safety margins.

4.30. The availability of adequate engineering solutions for implementing measures for site protection shall be evaluated. If such engineering solutions are not available, the site shall be deemed unsuitable.

4.31. If measures for site protection are required to be implemented, uncertainties shall be properly taken into account in the evaluation of extreme values of parameters for describing the severity of natural and human induced external hazards. Measures for site protection shall be classified, designed, built, maintained and operated in accordance with their safety significance.

Requirement 9: Site evaluation for multiple nuclear installations on the same site or on adjacent sites

The site evaluation shall consider the potential for natural and human induced external hazards to affect multiple nuclear installations on the same site as well as on adjacent sites.

4.32. Occurrences of natural and human induced external events and their credible combinations that could affect the safety of multiple installations on the same site or installations on adjacent sites shall be considered. The potential for hazards originating from one nuclear installation to affect other nuclear installations located on the same site or on adjacent sites shall be assessed.

4.33. For identified accident scenarios, the combined effects of accidents at nuclear installations located on the same site or at adjacent and nearby sites on people and the environment shall be evaluated (see Requirement 12).

Requirement 10: Changes of hazards and site characteristics with time

The external hazards and the site characteristics shall be assessed in terms of their potential for changing over time and the potential impact of these changes shall be evaluated.

4.34. The site characteristics and the natural and human induced external hazards that can change over time and which could affect the safety of a nuclear installation shall be identified. The potential consequences of such changes shall be duly assessed for the planned lifetime of the nuclear installation.

4.35. Due account shall be taken of uncertainties in the projections of any potential changes of the external hazards and site characteristics over time by means of appropriate safety margins in the related site specific design parameters.

Requirement 11: Special considerations for the ultimate heat sink for nuclear installations that require an ultimate heat sink

The evaluation of site specific natural and human induced external hazards for nuclear installations that require an ultimate heat sink shall consider hazards that could affect the availability and reliability of the ultimate heat sink.

4.36. As appropriate for the ultimate heat sink under consideration, data for the following shall be evaluated:

(a) Air temperature and humidity;
(b) Water depth and temperature;
(c) Water quality characteristics, including turbidity, suspended solids, floating debris, and chemical and biochemical changes (both natural and human induced changes);
(d) Availability and sustainability of the water flow (for a river), minimum and maximum water level and the period of time for which safety related supplies of cooling water are at a minimum level, with account taken of the potential for failure of water control structures.

4.37. All natural and human induced external events that could cause a loss of the ultimate heat sink shall be identified and evaluated.

Requirement 12: Potential effects of the nuclear installation on people and the environment

In determining the potential radiological impact of the nuclear installation on the region for operational states and accident conditions, including accidents that could warrant emergency response actions, appropriate estimates shall be made of the potential releases of radioactive material, with account taken of the design of the nuclear installation and its safety features.

4.38. The potential effects of the nuclear installation on people and the environment shall be estimated by considering the postulated accident scenarios (including the resulting source terms) and taking into account the feasibility of planning effective emergency response actions at the site and in the external zone. These estimates shall be confirmed when the design of the nuclear installation and its safety features has been established.

4.39. The direct and indirect pathways by which radioactive releases from the nuclear installation could potentially affect the public and the environment shall be identified and evaluated. In this evaluation, specific regional and site characteristics, including the population distribution in the region, shall be taken into account, with special attention paid to the transport and accumulation of radionuclides in the biosphere.

4.40. It shall be demonstrated that the information provided to assess the potential effects on the population associated with accident conditions, including accidents that could warrant emergency response actions being taken in the external zone, is consistent with achieving the safety objective for site evaluation.

Requirement 13: Feasibility of planning effective emergency response actions

The feasibility of planning effective emergency response actions on the site and in the external zone shall be evaluated, with account taken of the characteristics of the site and the external zone as well as any external events that could hinder the establishment of complete emergency arrangements prior to operation.

4.41. Requirement 13 applies also to the infrastructure of the external zone where emergency response actions might be warranted.

4.42. An assessment shall be made of the feasibility of planning effective emergency response actions in accordance with GSR Part 7 [9].

Nuclear installations on the same site and at adjacent or nearby sites shall be considered in the assessment, with special emphasis on nuclear installations that could experience concurrent accidents.

4.43. Any causal relationships between external events and the condition of the infrastructure on the site and in the external zone shall be considered when evaluating the feasibility of planning effective emergency response actions.

Requirement 14: Data collection in site evaluation for nuclear installations

The data necessary to perform an assessment of natural and human induced external hazards and to assess both the impact of the environment on the safety of the nuclear installation and the impact of the nuclear installation on people and the environment shall be collected.

4.44. Data on natural and human induced external hazards with the potential to affect the safety of the nuclear installation shall be collected throughout the lifetime of the nuclear installation. Data shall be confirmed to be relevant (spatially and temporally) to the site, with preference given to the use of site specific data in site evaluation.

4.45. The extent, objectives and scope of the data collection process shall be defined on the basis of the safety objective for site evaluation, and shall be commensurate with the hazard posed by the nuclear installation to people and the environment.

4.46. At a minimum, the data collection process shall include the following:

(a) Information on natural and human induced external hazards, including information on sources of hazards, propagation of hazards and the potential effects on the nuclear installation and on people and the environment;
(b) Information describing site conditions and regional environmental conditions;
(c) Information on the proposed engineering and administrative measures for site protection and mitigatory measures;
(d) Information on the potential impact of the nuclear installation on people and the environment for operational states and accident conditions;
(e) Information required for planning effective emergency response actions on the site and off the site in all environmental conditions and for all states of the nuclear installation;

(f) Information on conditions for access to the site and information for supporting design and development of the site infrastructure.

4.47. Information and records, if available, of the occurrence and severity of important prehistoric, historical and recent natural phenomena shall be obtained as appropriate for the hazard to be evaluated and shall be analysed for reliability, accuracy, temporal and spatial relevance, and completeness.

4.48. The data shall be maintained and reviewed periodically, and/or as necessary as part of a review of the site evaluation within the framework of the periodic safety review of the nuclear installation, for example, to address developments in data gathering techniques and in the analysis and use of data and to confirm that the data remain relevant to the site within the context of evolving hazards.

4.49. The data collected for site investigations shall be of sufficient quality and quantity to support the selected methodology for hazard evaluation.

4.50. The details of the information collected for each hazard shall be appropriate for the distance between the source of the hazard and the site and the potential impact on the site. The sources of uncertainties relating to data collection shall be documented.

5. EVALUATION OF EXTERNAL HAZARDS

5.1. This section establishes requirements for the evaluation of external hazards. These requirements are to be applied as appropriate for the type of nuclear installation as well as the site under consideration.

SEISMIC HAZARDS

Requirement 15: Evaluation of fault capability

Geological faults larger than a certain size and within a certain distance of the site and that are significant to safety shall be evaluated to identify whether these faults are to be considered capable faults. For capable faults, potential challenges to the safety of the nuclear installation in terms of ground motion and/or fault displacement hazards shall be evaluated.

5.2. Capable faults[5] shall be identified and evaluated. The evaluation shall consider the fault characteristics in the site vicinity. The methods used and the investigations made shall be sufficiently detailed to support safety related decisions.

5.3. The potential effect of fault displacement on safety related structures, systems and components shall be evaluated. The evaluation of fault displacement hazards shall include detailed geological mapping of excavations for safety related engineered structures to enable the evaluation of fault capability for the site.

5.4. A proposed new site shall be considered unsuitable when reliable evidence shows the existence of a capable fault that has the potential to affect the safety of the nuclear installation and which cannot be compensated for by means of a combination of measures for site protection and design features of the nuclear installation. If a capable fault is identified in the site vicinity of an existing nuclear installation, the site shall be deemed unsuitable if the safety of the nuclear installation cannot be demonstrated.

Requirement 16: Evaluation of ground motion hazards

An evaluation of ground motion hazards shall be conducted to provide the input needed for the seismic design or safety upgrading of the structures, systems and components of the nuclear installation, as well as the input for performing the deterministic and/or probabilistic safety analyses necessary during the lifetime of the nuclear installation.

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[5] A fault is considered capable if, on the basis of geological, geophysical, geodetic or seismological data (including palaeoseismological and geomorphological data), one or more of the following conditions applies:

(a) The fault shows evidence of past movement or movements (significant surface deformations and/or dislocations) of a recurring nature within such a period that it is reasonable to infer that further movements at or near the surface could occur. In highly active areas, where both earthquake data and geological data consistently and/or exclusively reveal short earthquake recurrence intervals, periods of the order of tens of thousands of years may be appropriate for the assessment of capable faults. In less active areas, it is likely that much longer periods will be required.

(b) A structural relationship with a known capable fault has been demonstrated such that movement of one could cause movement of the other at or near the surface.

(c) The maximum potential earthquake associated with a seismogenic structure is sufficiently large and at such a depth that it is reasonable to infer that, in the geodynamic setting of the site, movement at or near the surface could occur.

5.5. Hazards due to earthquake induced ground motion shall be assessed by means of appropriate methods. The effect of the vibratory ground motion in combination with other seismically induced events, if any, shall be considered. The potential for seismicity due to human activities[6] shall also be considered.

VOLCANIC HAZARDS

Requirement 17: Evaluation of volcanic hazards

Hazards due to volcanic activity that have the potential to affect the safety of the nuclear installation shall be evaluated.

5.6. Capable volcanoes[7] shall be identified and evaluated. The evaluation shall consider the volcanic characteristics of a region of sufficient size to ensure that potentially hazardous volcanic phenomena are considered appropriately.

5.7. The hazards of capable volcanoes shall be evaluated to provide the input needed for determining the site specific design parameters or for re-evaluating the site, as well as for deterministic and/or probabilistic safety analyses performed during the lifetime of the nuclear installation.

5.8. A proposed new site shall be considered unsuitable if reliable evidence shows the existence of a capable volcano that has the potential to affect the safety of the nuclear installation and which cannot be compensated for by means of a combination of measures for site protection and design features of the nuclear installation.

5.9. An evaluation of volcanic hazards that focuses on determining the geological characteristics of volcanic phenomena and their spatial extent will usually be more certain than one focusing on an estimation of the likelihood of occurrence of hazardous phenomena. Volcanic hazards shall be evaluated using appropriate information, methods and models with adequate account taken of the uncertainties.

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[6] Such as construction of dams, mining, and operation of oil wells and gas wells.

[7] A capable volcano is a volcano that has a credible likelihood of undergoing future activity and producing hazardous phenomena, including non-eruptive phenomena, during the lifetime of a nuclear installation concerned, and which may potentially affect the site.

5.10. The effect of volcanic phenomena in combination with other volcanically induced hazards shall be considered. This shall include consideration of volcanic ash fall.

METEOROLOGICAL HAZARDS

Requirement 18: Evaluation of extreme meteorological hazards

Extreme meteorological hazards and their possible combinations that have the potential to affect the safety of the nuclear installation shall be evaluated.

5.11. Meteorological phenomena such as wind, precipitation, snow and ice, air and water temperature, humidity, storm surges and sand or dust storms, as well as their credible combinations, shall be evaluated for their extreme values[8] based on available records. If necessary, efforts shall be made to extend the database on meteorological hazards (e.g. by incorporating historical climate data, numerical models and simulations).

5.12. Appropriate methods shall be applied for the evaluation of meteorological hazards, taking into account the amount of data available (both measured data and historical data) and known past changes in relevant characteristics of the region.

Requirement 19: Evaluation of rare meteorological events

The potential for the occurrence of rare meteorological events[9] such as lightning, tornadoes and cyclones, including information on their severity and frequency, shall be evaluated.

Lightning

5.13. The potential for the occurrence and the frequency and severity of lightning shall be evaluated for the site vicinity.

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[8] Extreme values of meteorological parameters are identified by means of statistical analysis of measurement data for different meteorological parameters.

[9] Rare meteorological events are unlikely to be measured at any specific location because of their very low frequency of occurrence at any single place and the destructive effects of the phenomena, which might result in damage to standard measuring instruments.

Tornadoes and cyclones

5.14. The potential for the occurrence and the frequency and severity of tornadoes, cyclones and associated missiles shall be evaluated for the site. The hazards associated with tornadoes and cyclones shall be derived and expressed in terms of parameters such as rotational wind speed, translational wind speed, radius of maximum rotational wind speed, pressure differentials and rate of change of pressure.

FLOODING HAZARDS

Requirement 20: Evaluation of flooding hazards

Hazards due to flooding, considering natural and human induced events including their possible combinations, shall be evaluated.

Floods due to precipitation and other natural causes

5.15. The potential for flooding in the region surrounding the site due to one or more natural causes, such as storm surge, wind generated waves, meteorological tsunamis or seiches, or extreme precipitation — or due to a combination of such events that have a common cause or a relatively high frequency of occurrence — shall be evaluated.

5.16. Appropriate meteorological, hydrological and hydraulic models shall be developed to derive the flooding hazards for the site, including secondary effects such as debris, ice and sediments. Where available, relevant information from studies of historic and prehistoric floods shall be used to inform estimates of the frequency and magnitude of riverine floods.

5.17. The potential for instability of a coastal area or river channel due to erosion or sedimentation shall be investigated.

Water waves induced by earthquakes or other geological phenomena

5.18. The potential for tsunamis or seiches in the region that could affect the safety of the nuclear installation shall be evaluated. The potential for tsunamis or seiches from phenomena other than seismic sources (e.g. from submarine landslides) shall be evaluated, as appropriate for the region.

5.19. The hazards associated with tsunamis or seiches shall be derived from historical records and any available information on prehistoric floods, as well as from physical and/or analytical modelling. Such hazards shall include potential draw-down and run-up[10] that could result in physical effects on the site.

5.20. The hazards associated with tsunamis or seiches shall be evaluated as appropriate for the region, using nearshore bathymetry and coastal topography, with account taken of any amplification due to the coastal configuration (including artificial structures).

Floods and waves caused by failure of water control structures

5.21. Upstream water control structures such as dams shall be analysed to determine the potential hazard associated with the failure of one or more of the upstream structures, including in combination with flooding from other causes.

5.22. If a preliminary examination of the nuclear installation indicates that it would not be able to safely withstand the effects of the failure of one or more of the upstream water control structures, then the hazards associated with the nuclear installation shall be evaluated with the inclusion of such effects. Alternatively, such upstream structures shall be analysed by methods equivalent to those used in determining the hazards associated with the nuclear installation to demonstrate that the upstream structures could survive the event concerned.

5.23. Flooding and associated phenomena caused by an accumulation of water due to a blockage of rivers upstream or downstream (e.g. caused by landslides or ice), or due to a change in land use, shall be considered.

GEOTECHNICAL HAZARDS AND GEOLOGICAL HAZARDS

Requirement 21: Geotechnical characteristics and geological features of subsurface materials

The geotechnical characteristics and geological features of subsurface materials shall be investigated, and a soil and rock profile for the site that considers the variability and uncertainty in subsurface materials shall be derived.

[10] Draw-down is a lowering of the water level at a coastal site. Run-up is a sudden surge of water up a beach or a structure.

5.24. The static and dynamic geotechnical characteristics and geological features of subsurface materials at the site, including any backfill, shall be established. Laboratory and field based methods shall be used, in conjunction with appropriate sampling techniques and sufficient repetition of each test, to characterize each parameter of the subsurface materials at the site.

5.25. The stability and bearing capacity of foundation materials shall be assessed, including consideration of the potential for excessive settlement under static and seismic loading.

5.26. The physical and the geochemical properties of the soil and groundwater shall be studied by appropriate methods and taken into account in the evaluation of the subsurface material at the site.

Requirement 22: Evaluation of geotechnical hazards and geological hazards

Geotechnical hazards and geological hazards, including slope instability, collapse, subsidence or uplift, and soil liquefaction, and their effect on the safety of the nuclear installation, shall be evaluated.

Slope instability

5.27. The site and the site vicinity shall be evaluated to determine the potential for slope instability (such as landslides, rock fall and snow avalanches), caused by natural or human induced phenomena, which could affect the safety of the nuclear installation. In the evaluation of slope instability, the configuration of the site during and after site preparation activities shall be addressed. The evaluation of slope stability shall also take into account extreme meteorological conditions and rare meteorological events.

5.28. The potential for slope instability resulting from seismic loading shall be evaluated using parameters appropriate for describing the seismic hazards and the soil and groundwater characteristics at the site.

Collapse, subsidence or uplift of the site surface

5.29. The potential for collapse, subsidence or uplift of the surface that could affect the safety of the nuclear installation over its lifetime shall be evaluated using a detailed description of subsurface conditions obtained from reliable methods of investigation.

Soil liquefaction

5.30. The potential for liquefaction and non-linear effects of the subsurface materials at the site shall be evaluated using parameters appropriate for describing the seismic hazards and geotechnical properties of the subsurface materials at the site.

5.31. The evaluation of soil liquefaction shall include the use of accepted methods for field and laboratory testing in combination with analytical methods to assess the hazards.

OTHER NATURAL HAZARDS

Requirement 23: Evaluation of other natural hazards

Other natural phenomena that are specific to the region and which have the potential to affect the safety of the nuclear installation shall be investigated.

5.32. Other natural external hazards, such as wild fires, drought, hail, frazil ice formation, diversion of a river, debris avalanche and biological hazards (e.g. jellyfish, small animals and barnacles) shall be identified and assessed so that the site specific design parameters for these hazards can be derived.

HUMAN INDUCED EVENTS

Requirement 24: Evaluation of hazards associated with human induced events

The hazards associated with human induced events on the site or in the region shall be evaluated.

5.33. Human induced events to be addressed shall include, but shall not be limited to:

(a) Events associated with nearby land, river, sea or air transport (e.g. collisions and explosions);
(b) Fire, explosions, missile generation and releases of hazardous gases from industrial facilities near the site;
(c) Electromagnetic interference.

5.34. Human activities that might influence the type or severity of natural hazards, such as resource extraction or other significant re-contouring of land or water or reservoir induced seismicity, shall be considered.

Aircraft crashes

5.35. The potential for accidental aircraft crashes on the site shall be assessed with account taken, to the extent practicable, of potential changes in future air traffic and aircraft characteristics.

Chemical hazards

5.36. Current or foreseeable activities in the region surrounding the site that involve the handling, processing, transport and/or storage of chemicals having a potential for explosions or for producing gas clouds capable of deflagration or detonation shall be addressed.

5.37. Hazards associated with chemical explosions or other releases shall be expressed in terms of heat, overpressure and toxicity (if applicable), with account taken of the effect of distance and non-favourable combinations of atmospheric conditions at the site. In addition, the potential effects of such events on site workers shall be evaluated.

6. EVALUATION OF THE POTENTIAL EFFECTS OF THE NUCLEAR INSTALLATION ON THE REGION

Requirement 25: Dispersion of radioactive material

The dispersion in air and water of radioactive material released from the nuclear installation in operational states and in accident conditions shall be assessed.

Atmospheric dispersion of radioactive material

6.1. The analysis of the atmospheric dispersion of radioactive material shall take into account the orography, land cover and meteorological features of the region, including parameters such as wind speed and direction, air temperature, precipitation, humidity, atmospheric stability parameters, prolonged atmospheric

inversions and any other parameters required for modelling of atmospheric dispersion. If possible, long term meteorological data for nearby locations shall be obtained, evaluated for quality and used.

6.2. A programme for meteorological measurements shall be prepared and carried out at or near the site using instrumentation capable of measuring and recording the main meteorological parameters at appropriate elevations, locations and sampling intervals. Data from at least one representative full year shall be collected and used in the analyses of atmospheric dispersion, together with any other relevant data available from other information sources. The meteorological data shall be expressed in terms of appropriate meteorological parameters.

Dispersion of radioactive material through surface water and groundwater

6.3. A survey programme shall be designed to gather relevant data to characterize the hydrogeological and hydrological parameters at the site and in the region to permit the assessment of the potential movement of radionuclides through surface water and groundwater and the subsequent assessment of the radiological impact. This measurement programme shall be carried out for at least one full year prior to hydrogeological investigations (see para. 6.5). The data shall be expressed in terms of appropriate parameters for surface hydrology and groundwater.

6.4. A programme of surface water investigations (including the interactions between surface water and groundwater) for the region shall be developed. The description of surface water shall include the main physical and chemical characteristics of the water bodies, both natural and artificial, the major structures for water control, the locations of water intake structures and information on water use in the region.

6.5. A programme of hydrogeological investigations for the region shall be developed, including descriptions of the main characteristics of the water-bearing formations and their interaction with surface water, as well as data on the uses of groundwater in the region.

6.6. The programme of hydrogeological investigations for the region shall include investigations of the migration and retention characteristics of radionuclides in groundwater and investigations of the associated exposure pathways.

6.7. The hydrogeological and hydrological investigations shall determine, to the extent necessary, the dilution and dispersion characteristics of water bodies,

the re-concentration ability of sediments and biota, the migration and retention characteristics of radionuclides, the transfer mechanisms for radionuclides in the hydrosphere, as well as the associated exposure pathways.

Requirement 26: Population distribution and public exposure

The existing and projected population distribution within the region over the lifetime of the nuclear installation shall be determined and the potential impact of radioactive releases on the public, in both operational states and accident conditions, shall be evaluated and periodically updated.

6.8. Information on the existing and projected population distribution in the region, including resident populations and (to the extent possible) transient populations, shall be collected and kept up to date over the lifetime of the nuclear installation. Special attention shall be paid to vulnerable populations and residential institutions (e.g. schools, hospitals, nursing homes and prisons) when evaluating the potential impact of radioactive releases and considering the feasibility of implementing protective actions.

6.9. The most recent census data for the region, or information obtained by extrapolation of the most recent data on resident populations and transient populations, shall be used in obtaining the population distribution. In the absence of reliable data, a special study shall be carried out.

6.10. The data shall be analysed to obtain the population distribution in terms of the direction and distance from the site. This information shall be used to carry out an evaluation of the potential radiological impact of normal discharges and accidental releases of radioactive material, including reasonable consideration of releases due to severe accidents, with the use of site specific design parameters and models as appropriate.

Requirement 27: Uses of land and water in the region

The uses of land and water shall be characterized in order to assess the potential effects of the nuclear installation on the region.

6.11. The characterization of the uses of land and water shall include investigations of the land and surface water and groundwater resources that might be used by the population or that serve as a habitat for organisms in the food chain.

7. MONITORING AND PERIODIC REVIEW OF THE SITE

Requirement 28: Monitoring of external hazards and site conditions

All natural and human induced external hazards and site conditions that are relevant to the licensing and safe operation of the nuclear installation shall be monitored over the lifetime of the nuclear installation.

7.1. The monitoring of external hazards and site conditions shall be commenced no later than the start of construction and shall be continued until decommissioning. The monitoring plan shall be developed as part of the objectives and scope of the site evaluation.

7.2. The monitoring plan shall include the parameters to be monitored, the type of data to be collected, the methodology for data collection (including the location and frequency of data collection), the necessary resolution and precision of any measurements, data backup requirements, as well as requirements for data processing and analysis.

7.3. Before commissioning of the nuclear installation begins, the levels of background radioactivity in the atmosphere, hydrosphere and lithosphere and in biota in the region shall be measured so as to make it possible to determine any additional radioactivity due to the operation of the nuclear installation.

Requirement 29: Review of external hazards and site conditions

All natural and human induced external hazards and site conditions shall be periodically reviewed by the operating organization as part of the periodic safety review and as appropriate throughout the lifetime of the nuclear installation, with due account taken of operating experience and new safety related information.

7.4. As part of periodic safety review (or as part of safety assessments conducted under alternative arrangements), natural and human induced external hazards and site conditions shall be reviewed throughout the lifetime of the nuclear installation using updated information. Such reviews shall be undertaken at regular intervals (typically no less than once in ten years), and in the event of any of the following:

(a) An update of the regulatory requirements;

(b) Indications of inadequate design against external hazards;
(c) New technical findings, such as the vulnerability of particular structures, systems and components to external hazards;
(d) New information, experience and lessons from the occurrence of actual external events that affected the safety of another nuclear installation or an industrial facility;
(e) Changes of hazards over time for which new information and assessments have become available;
(f) A need to provide additional confidence that there are sufficient margins to prevent cliff edge effects;
(g) As part of a programme for long term operation, or in support of an application for an extension to the operating licence for the nuclear installation;
(h) The development of new methods to analyse hazards that substantially improve earlier estimates.

7.5. The site specific external hazards and the site conditions shall be re-evaluated, as necessary, based on the outcome of the periodic review of site specific hazards or because of new data relevant to the radiological environmental impact assessment or to the safe operation of the nuclear installation.

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Other safety related IAEA publications are issued as **Emergency Preparedness and Response** publications, **Radiological Assessment Reports**, the International Nuclear Safety Group's **INSAG Reports**, **Technical Reports** and **TECDOCs**. The IAEA also issues reports on radiological accidents, training manuals and practical manuals, and other special safety related publications.

Security related publications are issued in the **IAEA Nuclear Security Series**.

The **IAEA Nuclear Energy Series** comprises informational publications to encourage and assist research on, and the development and practical application of, nuclear energy for peaceful purposes. It includes reports and guides on the status of and advances in technology, and on experience, good practices and practical examples in the areas of nuclear power, the nuclear fuel cycle, radioactive waste management and decommissioning.

INVESTIGATION OF SITE CHARACTERISTICS AND EVALUATION OF RADIATION RISKS TO THE PUBLIC AND THE ENVIRONMENT IN SITE EVALUATION FOR NUCLEAR INSTALLATIONS

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The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world".

IAEA SAFETY STANDARDS SERIES No. SSG-92

INVESTIGATION OF SITE CHARACTERISTICS AND EVALUATION OF RADIATION RISKS TO THE PUBLIC AND THE ENVIRONMENT IN SITE EVALUATION FOR NUCLEAR INSTALLATIONS

SPECIFIC SAFETY GUIDE

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2025

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FOREWORD

by Rafael Mariano Grossi
Director General

The IAEA's Statute authorizes it to "establish…standards of safety for protection of health and minimization of danger to life and property". These are standards that the IAEA must apply to its own operations, and that States can apply through their national regulations.

The IAEA started its safety standards programme in 1958 and there have been many developments since. As Director General, I am committed to ensuring that the IAEA maintains and improves upon this integrated, comprehensive and consistent set of up to date, user friendly and fit for purpose safety standards of high quality. Their proper application in the use of nuclear science and technology should offer a high level of protection for people and the environment across the world and provide the confidence necessary to allow for the ongoing use of nuclear technology for the benefit of all.

Safety is a national responsibility underpinned by a number of international conventions. The IAEA safety standards form a basis for these legal instruments and serve as a global reference to help parties meet their obligations. While safety standards are not legally binding on Member States, they are widely applied. They have become an indispensable reference point and a common denominator for the vast majority of Member States that have adopted these standards for use in national regulations to enhance safety in nuclear power generation, research reactors and fuel cycle facilities as well as in nuclear applications in medicine, industry, agriculture and research.

The IAEA safety standards are based on the practical experience of its Member States and produced through international consensus. The involvement of the members of the Safety Standards Committees, the Nuclear Security Guidance Committee and the Commission on Safety Standards is particularly important, and I am grateful to all those who contribute their knowledge and expertise to this endeavour.

The IAEA also uses these safety standards when it assists Member States through its review missions and advisory services. This helps Member States in the application of the standards and enables valuable experience and insight to be shared. Feedback from these missions and services, and lessons identified from events and experience in the use and application of the safety standards, are taken into account during their periodic revision.

I believe the IAEA safety standards and their application make an invaluable contribution to ensuring a high level of safety in the use of nuclear technology. I encourage all Member States to promote and apply these standards, and to work with the IAEA to uphold their quality now and in the future.

THE IAEA SAFETY STANDARDS

BACKGROUND

Radioactivity is a natural phenomenon and natural sources of radiation are features of the environment. Radiation and radioactive substances have many beneficial applications, ranging from power generation to uses in medicine, industry and agriculture. The radiation risks to workers and the public and to the environment that may arise from these applications have to be assessed and, if necessary, controlled.

Activities such as the medical uses of radiation, the operation of nuclear installations, the production, transport and use of radioactive material, and the management of radioactive waste must therefore be subject to standards of safety.

Regulating safety is a national responsibility. However, radiation risks may transcend national borders, and international cooperation serves to promote and enhance safety globally by exchanging experience and by improving capabilities to control hazards, to prevent accidents, to respond to emergencies and to mitigate any harmful consequences.

States have an obligation of diligence and duty of care, and are expected to fulfil their national and international undertakings and obligations.

International safety standards provide support for States in meeting their obligations under general principles of international law, such as those relating to environmental protection. International safety standards also promote and assure confidence in safety and facilitate international commerce and trade.

A global nuclear safety regime is in place and is being continuously improved. IAEA safety standards, which support the implementation of binding international instruments and national safety infrastructures, are a cornerstone of this global regime. The IAEA safety standards constitute a useful tool for contracting parties to assess their performance under these international conventions.

THE IAEA SAFETY STANDARDS

The status of the IAEA safety standards derives from the IAEA's Statute, which authorizes the IAEA to establish or adopt, in consultation and, where appropriate, in collaboration with the competent organs of the United Nations and with the specialized agencies concerned, standards of safety for protection of health and minimization of danger to life and property, and to provide for their application.

With a view to ensuring the protection of people and the environment from harmful effects of ionizing radiation, the IAEA safety standards establish fundamental safety principles, requirements and measures to control the radiation exposure of people and the release of radioactive material to the environment, to restrict the likelihood of events that might lead to a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation, and to mitigate the consequences of such events if they were to occur. The standards apply to facilities and activities that give rise to radiation risks, including nuclear installations, the use of radiation and radioactive sources, the transport of radioactive material and the management of radioactive waste.

Safety measures and security measures[1] have in common the aim of protecting human life and health and the environment. Safety measures and security measures must be designed and implemented in an integrated manner so that security measures do not compromise safety and safety measures do not compromise security.

The IAEA safety standards reflect an international consensus on what constitutes a high level of safety for protecting people and the environment from harmful effects of ionizing radiation. They are issued in the IAEA Safety Standards Series, which has three categories (see Fig. 1).

Safety Fundamentals

Safety Fundamentals present the fundamental safety objective and principles of protection and safety, and provide the basis for the Safety Requirements. The principles are expressed as 'must' statements.

Safety Requirements

Safety Requirements are governed by the objective and principles of the Safety Fundamentals. They establish the requirements to be met to ensure the protection of people and the environment, both now and in the future. The format and style of the Safety Requirements facilitate their use for the establishment of a national regulatory framework. Requirements are presented as 'overarching' requirements[2] in bold, followed by a number of associated requirements; all are equally important and are expressed as 'shall' statements.

Safety Guides

Safety Guides provide recommendations on how to comply with the Safety Requirements, indicating an international consensus that it is necessary to take the

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[1] See also publications issued in the IAEA Nuclear Security Series.

[2] The IAEA Regulations for the Safe Transport of Radioactive Material do not include overarching requirements.

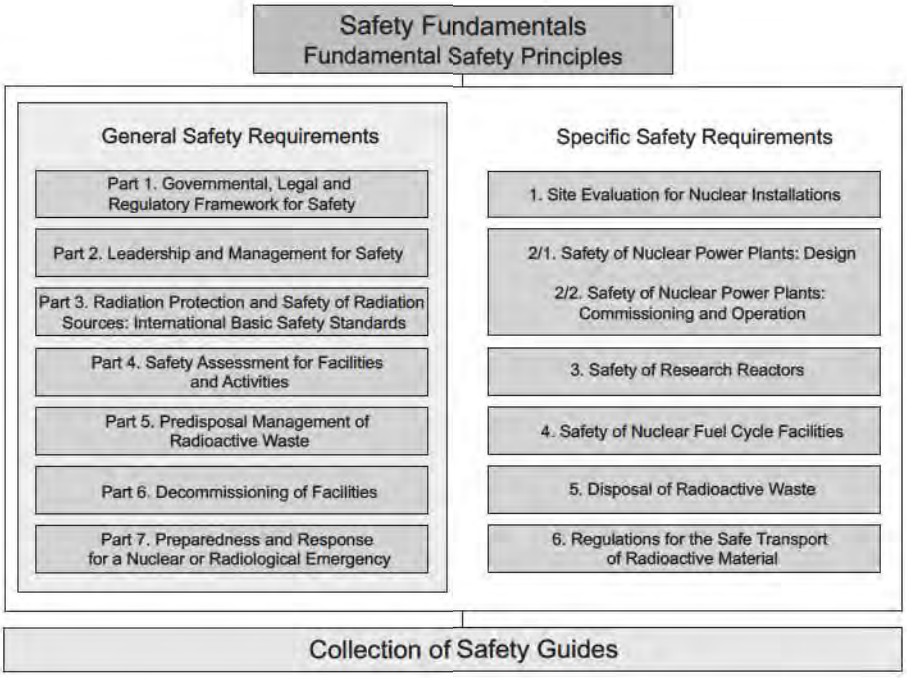


FIG. 1. The long term structure of the IAEA Safety Standards Series.

measures recommended (or alternative measures that achieve the same level of protection). Safety Guides present international good practices and, increasingly, best practices. The recommendations provided in Safety Guides are expressed as 'should' statements.

APPLICATION OF THE IAEA SAFETY STANDARDS

The principal users of safety standards in IAEA Member States are regulatory bodies and other relevant national authorities. The IAEA safety standards are also used by co-sponsoring organizations and by many organizations that design, construct and operate nuclear facilities, as well as organizations involved in the use of radiation and radioactive sources.

The IAEA safety standards are applicable, as relevant, throughout the entire lifetime of all facilities and activities — existing and new — utilized for peaceful purposes and to protective actions to reduce existing radiation risks. They can be used by States as a reference for their national regulations in respect of facilities and activities.

The IAEA's Statute makes the safety standards binding on the IAEA in relation to its own operations and also on States in relation to IAEA assisted operations.

The IAEA safety standards also form the basis for the IAEA's safety review services, and they are used by the IAEA in support of competence building, including the development of educational curricula and training courses.

International conventions contain requirements similar to those in the IAEA safety standards and make them binding on contracting parties. The IAEA safety standards, supplemented by international conventions, industry standards and detailed national requirements, establish a consistent basis for protecting people and the environment. There will also be some special aspects of safety that need to be assessed at the national level. For example, many of the IAEA safety standards, in particular those addressing aspects of safety in planning or design, are intended to apply primarily to new facilities and activities. The requirements established in the IAEA safety standards might not be fully met at some existing facilities that were built to earlier standards. The way in which IAEA safety standards are to be applied to such facilities is a decision for individual States.

The scientific considerations underlying the IAEA safety standards provide an objective basis for decisions concerning safety; however, decision makers must also make informed judgements and must determine how best to balance the benefits of an action or an activity against the associated radiation risks and any other detrimental impacts to which it gives rise.

DEVELOPMENT PROCESS FOR THE IAEA SAFETY STANDARDS

The preparation and review of the safety standards involves the IAEA Secretariat and five Safety Standards Committees, for emergency preparedness and response (EPReSC) (as of 2016), nuclear safety (NUSSC), radiation safety (RASSC), the safety of radioactive waste (WASSC) and the safe transport of radioactive material (TRANSSC), and a Commission on Safety Standards (CSS) which oversees the IAEA safety standards programme (see Fig. 2).

All IAEA Member States may nominate experts for the Safety Standards Committees and may provide comments on draft standards. The membership of the Commission on Safety Standards is appointed by the Director General and includes senior governmental officials having responsibility for establishing national standards.

A management system has been established for the processes of planning, developing, reviewing, revising and establishing the IAEA safety standards. It articulates the mandate of the IAEA, the vision for the future application of the safety standards, policies and strategies, and corresponding functions and responsibilities.

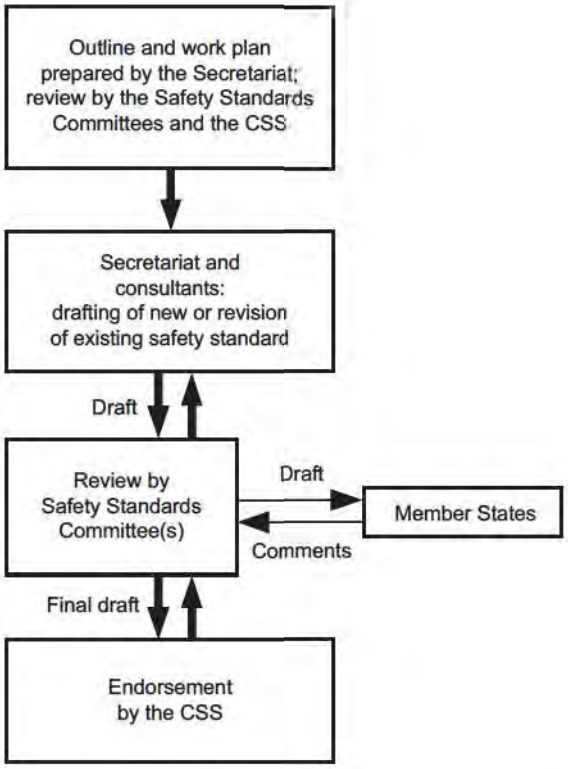


FIG. 2. The process for developing a new safety standard or revising an existing standard.

INTERACTION WITH OTHER INTERNATIONAL ORGANIZATIONS

The findings of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and the recommendations of international expert bodies, notably the International Commission on Radiological Protection (ICRP), are taken into account in developing the IAEA safety standards. Some safety standards are developed in cooperation with other bodies in the United Nations system or other specialized agencies, including the Food and Agriculture Organization of the United Nations, the United Nations Environment Programme, the International Labour Organization, the OECD Nuclear Energy Agency, the Pan American Health Organization and the World Health Organization.

INTERPRETATION OF THE TEXT

Safety related terms are to be understood as they appear in the IAEA Nuclear Safety and Security Glossary (see https://www.iaea.org/resources/publications/iaea-nuclear-safety-and-security-glossary). Otherwise, words are used with the spellings and meanings assigned to them in the latest edition of The Concise Oxford Dictionary. For Safety Guides, the English version of the text is the authoritative version.

The background and context of each standard in the IAEA Safety Standards Series and its objective, scope and structure are explained in Section 1, Introduction, of each publication.

Material for which there is no appropriate place in the body text (e.g. material that is subsidiary to or separate from the body text, is included in support of statements in the body text, or describes methods of calculation, procedures or limits and conditions) may be presented in appendices or annexes.

An appendix, if included, is considered to form an integral part of the safety standard. Material in an appendix has the same status as the body text, and the IAEA assumes authorship of it. Annexes and footnotes to the main text, if included, are used to provide practical examples or additional information or explanation. Annexes and footnotes are not integral parts of the main text. Annex material published by the IAEA is not necessarily issued under its authorship; material under other authorship may be presented in annexes to the safety standards. Extraneous material presented in annexes is excerpted and adapted as necessary to be generally useful.

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1. INTRODUCTION

BACKGROUND

1.1. IAEA Safety Standards Series No. SSR-1, Site Evaluation for Nuclear Installations [1], establishes requirements for:

(a) Defining the information to be used in the site evaluation process;
(b) Evaluating a site such that the site specific hazards and the safety related site characteristics are adequately taken into account, in order to derive appropriate site specific design parameters;
(c) Investigating site characteristics and assessing the radiological environmental impact of nuclear installations;
(d) Analysing the characteristics of the population and the region surrounding the site to determine whether there would be significant difficulties in implementing emergency response actions effectively.

1.2. IAEA Safety Standards Series Nos SSR-3, Safety of Research Reactors [2], SSR-4, Safety of Nuclear Fuel Cycle Facilities [3], GSR Part 3, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards [4], and GSR Part 7, Preparedness and Response for a Nuclear or Radiological Emergency [5], establish requirements on these topics. This Safety Guide provides recommendations on how to meet these requirements.

1.3. This Safety Guide takes into account progress in the investigation of site characteristics and assessment of the radiological environmental impact of nuclear installations, as well as in regulatory practices in Member States. It considers lessons identified from discharges[1] and accident conditions at nuclear installations, feedback from safety review missions and the results of recent research in relevant fields.

1.4. This Safety Guide provides new or updated recommendations that address the following topics:

(a) Recent updates in the investigation of site characteristics and radiological environmental impact assessment for nuclear installations;

[1] As defined in the IAEA Nuclear Safety and Security Glossary [6], a discharge is a planned and controlled release of (usually gaseous or liquid) radioactive substances to the environment.

(b) Methodologies for the analysis of dispersion and transfer of radionuclides;
(c) Linking of the results of analyses with the assessment of overall radiological impact (including dose assessment);
(d) Development of a complete set of potential release scenarios;
(e) Application of a graded approach to the radiological environmental impact assessment of nuclear installations;
(f) Monitoring of radioactivity in the environment.

1.5. This Safety Guide supersedes IAEA Safety Standards Series No. NS-G-3.2, Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluation for Nuclear Power Plants.[2]

OBJECTIVE

1.6. The main objective of this Safety Guide is to provide recommendations on the investigation of site characteristics and the evaluation of radiation risks[3] to the public and the environment in site evaluation for nuclear installations, to meet the applicable safety requirements established in SSR-1 [1], SSR-3 [2], SSR-4 [3], GSR Part 3 [4] and GSR Part 7 [5]. It provides specific recommendations on radiological environmental impact assessment for nuclear installations in the site evaluation process.

1.7. This Safety Guide is intended for use by organizations involved in the investigation of site characteristics and the evaluation of radiation risks for nuclear installations, which includes radiological environmental impact assessment (e.g. by operating organizations, designers or technical support organizations), as well as by regulatory bodies. The applicability of the guidance will vary depending on site characteristics and the life stage of a nuclear installation.

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[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluation for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-3.2, IAEA, Vienna (2002).

[3] As defined in the IAEA Nuclear Safety and Security Glossary [6], radiation risks are detrimental health effects of exposure to radiation (including the likelihood of such effects occurring), and any other safety related risks (including those to the environment) that might arise as a direct consequence of: (a) Exposure to radiation; (b) The presence of radioactive material (including radioactive waste) or its release to the environment; (c) A loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation.

SCOPE

1.8. This Safety Guide provides recommendations on how to assess the radiological environmental impact due to discharges and accidental releases from a new or existing nuclear installation on people and the environment. It covers the investigation of site characteristics, such as population distribution, land and water use in the region, background levels of radioactivity in the environmental media, and meteorological, hydrological and hydrogeological characteristics of the region.

1.9. This Safety Guide provides recommendations on the development of the site evaluation report for a nuclear installation. It also provides recommendations on the development of the radiological impact assessment, which is part of the environmental impact assessment report, and relevant sections of the safety analysis report. The recommendations apply to the site evaluation process and other assessments performed throughout the lifetime of a nuclear installation (e.g. periodic safety review) or when site characteristics change.

1.10. This Safety Guide also covers analysis of the dispersion of radionuclides in the atmosphere, surface water and groundwater, and assessment of overall radiological impact and dose assessment in the process of site evaluation.

1.11. Data collection within the scope of this publication (e.g. site specific natural and infrastructural conditions in the region of the site) supports the determination of off-site emergency planning zones and emergency planning distances. The feasibility of planning effective emergency response actions and the application of a management system for those actions are also addressed.

1.12. Although an environmental impact assessment covers potential radiological and non-radiological impacts, the latter are out of the scope of this Safety Guide. Nevertheless, care should be taken to ensure that the non-radiological impact assessment is consistent with the radiological impact assessment in terms of estimating the transfer of releases to the environment and defining the representative person.

1.13. Environmental impacts of alternatives, which need to be considered as part of the environmental impact assessment, are not a subject of this Safety Guide. The conditions at the site and in the vicinity could change over time (e.g. population size, distribution) and this needs to be assessed. However, this Safety Guide covers present conditions (e.g. current nuclear facilities on the site) as part of the assessment of environmental impacts from the proposed actions.

1.14. In addition to the characteristics investigated in this Safety Guide, other site characteristics are considered in site evaluation for a nuclear installation. They relate to natural external hazards and include meteorological hazards (e.g. lightning, extreme winds, tropical cyclones, typhoons and hurricanes, tornadoes, waterspouts, extreme rainfall and snowfall, extreme temperatures), hydrological hazards (e.g. storm surges, waves, tsunamis, seiches), seismic hazards (e.g. vibratory ground motion hazards, fault displacements), geological hazards (e.g. slope instability, collapse, subsidence or uplift, soil liquefaction) and volcanic hazards (e.g. tephra fallout, pyroclastic flows, lava flows). Site characteristics also relate to hazards associated with human induced events (e.g. hazards associated with events occurring on nearby land, rivers or seas or in the air due to collisions and explosions, fire, missile generation and releases of hazardous gases from industrial facilities near the site). These characteristics are covered in more detail in IAEA Safety Standards Series Nos SSG-18, Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations [7]; SSG-9 (Rev. 1), Seismic Hazards in Site Evaluation for Nuclear Installations [8]; SSG-93, Geotechnical Aspects in the Siting and Design of Nuclear Installations [9]; SSG-21, Volcanic Hazards in Site Evaluation for Nuclear Installations [10]; and SSG-79, Hazards Associated with Human Induced External Events in Site Evaluation for Nuclear Installations [11]. Any design changes implemented as a result of the external hazard assessment will affect the radiological impact assessments for the nuclear installation.

1.15. The recommendations provided in this Safety Guide are applicable to all types of nuclear installations as defined in Ref. [6], but not to transportable installations. Although the recommendations are predominantly written with nuclear power plants in mind, they are also applicable to other nuclear installations through the use of a graded approach (see Section 10).

1.16. The assessments of radiological environmental impacts due to malicious acts at nuclear installations are outside the scope of this Safety Guide, although some of the recommendations provided might also be consistent with the needs of nuclear security. Specific guidance on the protection of nuclear power plants against malicious acts is provided in IAEA Nuclear Security Series No. 48-T, Identification and Categorization of Sabotage Targets, and Identification of Vital Areas at Nuclear Facilities [12].

STRUCTURE

1.17. Section 2 summarizes the relevant safety requirements and provides recommendations on identifying exposure pathways, the general approach to environmental impact assessment, site characterization for such an assessment, the assessment of transfer of radionuclides to the environment, the approach for existing sites and addressing climate change. Recommendations on baseline environmental characteristics of the site and region, including population distribution, are provided in Section 3. Recommendations on the analysis of the dispersion of radionuclides in the atmosphere are provided in Section 4. Recommendations on the analysis of the dispersion of radionuclides in surface water and groundwater are provided in Sections 5 and 6, respectively. Recommendations on the assessment of overall radiological impact are provided in Section 7. Section 8 provides recommendations on the monitoring of radioactivity in the environment. Recommendations in relation to the feasibility of effective emergency response actions are provided in Section 9. Recommendations on the application of a graded approach to radiological environmental impact assessment for nuclear installations are provided in Section 10. Section 11 provides recommendations on the application of the management system for activities that are performed for the investigation of site characteristics and evaluation of radiation risks to the public and the environment in site evaluation for nuclear installations. The Appendix provides a methodology for the application of a graded approach to the analysis of dispersion of radionuclides in groundwater.

2. REQUIREMENTS FOR AND THE GENERAL APPROACH TO INVESTIGATING SITE CHARACTERISTICS AND EVALUATING RADIATION RISKS IN SITE EVALUATION FOR NUCLEAR INSTALLATIONS

REQUIREMENTS FOR EVALUATION OF THE POTENTIAL EFFECTS OF NUCLEAR INSTALLATIONS ON PEOPLE AND THE ENVIRONMENT

2.1. Requirement 5 of SSR-1 [1] states:

> "**The site and the region shall be investigated with regard to the characteristics that could affect the safety of the nuclear installation and the potential radiological impact of the nuclear installation on people and the environment.**"

2.2. Requirement 12 of SSR-1 [1] states:

> "**In determining the potential radiological impact of the nuclear installation on the region for operational states and accident conditions, including accidents that could warrant emergency response actions, appropriate estimates shall be made of the potential releases of radioactive material, with account taken of the design of the nuclear installation and its safety features.**"

2.3. Requirement 25 of SSR-1 [1] states that "**The dispersion in air and water of radioactive material released from the nuclear installation in operational states and in accident conditions shall be assessed.**"

2.4. Requirement 29 of SSR-1 [1] states:

> "**All natural and human induced external hazards and site conditions shall be periodically reviewed by the operating organization as part of the periodic safety review and as appropriate throughout the lifetime of the nuclear installation, with due account taken of operating experience and new safety related information.**"

2.5. Paragraph 7.5 of SSR-1 [1] states:

> "The site specific external hazards and the site conditions shall be re-evaluated, as necessary, based on the outcome of the periodic review of site specific hazards or because of new data relevant to the radiological environmental impact assessment or to the safe operation of the nuclear installation."

2.6. Paragraphs 5.1–5.12 of SSR-3 [2] provide requirements for site evaluation specific to research reactors.

2.7. Paragraphs 5.1–5.12 of SSR-4 [3] provide requirements for site evaluation specific to nuclear fuel cycle facilities.

IDENTIFICATION OF EXPOSURE PATHWAYS IN SITE EVALUATION FOR NUCLEAR INSTALLATIONS

2.8. Paragraph 4.39 of SSR-1 [1] states:

> "The direct and indirect pathways by which radioactive releases from the nuclear installation could potentially affect the public and the environment shall be identified and evaluated. In this evaluation, specific regional and site characteristics, including the population distribution in the region, shall be taken into account, with special attention paid to the transport and accumulation of radionuclides in the biosphere."

2.9. Exposure pathways are routes by which radiation or radionuclides can reach humans and cause exposure. Possible exposure pathways for radionuclides released to the atmosphere and surface water during normal operation of nuclear installations such as nuclear power plants are listed in para. 5.27 of IAEA Safety Standards Series No. GSG-10, Prospective Radiological Environmental Impact Assessment for Facilities and Activities [13]. Figure 1 of IAEA Safety Standards Series No. GSG-19, Monitoring for Protection of the Public and the Environment [14], shows the possible exposure pathways for members of the public as a result of releases of radioactive substances to the environment. The exposure pathways are as follows:

(a) Inhalation of airborne material in an atmospheric plume (e.g. gases, vapours, aerosols);
(b) Inhalation of resuspended material;
(c) Ingestion of crops;

(d) Ingestion of animal food products (e.g. milk, meat, eggs);
(e) Ingestion of drinking water;
(f) Ingestion of aquatic food (e.g. freshwater or seawater fish, crustaceans, molluscs);
(g) Ingestion of forest food (e.g. wild mushrooms, wild berries, game);
(h) Ingestion of breast milk or locally prepared food for infants;
(i) Inadvertent ingestion of soil and sediments;
(j) External exposure from radionuclides in an atmospheric plume (i.e. cloud shine);
(k) External exposure from radionuclides deposited on the ground (i.e. ground shine) and on surfaces;
(l) External exposure from radionuclides in water and sediments (e.g. from activities on shores, swimming and fishing).

2.10. In addition, there might be exposure due to irradiation from activity deposited from the atmospheric plume on people's skin, clothing or vehicles, and exposure due to irradiation from activity on the site (see the additional exposure pathways described in para. 5.29 of GSG-10 [13]) without any activity having been released from the installation. As these would also be expected pathways for accidental releases, their relative significance is much higher during such situations.

2.11. The first step in evaluating a site for a nuclear installation in terms of radiation risks should be to identify all possible exposure pathways and then determine which are significant in terms of exposure of the public or the environment.

2.12. The significance of the pathway depends on the quantities and the chemical and physical form of the radionuclides released. It also depends on other characteristics of the release that might affect the subsequent dispersion of radionuclides and their behaviour in the environment, the location and medium into which the release is made and the characteristics of the environment and population around the site.

2.13. It should therefore be confirmed that significant pathways have been identified, especially if there are specific characteristics about the installation design, its operation, the site, land and water use around the site, farming practices or the surrounding location. For example, the presence of desalination plants producing water (either at or close to the discharge outlets) for drinking or irrigation might give rise to exposure pathways.

2.14. Accidental releases may encompass a spectrum of scenarios, such as design basis accidents and design extension conditions, including sequences

without significant fuel degradation and sequences with core melting, involving different source terms and release locations and releases to different media. Different States may use different criteria to assess the adverse consequences from accidental releases, such as individual dose, or a risk measure (i.e. a combination of a consequence and the likelihood of that consequence occurring) such as individual risk or societal risk. In most cases, atmospheric releases are the dominant contributors to the total risk but there might be other scenarios involving accidental releases to surface water or groundwater. Evaluating the consequences of accidental releases to surface water and groundwater may necessitate detailed analysis. However, if the conditional probability of a consequence is calculated, with a reasonable level of confidence that is considered acceptable to the regulatory body, and it does not make a significant contribution to the overall risk, then detailed analysis of the consequence might not be needed. If both the probability of occurrence and the estimated contribution of a potential hazard to the overall risk are significant, then a detailed analysis should be performed. Reference [15] presents criteria for assessing overall risk.

2.15. Once the significant exposure pathways have been identified, the local environment should be characterized sufficiently to allow exposure from these pathways to be calculated with an appropriate level of detail. The level of characterization detail should be commensurate with the importance of the pathway for the particular scenario being modelled. In accordance with para. 4.1 of SSR-1 [1], a graded approach, commensurate with the radiation risk posed to people and the environment, is required to be applied for this purpose (see also Section 10).

2.16. During operational states (i.e. normal operation and anticipated operational occurrences), there are authorized and regulated effluent discharges to the atmosphere and surface water. In accident conditions, additionally there might be direct releases to groundwater or to the ground surface. The initial release into each of these media and the resulting significant exposure pathways are discussed in paras 2.17–2.31. However, as a result of facility design, there should be no, or only minor, radiological impact beyond the immediate vicinity of the installation as a result of anticipated operational occurrences or design basis accidents (see para. 7.31 of IAEA Safety Standards Series No. SSG-2 (Rev. 1), Deterministic Safety Analysis for Nuclear Power Plants [16]).

Atmospheric releases

2.17. The significant exposure pathways depend on the nature of the atmospheric release, including the source term, location, and effective height at which the

release is made. Recommendations on the determination of the source term for releases to the environment for anticipated operational occurrences and accident conditions are provided in SSG-2 (Rev. 1) [16]. The source term defines the quantities and the physical, isotopic and chemical forms of the radionuclides released, as well as the time profile of the release. Factors affecting the subsequent transfer and behaviour of the radionuclides in the environment include the stack height and the energy associated with the atmospheric release.

2.18. For discharges under normal operation, the measures taken to mitigate the atmospheric release, control the discharge and ensure that exposures are as low as reasonably achievable (taking into account economic and social factors; see GSR Part 3 [4]) and in compliance with regulatory and operational limits, tend to focus on radionuclides and pathways that are radiologically significant. For this reason, some less obvious radionuclides (e.g. radiocarbon (^{14}C), tritium (^{3}H)), which can be difficult to remove, and those that might accumulate in the environment during the lifetime of the installation and/or less obvious pathways might become more significant. Additionally, facility design should ensure negligible radiological impact beyond the immediate vicinity of the plant from any anticipated operational occurrence. The radiological acceptance criteria for doses and correspondingly for releases for each anticipated operational occurrence should be comparable with annual limits for normal operation and more restrictive than for design basis accidents. Acceptable effective dose limits are similar to those for normal operation (see para. 7.23 of SSG-2 (Rev. 1) [16]).

2.19. The significant exposure pathways from atmospheric releases can also be identified through monitoring of the environment (see Section 8). Ideally, this monitoring should be performed for as long as there is a possibility of radioactive release to the environment (this is usually until the installation has been decommissioned). This allows any periodic (e.g. seasonal) or long term trends to be observed.

2.20. Discharges from nuclear installations are expected to continue throughout the lifetime of the nuclear installations, from construction to decommissioning, and therefore accumulation of activity in the environment over this period should be considered for those radionuclides whose half-lives are significant compared with the operating lifetime of the installation in question.

2.21. Radiocarbon and tritium can be particularly difficult to model in the environment because, whatever their chemical form at release, they can soon be incorporated into CO_2 or water, respectively, or be incorporated into organic

molecules in environmental media and become part of the food chain, contributing in this way to individual dose.

2.22. For an accidental atmospheric release leading to exposure of the public, the significant pathways depend on the source term and the nature of the release. The most common scenario for an accidental atmospheric release is usually direct inhalation of the plume, which forms the most significant pathway in the short term as it is a direct route of internal exposure of radionuclides in gas or vapour forms or as suspended particulate. An atmospheric release scenario in which inhalation would not be a significant pathway would involve only noble gases (which are not absorbed by the body when inhaled) or a scenario where the initial plume does not lead directly to exposure of people.

2.23. Other pathways that can lead to exposure are ground shine (i.e. radiation from activity deposited on the ground), sky shine (i.e. radiation deflected by the air) and cloud shine (i.e. radiation from activity in an airborne plume). These pathways are usually less significant than direct inhalation for members of the public.

2.24. For the pathways listed in para. 2.9(b)–(i), (k) and (l), exposure usually occurs as a result of deposition of radionuclides from the plume. Deposition can be either 'dry' or 'wet'. Dry deposition occurs when contaminants in the plume adsorb to suspended particulates in the air, which are then deposited on the ground (for an elevated release, deposition might be some distance from the release point). Wet deposition occurs when precipitation (e.g. rain, snow) washes material from the plume. Dry or wet deposition leads to plume depletion.

2.25. If deposition occurs, the first pathway that should be considered is direct radiation from the deposited activity. The significance of this pathway depends on the rate of deposition, which in turn depends on the chemical and physical form of the nuclides and their radiation emissions. For example, elemental iodine as a reactive chemical form has a high deposition velocity. The relative significance of different radionuclides also depends on the time frame over which the dose is integrated: radionuclides with longer radioactive half-lives and longer biological half-lives become increasingly important for longer integration times. For integration times comparable with the duration of the direct inhalation of the plume (typically a few days), inhalation is usually the dominant pathway; for much longer integration times (e.g. years), the deposition pathway can become dominant for longer lived radionuclides. External exposure from deposition can be a long term pathway of exposure for long lived radionuclides to members of the public. For long integration times (e.g. > 1 year), the weathering and migration

of radionuclides through soils — which reduce the dose from this pathway — may also need to be considered.

2.26. The quantities of radionuclides deposited on the ground are also important in determining the dose by ingestion. Compared with direct inhalation, the impact is usually lower since only a small fraction of the plume is deposited and incorporated into the food chain and there is some time delay before consumption, during which short lived radionuclides decay. Contamination and consumption of crops is a pathway that can lead to exposure far from the release point as the produce is transported. However, monitoring of commercially produced food, milk and drinking water and the application of operational intervention levels (see GSR Part 7 [5]) should lead to the control of exposure via this pathway. Ingestion of forest food (e.g. wild mushrooms, wild berries, game) might be less amenable to control, but its impact is usually limited to areas close to the original contamination. This pathway can be a significant contributor to the risk of exposure for individuals and hence to societal risk (e.g. total number of fatalities in the exposed population, total economic cost, societal stress) [17].

2.27. Resuspension of deposited radionuclides that are then inhaled leads to a longer term impact on the public, but given that only a small fraction of the plume is deposited and then resuspended, the impact on any individual is negligible compared with direct inhalation. For those people who do not inhale the plume directly during an accidental release, resuspension should be considered as a possibly significant pathway.

Discharges and releases to surface water

2.28. Discharges and releases to surface water can lead to human exposure and exposure of non-human species due to direct irradiation from activity in the water and suspended sediments, although water provides much more shielding than air provides for atmospheric releases. Activity might also accumulate in sediments (which can lead to exposure pathways such as direct radiation and possible eventual resuspension and inhalation) as a result of releases to surface water. Radionuclides can also enter the aquatic food chain. These activities should also be considered when determining the relative significance of surface water pathways.

2.29. For accidental releases to surface water, the shielding provided by the water, the lower likelihood of anybody being directly exposed compared with an atmospheric release, and the greater dispersion (especially for releases to the sea) usually mean that aquatic pathways are less significant than terrestrial pathways.

These factors should be taken into account when determining the relative significance of surface water pathways.

Releases to groundwater

2.30. Direct releases to groundwater should not be authorized. However, radionuclides might enter groundwater indirectly, for example through exchange with river water in which discharges are allowed, via atmospheric release and subsequent deposition on the ground or surface water, or via sinking streams in karstic terrains. Accidental releases to groundwater might occur, for example as a result of spillage of radioactive waste, leaks of contaminated water, or core melt through the basemat for some nuclear installations. Unlike direct releases to the atmosphere, which lead to immediate exposure, activity released to groundwater might be transferred through the groundwater for many years before it reaches a location where exposure of the public could occur. During this time, short lived radionuclides decay, and the shielding of the ground significantly limits exposure by direct radiation. These accidental releases could, however, lead to long term contamination with few, if any, remediation solutions. Any extraction of groundwater for drinking water or irrigation could result in more immediate exposure via the pathways described in para. 6.37. However, this water could easily be monitored, and its use for drinking or irrigation could be suspended if activity levels were above the established limits. All these factors should be considered when determining the significance of this pathway.

Releases to ground surface

2.31. As with releases to groundwater (see para. 2.30), planned direct discharges to the ground surface should not be authorized. Accidental liquid releases to the ground surface could occur, however, leading to contaminated ground and potentially to resuspension of radionuclides or to radionuclides entering the food chain. This should be considered as a possibility when investigating different potential pathways.

GENERAL APPROACH TO RADIOLOGICAL ENVIRONMENTAL IMPACT ASSESSMENT FOR NUCLEAR INSTALLATIONS

2.32. The components of radiological environmental impact assessment for protection of the public and of non-human species in normal operation, and for consideration of potential exposure, are shown in figs 2 and 3 of GSG-10 [13].

2.33. The first step in conducting the assessment is to select the source term(s). The selection process might be complex, taking into account factors such as installation design, materials used and changes of inventory during operation of the installation (e.g. due to fission products). For installations using well known technology employed elsewhere, data from these other operations could be used to select and confirm the source term. For developments where the technology is yet to be decided, the plant parameter envelope approach could be taken initially, whereby the maximum source term for the options under consideration is used, based on published data from vendors or from previous projects. For small modular reactors, based on current technology, one option could be to scale the source terms from large reactors. For novel types of reactors (e.g. evolutionary and innovative designs), the only data available might be from the reactor vendors; in this case, the project developers should ensure that the source term estimates are conservative. For other types of installations, a similar or simplified approach may be adopted depending on the complexity and potential hazard associated with the installation. To the extent possible, in the light of the available data, several source terms should be selected corresponding to the different plant states (i.e. normal operation, anticipated operational occurrences, design basis accidents and design extension conditions, including severe accidents as defined in Ref. [6]) and considering the number of operating units to fully capture the environmental impact for normal and accident conditions (see paras 4.15–4.21). Further recommendations on selecting the source term(s) are provided in SSG-2 (Rev. 1) [16] and in IAEA Safety Standards Series No. SSG-4 (Rev. 1), Development and Application of Level 2 Probabilistic Safety Assessment for Nuclear Power Plants [18].

2.34. The next step is to model the dispersion of radionuclides in the environment (see Sections 4–6). The end points of the radiological environmental impact assessments are generally activity concentrations in the various environmental media (e.g. air, water, ground) that can lead to human exposure. These activity concentrations are then used to calculate the doses to a representative person (see Section 7). Exposure from direct radiation should also be calculated, if applicable.

2.35. Releases to the atmosphere or to water could lead to many people being exposed by several pathways. To assess the risk to the public, a representative person is selected, for whom the individual dose is calculated. Representative persons can be identified by determining the most significant exposure pathways (see para. 2.11). For example, for the inhalation pathway the representative person could be somebody living close to the site in the prevailing wind direction; for the ingestion pathway it could be a consumer who ingests a high fraction of locally produced food. However, all pathways need to be considered when assessing

the dose to the representative person. Further recommendations on selecting the representative person are provided in Section 7, and guidance is also given in Ref. [19]. The doses from all the significant pathways that lead to exposure of the representative person should be added together to give the total effective dose.

SITE CHARACTERIZATION AND RADIOLOGICAL ENVIRONMENTAL IMPACT ASSESSMENT

2.36. The characterization of the environment should be sufficient to allow the radiation exposure of the public to be modelled for the purposes of the radiological environmental impact assessment. The characterization of the population, including their habits and land use, should be sufficient to allow the identification of a representative person. Further recommendations on baseline environmental data are provided in Section 3.

APPROACH TO ASSESSING THE TRANSFER OF RADIONUCLIDES TO THE ENVIRONMENT

2.37. For new sites, it is not necessary to model explicitly every single process involving the transfer of radioactivity between different environmental compartments. However, all processes should be considered and their relative significance assessed, allowing some processes to be discounted if their significance is small with regard to the impact on the end points being considered. If the effort involved, with regard to time and resources, would be disproportionate to the difference in the calculated end points — and considering other uncertainties, such as those in the source term — then few insights would be gained from detailed modelling. For example, for a postulated accidental release to the atmosphere, the uncertainties in the source terms might be larger than any differences in the end results caused by differences in the detailed modelling. Inevitably in these situations, some judgement may be involved, but any simplification made in the analysis should be justified. In making such judgements, the overall objectives of the analysis (e.g. demonstrating regulatory compliance) should be considered.

2.38. Sites with existing installations have the advantage that the environment should already have been characterized and there might be data from measured discharges and environmental monitoring that can inform the modelling of

proposed discharges. There are two general cases in which new environmental impact assessments might be needed for an existing site:

(a) Where a modification to an existing installation could affect the potential for releases;
(b) Where a new installation is planned.

2.39. Where existing nuclear installations are located at or close to the site for the proposed new installation, the total impacts from the new installation in addition to those from existing installations should be considered.

CLIMATE CHANGE

2.40. Climate changes in terms of the meteorological, hydrological and geological conditions in the region of the nuclear installation site over the lifetime of the installation should be considered in the radiological environmental impact assessment. Due to the long term trends associated with climate change, the environmental impact assessment and the associated monitoring plans should be periodically reviewed and updated as necessary to reflect any changes that are identified and to take any necessary actions to reduce potential impacts to the environment.

3. BASELINE ENVIRONMENTAL DATA INCLUDING POPULATION DISTRIBUTION

3.1. Requirement 3 of SSR-1 [1] states:

> "**The scope of the site evaluation shall encompass factors relating to the site and factors relating to the interaction between the site and the installation, for all operational states and accident conditions, including accidents that could warrant emergency response actions.**"

3.2. Requirement 4 of SSR-1 [1] states that "**The suitability of the site shall be assessed at an early stage of the site evaluation and shall be confirmed for the lifetime of the planned nuclear installation.**"

3.3. Paragraph 4.6 of SSR-1 [1] states (citation omitted):

"In the assessment of the suitability of a site for a nuclear installation, the following aspects shall be addressed at an early stage of the site evaluation:

.....

(b) The characteristics of the site and its environment that could influence the transfer of radioactive material released from the nuclear installation to people and to the environment;
(c) The population density, population distribution and other characteristics of the external zone, in so far as these could affect the feasibility of planning effective emergency response actions, and the need to evaluate the risk to individuals and to the population."

3.4. Requirement 14 of SSR-1 [1] states:

"**The data necessary to perform an assessment of natural and human induced external hazards and to assess both the impact of the environment on the safety of the nuclear installation and the impact of the nuclear installation on people and the environment shall be collected.**"

3.5. Paragraph 4.46 of SSR-1 [1] states:

"At a minimum, the data collection process shall include the following:

.....

(d) Information on the potential impact of the nuclear installation on people and the environment for operational states and accident conditions;
(e) Information required for planning effective emergency response actions on the site and off the site in all environmental conditions and for all states of the nuclear installation".

3.6. To meet the requirements quoted in paras 3.2 and 3.3, the selected site for a new nuclear installation is expected to go through a characterization process. Depending on the complexity of the site, the data collection and investigations might take several years before the application for the construction licence for the proposed nuclear installation is submitted to the regulatory body. Data

collection and investigations should continue during the construction, operation and decommissioning stages of the installation to confirm that the public and the environment continue to be protected and that the environmental impacts are in accordance with the predictions. This can be done as part of a review of the site evaluation within the framework of the periodic safety review. As stated in para. 4.48 of SSR-1 [1]:

> "The data shall be maintained and reviewed periodically, and/or as necessary as part of a review of the site evaluation within the framework of the periodic safety review of the nuclear installation, for example, to address developments in data gathering techniques and in the analysis and use of data and to confirm that the data remain relevant to the site within the context of evolving hazards."

3.7. In order to assess the potential effects of the nuclear installation on the region, the site characterization efforts conducted prior to construction in compliance with Requirements 25–27 of SSR-1 [1] serve the following purposes:

(a) To establish the baseline environmental conditions at the selected site (using data quality objectives), which can later be used to measure the incremental environmental impacts of the nuclear installation during construction, operation and decommissioning;
(b) To apply calculational models for prospective radiological dose assessments;
(c) To evaluate the feasibility of planning effective emergency response actions;
(d) To establish the beginning of the monitoring programme at and in the vicinity of the site (see Section 8).

3.8. For the purpose of assessing the radiological environmental impact of a nuclear installation, background environmental data should be compiled for the following areas:

(a) Population distribution;
(b) Uses of land and water in the region of the site;
(c) Background radioactivity in environmental media;
(d) Meteorological characteristics of the region;
(e) Hydrological, geological and hydrogeological characteristics of the site catchment for surface water and groundwater.

The background environmental data needed for assessing non-radiological impacts (see para. 1.13), such as chemical, physical and socioeconomic impacts and the impact on culturally and historically significant properties at or near the

site, are ideally compiled at the same time as the data needed for radiological impact assessments.

3.9. Efforts should be made to collect data that allow transboundary impacts to be assessed. When a site is near a national border, there should be appropriate cooperation with the neighbouring countries in the vicinity of the nuclear installation. Efforts should be made to exchange relevant information.

3.10. The extent of the geographical area for which these data are compiled should be based on the anticipated effects of the environment on the safety of the nuclear installation intended to be built and the anticipated effects of the nuclear installation on the environment during operational states and in accident conditions. The geographical extent of the investigations should be wide enough to include both the peak radionuclide concentration and the maximum predicted dose plotted as a function of distance from the installation.

3.11. The spatial and temporal resolution of data collection activities should follow a graded approach, as described in Section 10. Consequently, more data should be collected for locations where installations with a higher radiological hazard are sited.

POPULATION DISTRIBUTION

3.12. Requirement 26 of SSR-1 [1] states:

> "**The existing and projected population distribution within the region over the lifetime of the nuclear installation shall be determined and the potential impact of radioactive releases on the public, in both operational states and accident conditions, shall be evaluated and periodically updated.**"

3.13. Paragraph 6.8 of SSR-1 [1] states:

> "Information on the existing and projected population distribution in the region, including resident populations and (to the extent possible) transient populations, shall be collected and kept up to date over the lifetime of the nuclear installation. Special attention shall be paid to vulnerable populations and residential institutions (e.g. schools, hospitals, nursing homes and prisons) when evaluating the potential impact of radioactive releases and considering the feasibility of implementing protective actions."

3.14. Paragraph 6.9 of SSR-1 [1] states:

> "The most recent census data for the region, or information obtained by extrapolation of the most recent data on resident populations and transient populations, shall be used in obtaining the population distribution. In the absence of reliable data, a special study shall be carried out."

3.15. Paragraph 6.10 of SSR-1 [1] states:

> "The data shall be analysed to obtain the population distribution in terms of the direction and distance from the site. This information shall be used to carry out an evaluation of the potential radiological impact of normal discharges and accidental releases of radioactive material, including reasonable consideration of releases due to severe accidents, with the use of site specific design parameters and models as appropriate."

3.16. The distribution and characteristics of the regional population should be studied at the site characterization stage in order to evaluate the radiological impacts of discharges and accidental releases and to assist in evaluating the feasibility of planning effective emergency response actions.

3.17. Data on the present population[4] in the external zone[5] should be obtained from census data, from local authorities or by means of special field surveys, and those data should be as accurate and as up to date as possible. Similar data should also be collected for the region outside the external zone to distances determined in accordance with national practice and regulatory requirements and with the expected range of the impact of the project. The data should include the number of people normally present in the area, and the location of houses, hospitals, nursing homes, prisons, military bases, schools, industrial facilities, other institutions and recreational facilities such as parks and marinas.

3.18. The information collected on the present population should relate to the doses that might be received by individuals from direct radiation and from the release of radionuclides from the nuclear installation during operational states and in accident conditions. It should also address factors that would affect the

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[4] 'Present population' includes both the resident population and the transient population.

[5] The 'external zone' is the area immediately surrounding a proposed site area in which population distribution and density, and land and water uses, are considered with respect to their impact on planning effective emergency response actions. This is the area that would be the emergency planning zone if the facility were in place [6].

feasibility of planning effective emergency response actions. This should include information on major places of work, means of communication, typical living habits (e.g. recreational and work activities, the fraction of time spent indoors versus outdoors) and typical diet of the inhabitants. Typical production rates of food items locally grown and the fractions locally consumed should be given.

3.19. The presence of a major industrial facility in a city or town in the region should be considered. For example, the facility might have a large workforce that would need to be evacuated in an emergency, or the facility might handle or process hazardous materials and need its own emergency arrangements that would need to be coordinated with the emergency plan of the nuclear installation.

3.20. The information collected on the transient population should cover the short term transient population (e.g. tourists, nomads) and the long term transient population (e.g. seasonal inhabitants, students). The maximum size of the transient population and its periods of occupancy in the external zone should be estimated. In the area outside the external zone, estimates of the approximate size of the transient population and its periods of occupancy should also be made.

3.21. A projection of the present population in the region should be made both for the expected year of commissioning of the nuclear installation and for selected years over the lifetime of the installation (e.g. every tenth year), if this is feasible and the population is expected to change appreciably in the future. Projections should be made on the basis of population growth rate, migration trends and plans for possible development in the region, including the project itself. The projected figures for resident population and transient population should be extrapolated separately if these population data are available.

3.22. The representative person associated with each nuclear installation should be identified (see paras 7.14–7.17 of this Safety Guide, section 5 of GSG-10 [13], and Ref. [19]).

3.23. The population data collected should be presented in a suitable format and at a suitable scale to permit their use with other relevant data, such as data on atmospheric dispersion and on uses of land and water. The data collected on the resident population and any transient populations should be in the form of numbers of people at specific locations represented as, for example, geographical coordinates, polar or Cartesian grid elements, or names of geographical features. In this way, the population data can be displayed on a map of the site and its surroundings at various scales; this can be done using a geographical information system (GIS). Collecting data at the highest spatial resolution possible allows

greater flexibility in the future use of the data. The spatial resolution should be the highest, at least for areas closer to the site, especially within the external zone.

USES OF LAND AND WATER IN THE REGION OF THE SITE

3.24. Requirement 27 of SSR-1 [1] states that "**The uses of land and water shall be characterized in order to assess the potential effects of the nuclear installation on the region.**"

3.25. The operation of a nuclear installation might affect the uses of land and water in the surrounding area. The availability of cooling water is an important consideration for the siting of a nuclear power plant. Therefore, as part of the site evaluation, the site topography (e.g. flat plains, mountains, hills, creeks, wetlands, valleys, forests) should be described and the uses of land and water should be investigated.

3.26. The investigations should cover the following aspects depending on their relevance for the site:

(a) Land devoted to agricultural uses, its extent and the main crops and their yields;
(b) Land devoted to dairy farming, its extent and its yields;
(c) Land devoted to industrial, institutional and recreational purposes, its extent and the characteristics of its use;
(d) Bodies of water used for commercial or recreational fishing, including details of the aquatic species fished, their abundance and their yields;
(e) Bodies of water used for commercial purposes (e.g. navigation), community water supply, irrigation and recreational purposes such as bathing and sailing;
(f) Land and bodies of water supporting wildlife and livestock;
(g) Direct and indirect pathways for potential radioactive contamination of the food chain;
(h) Products imported to or exported from the region that may form part of the food chain;
(i) Forest food and seaweed.

3.27. The characteristics of the land and water used in the region might affect the feasibility of planning effective emergency response actions (see Section 9).

3.28. Present uses of water that could be affected by changes in the water temperature and by radioactive substances discharged from a nuclear installation, together with the location, nature and extent of usage of the water, should be identified. Expected changes in uses of water in the region, such as for irrigation, fishing and recreational activities, should also be considered.

3.29. Special consideration should be given to any population centres for which drinking water is obtained from water bodies that might be affected by a nuclear installation. To the extent possible, future water flow and water uses should be projected over the lifetime of the installation. This might lead to changes in the representative person.

3.30. The movement and quality of groundwater should be studied to demonstrate the possibility and extent of groundwater contamination by radioactive material releases or leakages from the nuclear installation and to indicate whether groundwater could be a significant exposure pathway.

3.31. Different water uses should include the following data, depending on their relevance for the site:

(a) For water used for drinking by humans and animals, and for municipal and industrial purposes:
    (i) Average and maximum rates of water intake by humans and animals;
    (ii) Distance of the intake from the potential source of radioactive discharges;
    (iii) Mode of water consumption;
    (iv) Number of water users.
(b) For water used for irrigation:
    (i) Rate of water use;
    (ii) Area of irrigated land;
    (iii) Types and yields of agricultural products and their usual consumers.
(c) For water used for fishing:
    (i) The aquatic species fished, and their abundance and yields in water used for commercial, individual and recreational fishing;
    (ii) The usual consumers of commercial fishing.
(d) For water used for recreational purposes:
    (i) The number of persons engaging in swimming, sailing and other recreational uses;
    (ii) The time spent on these activities.

3.32. These investigations should cover a reasonably large area of the region where the site is located. The area should be identified according to the hydrological characteristics (relating to the basin or sub-basin) and hydrogeological characteristics (including possible recharge and discharge areas of the groundwater system) of the region where the site is located. The land area should encompass the region over which the peaks in pathway specific doses from various exposure routes are encountered. If the nuclear installation is located on a riverbank, users downstream from the site should be identified. If the site is near a lake, all users of the lake should be identified. If the site is on a coast, users of the sea out to a few tens of kilometres in all directions should be identified.

BACKGROUND RADIOACTIVITY IN ENVIRONMENTAL MEDIA

3.33. Paragraph 7.3 of SSR-1 [1] states:

> "Before commissioning of the nuclear installation begins, the levels of background radioactivity in the atmosphere, hydrosphere and lithosphere and in biota in the region shall be measured so as to make it possible to determine any additional radioactivity due to the operation of the nuclear installation."

3.34. Any exposure to radiation from nuclear installations is additional to the exposure from the natural background. The calculation of the dose from a nuclear installation should not include the dose due to this natural background.

3.35. The importance of establishing the baseline radiation levels during the pre-operational stage of a nuclear installation is emphasized in IAEA Safety Standards Series No. GSG-9, Regulatory Control of Radioactive Discharges to the Environment [20]. A monitoring programme should be implemented to measure external radiation exposure (dose rates) and activity concentrations in environmental media. To assess the exposure due to the nuclear installation, the monitoring results due to the natural background should be subtracted.

3.36. The background radioactivity of a site area should be measured as early as possible, before the proposed nuclear installation starts operation and any release to the environment from the nuclear installation occurs. Information should be collected and recorded on the levels of background radioactivity and activity concentrations of relevant radionuclides in environmental media within the zone around the installation that is likely to be affected by any planned or potential releases from the installation, in particular in locations where exposure is expected

to be higher (e.g. downwind from the proposed stack location, in sediments near outfalls from the proposed aquatic discharges). This zone should extend as far as necessary to include the location of the potential representative person; this distance depends on local site conditions. However, some of the environmental sampling locations should extend further to serve as control locations that could indicate potential changes in the composition of the background radioactivity during the operation of the installation.

3.37. If there are other sources of human-made radioactivity or enhanced natural radioactivity (e.g. another nearby nuclear installation or industrial facility, naturally occurring radioactive materials) that contribute to the radioactivity levels in the vicinity of the site, these should also be measured to determine the cumulative exposure of people around the site to human-made radiation. Any future discharges from these other sources should also be modelled, so that the total exposure of people in the area can be determined.

3.38. If there are any known existing exposure situations at the site or in the vicinity (e.g. from prior remediation activities or from a nuclear or radiological emergency that has been declared to be ended), those situations and the doses attributable to them should be identified. Requirements on existing exposure situations are established in GSR Part 3 [4].

3.39. The measurement programme set up to assess the background radioactivity in environmental media before the start of operation should guide the development of the long term monitoring programme to be followed during operation and decommissioning of the nuclear installation (see Section 8).

METEOROLOGICAL CHARACTERISTICS OF THE REGION AND DATA COLLECTION

3.40. Paragraph 6.2 of SSR-1 [1] states:

> "A programme for meteorological measurements shall be prepared and carried out at or near the site using instrumentation capable of measuring and recording the main meteorological parameters at appropriate elevations, locations and sampling intervals. Data from at least one representative full year shall be collected and used in the analyses of atmospheric dispersion, together with any other relevant data available from other information sources. The meteorological data shall be expressed in terms of appropriate meteorological parameters."

3.41. The objective of meteorological investigations should be the continuous collection and evaluation of data on site specific meteorological parameters needed to calculate the atmospheric dispersion of radionuclides discharged from a nuclear installation during operational states or released in accident conditions (see Section 4). Another separate objective relating to meteorological data is the collection of data to derive extreme and rare meteorological hazards for the nuclear installation; this is addressed in SSG-18 [7] and not discussed further in this Safety Guide.

3.42. Investigations should be undertaken in the region of the site to collect specific meteorological information. This information should be compiled as part of the analysis and estimation of site specific values of meteorological parameters. Further recommendations are provided in SSG-18 [7].

3.43. Meteorological investigations should extend for at least one full year to account for seasonal variations, and for as long as needed to determine the representative meteorological conditions for the site (i.e. a year of data that have a similar pattern to that seen for the total period in terms of parameters such as wind speed and wind direction distribution, seasonal precipitation and atmospheric stability distribution). In order to have a full set of data for at least one representative full year, at least three years and ideally up to ten years of data should be collected. The collection of data should continue for the lifetime of the nuclear installation to confirm that conditions have not changed significantly and that updated assessments can be performed using the latest data as necessary. When a change is identified, a new assessment should be performed using the latest data.

3.44. The meteorological data collected should be compatible — in terms of their nature, scope and precision — with the methods and models in which they are used in evaluating the radiation exposure of the public and the radiological impact on the environment for assessment against each regulatory requirement (see Section 4).

3.45. Meteorological measurements are often affected by terrain and local features. The terrain in the range of several kilometres around a nuclear installation site should be examined, paying particular attention to topographical features (e.g. valleys, principal ridges, coastlines) and to plant structures (e.g. cooling towers, masts supporting meteorological sensors). Building wake effects might also influence the representativeness of the data obtained. In collecting meteorological data, care should be taken to prevent local effects from unduly altering the values of the parameters being measured.

3.46. For the purpose of atmospheric dispersion analysis, data on the following meteorological parameters should be obtained concurrently:

(a) Wind vectors (i.e. wind direction and speed);
(b) Precipitation;
(c) Air temperature;
(d) Humidity;
(e) Air pressure;
(f) Specific indicators of atmospheric turbulence.

3.47. The data collected should adequately represent local meteorological conditions, and the extent to which the data represent the long term meteorological characteristics of the site should be indicated. The local data collected should be compared with any available concurrent and long term data from synoptic meteorological stations in the surrounding area to determine long term trends for the site or, if the local results seem anomalous, to investigate possible causes.

3.48. Meteorological investigation activities should be undertaken in accordance with accepted international standards, such as those presented in Ref. [21]. If meteorological equipment is installed, it should be positioned so as to obtain data representing the dispersion conditions at projected or actual release points. Equipment should be unobstructed and should be positioned far enough from any obstacles to minimize their effects on measurements. Ground cover and vegetation should be managed for the duration of the investigation programme, so that they do not obstruct the operation of the equipment. The positions and settings of the equipment should be selected for maximum exposure to the meteorological conditions. Activities should be undertaken in accordance with accepted international standards, such as those presented in Ref. [22].

3.49. If the meteorological investigation is to be conducted for a new installation at an existing site and there is a significant distance between the meteorological equipment of the existing facility and the proposed location of the new installation, it might be appropriate to conduct a validation study to utilize the existing meteorological data. This validation should be based on measurements made at the location of the new installation at a scale that provides a high level of confidence.

3.50. To conduct the programme for meteorological measurements, a meteorological tower should be installed at the site, or access to necessary data from a nearby, reliable source should be available. To ensure the measuring of meteorological parameters at appropriate elevations and to obtain realistic dispersion parameters, data should be collected at least 10 m above ground

(to allow for comparison with the data from the synoptic meteorological stations) and at the height of any proposed stack (to be determined on the basis of preliminary information).

3.51. Meteorological measurements should be made at more than one location. For example, where the effect of sea breezes is important, data from an additional meteorological station further inland should be used in order to evaluate characteristics of the diffusion regime for the sea breeze over land.

3.52. Meteorological data should be obtained at least hourly. The averaging time and the sampling time for the data should be in accordance with the regulatory requirements. The instruments should provide continuous recording so that the data collected are readily available in situ to provide the hourly data. The raw data should be stored until data qualification and statistical analysis have been performed. Hourly mean values derived from the programme for meteorological investigation should be stored for the lifetime of the installation. Data averaged over shorter periods of time (less than one hour) should be stored continuously for purposes of emergency response and recovery, as they can be used to assess the plume dispersion in the event of an accidental release.

3.53. Fluctuations in meteorological conditions are direct indicators of atmospheric turbulence. To support the computational models used for atmospheric dispersion in determining the atmospheric stability, data relating to the following parameters should be obtained (see also Section 4):

(a) Direct turbulence measurements (e.g. using a Doppler radar);
(b) Fluctuations in wind direction;
(c) Air temperature and temperature lapse rate;
(d) Wind speed combined with solar radiation levels or sky cover during the daytime plus sky cover or net radiation levels during the night time.

3.54. For some computational models, the height of a mixing or boundary layer may need to be determined (see also paras 4.35 and 4.39).

3.55. For regions with complex meteorological conditions, for example in relation to mountainous regions, measurements of turbulence indicators made at the site alone might not be sufficient. Depending on the particular characteristics of the region, it may be necessary to take additional measurements of wind and turbulence indicators a few kilometres from the site. Normal discharges of effluents or experimental discharges of tracers can be used for the development of

a local diffusion model, which is often a general model with adjustments derived from air concentration values measured at the site and in the region.

3.56. In developing site specific dispersion models, sufficient information should be acquired on the spatial and temporal distributions of parameters relating to wind direction and speed and atmospheric stability, to be able to understand and determine the trajectory of effluents. Such information could be obtained by way of a programme of field measurements and/or by the method of numerical weather prediction (see para. 3.59).

3.57. Precipitation should be reported at least hourly. Measurements of the intensity of precipitation and total precipitation as well as details of the type of precipitation should be used to evaluate the impact of precipitation on airborne concentrations of contaminants and on ground contamination. Data on humidity may also help to determine any effects of cooling towers (e.g. icing or fogging on roadways and bridges, visibility of cooling tower plumes, effects of salt drift on vegetation). Air humidity can modify the dispersion of aerosols, as it can increase the coalescence of particulates.

3.58. The wind speed and direction at different elevations and temperatures should be averaged at least once per hour, while for other variables such as solar radiation levels and precipitation levels, the period of integration should be one hour. Wind direction should be averaged as a vector (e.g. the use of circular mean from circular statistics), as well as a scalar value, to support multiple potential modelling methods.

3.59. Local meteorological data can also be derived from dynamic numerical atmospheric prediction models. In this method, data collected (usually by the national meteorological institute) from many sources (e.g. a network of land stations, satellites and observations from commercial aircraft, ships, buoys, radiosondes) are processed by the same models used for numerical weather prediction and interpolated for a specified location. In this way, hourly meteorological data can be obtained retrospectively for any location within the region over which the data have been collected and for as far back historically as the data exist.

3.60. The programme for regional meteorological investigation and all information relating to it should be documented for the purposes of site evaluation and design and for use in emergency plans.

HYDROLOGICAL, GEOLOGICAL AND HYDROGEOLOGICAL CHARACTERISTICS OF THE SITE CATCHMENT FOR SURFACE WATER AND GROUNDWATER

3.61. Paragraph 6.7 of SSR-1 [1] states:

> "The hydrogeological and hydrological investigations shall determine, to the extent necessary, the dilution and dispersion characteristics of water bodies, the re-concentration ability of sediments and biota, the migration and retention characteristics of radionuclides, the transfer mechanisms for radionuclides in the hydrosphere, as well as the associated exposure pathways."

3.62. As part of establishing the environmental background and baseline conditions at a site, the hydrological and hydrogeological characteristics of the region around the proposed nuclear installation should be investigated. Emphasis should be placed on investigations relating to the surface water and groundwater flows within the catchment area where the nuclear installation is located, keeping in mind the potential effects of water flow on the proposed installation and the potential effects of the proposed installation on the quantity and quality of water in the region. The region for investigations should be extended beyond the catchment area if the discharges to the atmosphere could reach and deposit in significant quantities on the ground and on surface water there.

3.63. The geology and surface hydrology of the site area should be studied in sufficient detail (including the factors that might affect surface hydrology, such as changes in land use and meteorological conditions) to indicate potential pathways for the transfer of radionuclides to surface water or groundwater. Any surface drainage system or standing water body accessible from a potential release point in an accident should be identified. Areas from which contaminated surface water might directly enter an aquifer should be determined. The relevant hydrogeological information for surface or near surface discharges includes information on soil moisture properties, infiltration rates, configuration of unsaturated zones and chemical retention properties under unsaturated conditions, as necessary.

Surface water

3.64. Typical surface water bodies in the vicinity of a nuclear installation range from rivers to inland freshwater lakes (natural or human-made) to marine systems (e.g. estuaries, seas, oceans). The distinction between natural and human-made lakes needs to be made since the natural dynamics of human-made lakes are altered by operational use (e.g. hydropower generation, irrigation). Recommendations on

the collection of background hydrological data for sites on these types of water bodies are provided in paras 3.66–3.71.

3.65. Recommendations on the parameters needed to analyse the dispersion of radionuclides in surface water are provided in Section 5.

Rivers

3.66. For sites on rivers, the collection of hydrological and other information should cover the following:

(a) The channel geometry defined by the mean width, the mean cross-sectional area and the mean slope over the river reaches of interest. (The water level can be computed from the channel geometry and the river flow rate.) If there are important irregularities such as dead zones or hydraulic equipment in the stream that could influence the dispersion of the plume, these should be described. Additional downstream measurements of channel geometry should be made as necessary to assess the dispersion process in the river.
(b) The river flow rate presented as monthly averages of the inverse of daily flows. The inverse rate of flow should be used, since the fully mixed concentration is proportional to the reciprocal of the flow rate if sediment sorption effects are not considered. The flow rates of other relevant and important water bodies (e.g. downstream tributaries of the river) should be measured if they affect dispersion. Although monthly flow averages are recommended for generic analysis, daily and even instantaneous stream flow data might have, if any, some effects on estimated dose assessments. The use of instantaneous flow data might result in higher flow rates for the river system in question.
(c) Extremes in the flow rate evaluated from available historical data.
(d) Seasonal variation of the water level over the reaches of interest.
(e) Tidal variations in water level and flow rate in the case of a tidal river.
(f) Data describing possible interactions between river water and groundwater, and the identification of those reaches of the channel where the river might gain water from or lose water to groundwater.
(g) River temperature, measured at representative locations (e.g. one location representative of upstream and one representative of downstream in the river) over at least a year and expressed as monthly averages of daily temperatures.
(h) The thickness of the top water layer, if thermal stratification of water in the river occurs.
(i) Extreme temperatures evaluated from available historical data.

(j) The concentrations of suspended matter measured:
  (i) At locations downstream of sections where the river is slowed, depleted or fed by tributaries;
  (ii) In discrete samples at appropriate time intervals (e.g. every two months for at least a year);
  (iii) Over a sufficient range of flows to establish curves of flow versus sedimentation and/or erosion rate.
(k) The characteristics of deposited sediments, including mineral and/or organic compositions and size classification.
(l) The distribution coefficients for sediments and for suspended matter for the various radionuclides that might be discharged.
(m) The background levels of radioactivity in water, sediment and aquatic food due to natural and artificial sources.
(n) Seasonal cycles of phytoplankton and zooplankton, with at least the periods of their presence and cyclical evolutions of their biomass.
(o) Spawning periods and feeding cycles of major fish species.
(p) Dams located upstream and the water volumes in the adjacent lakes.

Natural lakes

3.67. The natural lakes that are used as a source of cooling water for nuclear power plants tend to be large lakes. The information to be collected for such lakes should include the following:

(a) The general shore and bottom configuration in the region, and unique features of the shoreline in the vicinity of the discharge.
(b) Data on bathymetry out to a distance of several kilometres, and data on the amount and character of sediments in the shallow shelf waters.
(c) Speeds, temperatures and directions of any near shore currents that could affect the dispersion of discharged radioactive material. Measurements should be made at appropriate depths and distances, depending on the bottom profile and the location of the point of discharge.
(d) The duration of stagnation and characteristics of current reversals. After stagnation, a reversal in current usually leads to a large scale mass exchange between inshore and offshore waters that effectively removes pollutants from the shore zone.
(e) The thermal stratification of water layers and its variation with time, including the position of the thermocline and its seasonal changes.
(f) The load of suspended matter, sedimentation rates and sediment distribution coefficients, including data on sediment movements characterized by defining at least the areas of high rates of sediment accumulation.

(g) The background levels of radioactivity in water, sediment and aquatic food due to natural and artificial sources.
(h) Seasonal cycles of phytoplankton and zooplankton, with at least the periods of their presence and cyclical evolutions of their biomass.
(i) Spawning periods and feeding cycles of major fish species.
(j) If applicable, the extent of seasonal ice formation (thermal plumes can affect ice cover and fish spawning areas).

Human-made lakes

3.68. For sites on human-made lakes, the information to be collected should include the following:

(a) Parameters of the lake geometry, including length, width and depth at different locations;
(b) Rates of inflow and outflow (considering the operational programme);
(c) Expected fluctuations in water level on a monthly basis;
(d) The water quality at inflows, including temperature and suspended solids;
(e) The thermal stratification and its seasonal variations;
(f) Interaction with groundwater;
(g) Characteristics of bottom sediments (e.g. type and quantity);
(h) The distribution coefficients for sediments and for suspended matter for the various radionuclides that might be discharged;
(i) The rate of sediment deposition;
(j) The background levels of radioactivity in water, sediment and aquatic food due to natural and artificial sources;
(k) Seasonal cycles of phytoplankton and zooplankton, with at least the periods of their presence and cyclical evolutions of their biomass;
(l) Spawning periods and feeding cycles of major fish species;
(m) If applicable, the extent of seasonal ice formation (thermal plumes can affect ice cover and fish spawning areas).

Estuaries

3.69. For sites on estuaries, the following information should be collected:

(a) The salinity distribution determined along several verticals covering different cross-sections of the salinity intrusion zone. The data should be sufficient to delineate the flow pattern, which is directed towards the estuary mouth in the upper layer and towards the inner reaches in the lower layer of a fully or partially mixed estuary.

(b) Evaluations of sediment displacements, the load of suspended matter, the rate of buildup of deposited sediment layers and the movement of these sediments with the tide.
(c) Channel characteristics sufficiently upstream of the site to model the maximum upstream travel of radioactive effluents, if applicable.
(d) The distribution coefficients for sediments and for suspended matter for the various radionuclides that might be discharged.
(e) The background levels of radioactivity in water, sediment and aquatic food due to natural and artificial sources.
(f) Seasonal cycles of phytoplankton and zooplankton, with at least the periods of their presence and cyclical evolutions of their biomass.
(g) Spawning periods and feeding cycles of major fish species.

3.70. Measurements of water temperature, salinity and other relevant water quality parameters in estuaries should be made at appropriate depths, distances and times, depending on the river flow, tidal levels and the configuration of the water body in different seasons.

Open shores of seas and oceans

3.71. For sites located on the shores of seas and oceans, the information to be collected should include the following:

(a) The general shore and bottom configuration in the region, and unique features of the shoreline in the vicinity of the discharge.
(b) Data on bathymetry out to a distance of several kilometres, and data on the amount and character of sediments in the shallow shelf waters.
(c) Speeds, temperatures and directions of any near shore currents and tides that could affect the dispersion of discharged radioactive material. Measurements should be made at appropriate depths and distances, depending on the bottom profile and the location of the point of discharge.
(d) The duration of stagnation and characteristics of current reversals. After stagnation, a reversal in current usually leads to a large scale mass exchange between inshore and offshore waters that effectively removes pollutants from the shore zone.
(e) The thermal stratification, if it exists within a reasonable distance from the shoreline, of water layers and its variation with time, including the position of the thermocline and its seasonal changes.
(f) The load of suspended matter, sedimentation rates and sediment distribution coefficients, including data on sediment movements characterized by defining at least the areas of high rates of sediment accumulation.

(g) The background levels of radioactivity in water, sediment and aquatic food due to natural and artificial sources.
(h) Seasonal cycles of phytoplankton and zooplankton, with at least the periods of their presence and cyclical evolutions of their biomass.
(i) Spawning periods and feeding cycles of major fish species.

Groundwater

3.72. A conceptual model of the hydrogeological conditions at and around the site where the installation is proposed should be developed. To understand the transport and fate of contaminants, the hydrogeological conceptualization and characterization should include a description of the groundwater system in terms of the type of flow domain (e.g. intergranular, fractured, karstic), flow regime (e.g. confined, unconfined, leaky) and hydrological zones (e.g. vadose zone, phreatic zone). This conceptual model should indicate the following (see also Section 6):

(a) Hydrostratigraphical description of lithological units;
(b) Water inflows and outflows;
(c) Connectivity and interaction between the surface water bodies and groundwater;
(d) Spatial distribution of potentiometric level and groundwater flow direction.

3.73. The information to be collected, on a local and regional scale, to identify the hydrogeological system should include:

(a) Climatological and hydrological data;
(b) Initial concentrations of radionuclides;
(c) Major hydrogeological units, their hydraulic parameters and the ages or mean turnover times of groundwater;
(d) Recharge and discharge relationships.

3.74. In terms of climatological data, in regions where rainfall makes a substantial contribution to groundwater, hydrometeorological data on daily and monthly rainfall and the data needed to calculate the potential and actual evapotranspiration that have been systematically collected should be analysed throughout the period for which they are available. From the precipitation data, groundwater recharge should be calculated. Alternative methods such as tracers (chemical or isotopic) of the water cycle could be introduced to calculate groundwater recharge.

3.75. Data should be obtained on the various types of geological formations in the region and their stratigraphical distribution in order to characterize the regional groundwater system and its relationship with the local hydrogeological units. These data should include the following:

(a) Geological data: lithology, thickness, faults and fracture systems, extent and degree of homogeneity of the geological units;
(b) Hydrogeological data: description of the unsaturated zone, hydraulic conductivities and transmissivities, specific yield and storage coefficients, dispersivity, hydraulic gradients of the saturated zone for the geological units that form a flow domain, and an inventory of wells used around the site with their chronicles and pumping rates;
(c) The chemical composition of groundwater from the respective aquifers;
(d) Variations of water levels in wells and in the discharges of springs and rivers;
(e) Morphological features in karstic terrains, locations of closed depressions and active and potential sinkholes in the region.

3.76. For the relevant hydrogeological units, information should be collected on the following chemical and physical properties of the groundwater:

(a) Physical properties of groundwater (e.g. temperature, electrical conductivity, turbidity);
(b) Chemical properties of groundwater (e.g. pH, redox potential);
(c) Concentrations of major anions and cations;
(d) Sorption characteristics, when necessary for the selected grade of modelling.

4. ANALYSIS OF THE DISPERSION OF RADIONUCLIDES IN THE ATMOSPHERE

4.1. Paragraph 6.1 of SSR-1 [1] states:

> "The analysis of the atmospheric dispersion of radioactive material shall take into account the orography, land cover and meteorological features of the region, including parameters such as wind speed and direction, air temperature, precipitation, humidity, atmospheric stability parameters, prolonged atmospheric inversions and any other parameters required for modelling of atmospheric dispersion. If possible, long term meteorological data for nearby locations shall be obtained, evaluated for quality and used."

4.2. Dispersion of released radionuclides in the atmosphere is a major exposure pathway by which radioactivity that is either routinely discharged under authorization or accidentally released from a nuclear installation could be transported to locations where the public could be exposed. Exposure can be immediate, by inhalation of material in the plume or by external exposure from radiation in the cloud, or it can occur over an extended period of time from material deposited on the ground, which can cause external exposure, or from ingestion of radioactivity incorporated in the food chain.

4.3. Releases of radioactivity from nuclear installations to the atmosphere — or to the environment in general — occur as part of planned operation. These can be authorized or permitted routine discharges, including releases from anticipated operational occurrences (a deviation of an operational process from normal operation that is expected to occur at least once during the operating lifetime of a facility), or releases resulting from events that are not expected to occur with certainty, such as accidents. Such releases correspond to a planned exposure situation, including potential exposure.

4.4. For modelling the dispersion of radioactivity in the environment, a distinction should be made between continuous releases and short term releases, since each type of release involves a different approach. For example, routine or normal discharges might not be constant but might vary during the operational cycle or there might be spikes in the release during shutdown or maintenance, while some anticipated operational occurrences might not result in any release at all.

4.5. All releases should be subject to regulatory control, with normal operation (including anticipated operational occurrences) and accidental releases considered separately (see Section 7). Although routine releases are unlikely to be constant and might include short term and long term variability, for the purposes of applying for a permit or authorization, a constant continuous release is usually assumed based on the predicted releases plus a margin to allow for additional operational freedom. Some States might also consider some short term releases separately as part of normal operation.

4.6. Generally, different dispersion models are used to assess the potential impacts from continuous discharges and short term releases. However, the meteorological data that need to be acquired for each type of model are usually the same. In both cases, typical rather than extreme data are used, which can be collected from the site itself or by using numerical weather prediction models if sufficient quality data are available. However, as accidental releases are typically short term and might be potentially significant, assessments of accidental releases should consider the

likelihood and potential effects of unusual meteorological conditions that could lead to higher doses. As mentioned in para. 3.43, the meteorological site data should be collected over several years so that it is possible to select a representative year or years from the records. The extreme data used for external hazard analysis need to come from a data set collected over a much longer period and typically only available on a regional basis. For long range dispersion analysis (which is typically needed for evaluating societal impacts or transboundary impacts), time and spatially gridded data for use in Lagrangian modelling (see para. 4.26) might need to be acquired from national or international meteorological organizations.

4.7. Short term releases can occur at any time under any meteorological conditions, and this can result in quite different radiological consequences depending on the conditions (e.g. as a result of different wind directions). One way to assess the consequences is to perform multiple calculations for different meteorological conditions sampled from the meteorological data set collected hourly and to apply statistical methods to the results.

4.8. The calculations of the dispersion and concentration of radionuclides coupled with the calculations of dose should show whether the radiological consequences of routine discharges and potential accidental releases of radioactive material into the atmosphere are tolerable. The results of these calculations for normal operation, including anticipated operational occurrences, should be used to establish authorized or permitted limits for radioactive discharges from the installation into the atmosphere (see GSG-9 [20]) and those from accident conditions, along with their expected frequency and comparison with national requirements for risk and/or dose criteria. In both cases, the results may be used to inform the design process to optimize doses or mitigate risks.

4.9. The results of the meteorological investigation should be used for the following purposes:

(a) To confirm the suitability of a site;
(b) To provide the baseline environmental data for site evaluation;
(c) To determine whether local meteorological characteristics have altered since the site evaluation was made and before operation of the installation commences;
(d) To select appropriate dispersion models for the site;
(e) To establish limits for radioactive discharges into the atmosphere;
(f) To establish limits for design performance (e.g. containment leak rates, control room habitability);
(g) To assist in evaluating the feasibility of planning effective emergency response actions.

SELECTION OF RELEASE SCENARIOS FOR DISCHARGES AND ACCIDENTAL RELEASES TO THE ATMOSPHERE

4.10. The release scenario for normal operation is the discharge — usually assumed to be a constant continuous discharge — from a known discharge location. Other scenarios to consider might include maintenance or other events, including anticipated operational occurrences, expected to occur during operation and that might lead to a short term release and a different profile of release in terms of radionuclides and/or their quantities.

4.11. A range of possible accident scenarios should be analysed (depending on the complexity of the installation), spanning from high frequency, low consequence events to low frequency, high consequence events.

4.12. For a nuclear power plant, this analysis might encompass many scenarios to cover the spectrum of events that might occur — anticipated operational occurrences, design basis accidents and design extension conditions, including severe accidents. For some advanced reactors, the definition of certain plant states might need to be adapted. Releases resulting from severe accidents might encompass the performance of a full scope Level 2 probabilistic safety assessment[6] (see SSG-4 (Rev. 1) [18] and IAEA Safety Standards Series No. SSG-3 (Rev. 1), Development and Application of Level 1 Probabilistic Safety Assessment for Nuclear Power Plants [23]). If a Level 2 assessment is incomplete during the site evaluation process, a release scenario may be based on a deterministic approach, accounting for proper uncertainties. The deterministic analysis should be verified once the Level 2 assessment has been completed.

4.13. For sites with multiple units and installations with multiple facilities, the site should be evaluated for interactions between the nuclear installations. There might be multiple discharges from several locations that all need to be analysed. Accident conditions might also include scenarios involving releases from multiple

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[6] Three levels of probabilistic safety assessment are generally recognized:
- Level 1 comprises the assessment of failures leading to determination of the frequency of fuel damage.
- Level 2 includes the assessment of containment response, leading, together with Level 1 results, to the determination of frequencies of failure of the containment and release to the environment of a given percentage of the reactor core's inventory of radionuclides.
- Level 3 includes the assessment of off-site consequences, leading, together with the results of Level 2 assessment, to estimates of public risks [6].

See paras 1.4 and 1.5 of SSG-3 (Rev. 1) [23] for more details.

units that are either simultaneous or offset in time, which again might need to be analysed if these releases are significant contributors to the overall risk.

4.14. For nuclear installations with low potential hazard, the analysis of a few or even only one potential exposure pathway might be sufficient.

SELECTION OF SOURCE PARAMETERS FOR ANALYSING THE DISPERSION OF RADIONUCLIDES IN THE ATMOSPHERE

4.15. For discharges, the calculation of the source terms may necessitate a detailed analysis of fuel performance and the chemical regime for water cooled reactors, for example the generation of corrosion and activation products and the performance of waste treatment measures and filter systems.

4.16. Source terms for accident conditions differ from those for normal operation and anticipated operational occurrences (see SSG-2 (Rev. 1) [16] and IAEA Safety Standards Series No. SSG-90, Radiation Protection Aspects of Design for Nuclear Power Plants [24]). For example, they might involve larger quantities, different radionuclides and/or different physical and chemical characteristics.

4.17. Therefore, when selecting the source term parameters, consideration should be given to the following:

(a) Physical and chemical processes occurring during the accident sequence;
(b) Behaviour of any safety features or the effects of any mitigatory measures;
(c) Behaviour of radionuclides within the installation before they are released to the environment.

4.18. In addition to the quantities of radionuclides released, all the parameters that might affect the subsequent dispersion or behaviour of the radionuclides in the environment should be characterized. This characterization should include the following:

(a) Physical form (e.g. gas, aerosol);
(b) Chemical form;
(c) Release point and its height;
(d) Momentum and thermal energy associated with the release necessary to determine the effective height of the radioactive plume;
(e) Time profile for the release.

4.19. Sources of radioactivity in a nuclear power plant might include the following:

(a) Activated corrosion products that remain in the coolant during normal operation but that can be released to the environment in a loss of coolant accident (e.g. ^{58}Co, ^{60}Co).
(b) Fission products and actinides formed by fission or activation of uranium in fuel (e.g. ^{131}I, ^{137}Cs, ^{90}Sr, ^{238}Pu, ^{239}Np), and noble gases (^{85}Kr, ^{138}Xe). These are prevented from release in normal operation by many barriers.
(c) Radionuclides from the fuel matrix, fuel cladding, coolant circuit or containment. Volatile radionuclides can be released into the coolant through fuel rod failures or by a uranium contamination remaining on the outside surface of the cladding from the manufacturing process and/or from uranium impurities in the zirconium used in cladding in some fuel types ('tramp uranium'). The radionuclides can therefore be released when coolant is released or by off-gassing during normal operation. Large releases can also occur in severe accidents, when the fuel matrix and fuel cladding fail and the coolant circuit and containment might be breached.
(d) Activation products formed by the activation of substances present in the coolant water, which can be released when coolant is released or by off-gassing (e.g. ^{3}H, ^{14}C).

4.20. Radionuclides can also be released through fuel handling faults, radioactive waste handling faults or accidents involving waste or effluent storage.

4.21. In order to determine the source term, the fraction of the initial inventory released to the environment needs to be evaluated; if there are several barriers to the release, then the fraction released through each barrier needs to be assessed or modelled, as well as the processes that might lead to the mobilization of the source term. For potential exposures from nuclear power plants, numerical codes should be used (see also SSG-2 (Rev. 1) [16] and SSG-4 (Rev. 1) [18]).

4.22. Source term data should be supported by well documented numerical modelling and physical assumptions.

ATMOSPHERIC DISPERSION MODELS

4.23. Different tools are usually used for assessing the impacts of continuous and short term releases, although they may be based on the same type of atmospheric dispersion model. For continuous releases, the activities in the environmental compartments modelled increase until they reach an equilibrium level unless

the radionuclide half-lives are long compared with the operational lifetime of the facility. For short term releases, the activity levels in the environmental compartments rise to a peak and then decay.

4.24. The most important factor in atmospheric dispersion modelling is to ensure that the model can simulate the important processes with sufficient accuracy. The atmospheric dispersion computer models commonly used fall into two main types: Gaussian and Lagrangian.

4.25. The Gaussian model describes the atmospheric dispersion by the Gaussian equation in both the crosswind and vertical dimensions. The plume spread increases with distance from the release according to the meteorological parameters such as wind speed and the parameters for atmospheric stability. The simple equations can be modified to take account of surface roughness, wet and dry deposition, building wake effects and plume rise.

4.26. A Lagrangian type model tracks many notional particles (i.e. hypothetical packets of air), transferring each by the wind direction and wind speed and then modelling atmospheric turbulence effects by applying random motion. The atmospheric dispersion parameters used to determine the motion of each particle are interpolated in space and in time from a three dimensional spatial grid of time series data. The concentration in any grid element of the model is determined by the number of particles in the box representing that grid element. Utilizing these gridded data allows modelling to vary meteorological conditions by location, height and time. Effects due to surface topography are implicitly considered as they are embedded in the meteorological data, provided that the data have sufficient spatial resolution.

4.27. The advantages of the Gaussian model are as follows:

(a) It is a simple mathematical expression that is easy to implement.
(b) It can be modified to take into account, in a simple way, effects such as plume rise, building wake effects and wet and dry deposition.
(c) It is fast to execute so there is no need to sample from a meteorological data set; it is quite feasible to perform calculations for every hour of a data set of several years.
(d) It is principally considered to be conservative compared with more detailed models. However, under specific conditions (e.g. for locations close to the location of the release), the results might not be conservative.

(e) It needs a relatively simple meteorological data set of hourly data for the point of release, comprising data such as wind direction, wind speed, atmospheric stability category, mixing layer height and precipitation.
(f) It can be adapted to model temporal and spatial changes in meteorological conditions during the release (Gaussian puff models).
(g) More advanced Gaussian models have the ability to take account of more complex terrain and buildings in the vicinity of the release. A representative array of permanent surface meteorological stations should be considered for such models.

4.28. The disadvantages of the Gaussian model are as follows:

(a) Other than the more advanced Gaussian models mentioned in para. 4.27(g), it cannot satisfactorily model complex terrain.
(b) The range of validity is limited to the area over which the meteorological conditions remain reasonably constant and consequently it cannot satisfactorily model long range impacts.
(c) Calm or very low wind speed conditions can only be modelled with high uncertainties.
(d) The rate of dry deposition of material is dependent on particle size assumptions and might not satisfactorily model all release conditions.

4.29. The advantages of the Lagrangian model are as follows:

(a) It can model complex terrain and long range dispersion if an appropriate meteorological data set is available (i.e. fine enough spatial resolution for the terrain being modelled to be resolved in the meteorological data) and therefore generally gives a more accurate representation of the dispersion for a given set of meteorological conditions.
(b) It can model changes in meteorological conditions over time and space.

4.30. The disadvantages of the Lagrangian model are as follows:

(a) It has long computer run times.
(b) It needs a large complex meteorological data set including three dimensional data as a function of time for the area over which the model is being run.
(c) Compromises may be needed in other areas to reduce the overall computation effect, such as the number of radionuclides or meteorological sequences modelled and geographical resolution.
(d) It is difficult to use for continuous releases over an extended period.

4.31. A Lagrangian model could use single site data rather than a three dimensional grid but in this case — other than being less conservative — it offers few benefits over a simple Gaussian model. To take full advantage of the capabilities of a Lagrangian model, an extensive data set is needed, which should be collected from the national meteorological institute or from international sources of global data.

4.32. The decision on which model to use depends on the type of analysis needed and the characteristics of the site and surrounding area. If only an assessment of short range impacts is needed, and the surrounding area is reasonably flat, then the Gaussian model approach may be sufficient. If the surrounding area has complex topography, if long range results are needed for a transboundary assessment, or if an assessment of population risks in a large area is needed, the Lagrangian model may be more appropriate, assuming the necessary meteorological data of an appropriate resolution are available. For sites with complex topography and short range analysis, the more advanced Gaussian model could be used. For modelling dispersion in urban environments, more detailed approaches, such as those considering building heights and employing computational fluid dynamics, may be needed. There might still be large uncertainties associated with the source term, especially for accidental releases. Consequently, the additional insights gained from performing more sophisticated or more extensive analysis might not be commensurate with the additional effort and the decision on which model to use should be carefully evaluated.

USE OF METEOROLOGICAL AND OTHER DATA COLLECTED FOR MODELLING ATMOSPHERIC DISPERSION

4.33. Regardless of the means by which they have been acquired, the data should be compatible (in terms of their nature, scope and precision) with the methods and atmospheric dispersion models being used (i.e. Gaussian or Lagrangian models; see para. 4.24). For example, atmospheric stability can be characterized in different ways with different parameters. The data and models needed also depend on the regulatory requirements for the radiological impact on people or on the environment. For example, if an objective is to assess the risk to a whole population, then long range dispersion modelling is needed.

4.34. Generally, the same data collected for continuous releases can be used for short term releases. However, short term releases may also necessitate more long range data if long range dispersion modelling is part of the assessment — as might be the case for releases large enough to have an impact at long range.

4.35. The typical meteorological data needed for a Gaussian dispersion model include the following:

(a) Wind speed;
(b) Wind direction;
(c) Boundary (or mixing) layer height;
(d) Parameter(s) determining the atmospheric stability, such as the Pasquill–Gifford stability class, Doury scheme or Monin–Obukhov similarity theory;
(e) Precipitation.

4.36. Other data that may be used in the Gaussian dispersion model include the following:

(a) Deposition velocities for aerosol particles or chemical species to model dry deposition;
(b) Washout coefficients for aerosol particles or chemical species to model wet deposition;
(c) Release height;
(d) Energy or momentum of the release;
(e) Building dimensions to account for building wake effects;
(f) Surface roughness;
(g) Surface topography for more advanced Gaussian models.

Wind speed

4.37. The wind speed and atmospheric stability are related (see para. 4.40). Higher wind speeds might also have the effect of inhibiting plume rise effects. Higher wind speeds mean that radionuclides reach locations quicker, providing less time for any radioactive decay, but this is not usually significant unless very short lived radionuclides (e.g. with a half-life comparable to the time taken for the radioactivity to reach a particular location) are involved.

Wind direction

4.38. Wind direction can be very important if there is an uneven population distribution around the site, since the probability of exposure at any given location depends on the probability that the wind blows in that direction.

Boundary layer height

4.39. The boundary (or mixing) layer height is the height at which a temperature inversion occurs, creating an effective boundary for dispersion in the vertical direction. Gaussian dispersion models generally assume that the plume reflects down from the boundary layer with no transfer across the boundary, and up from the ground until fully mixed in the vertical direction. Lagrangian dispersion models may model transfer across the boundary and subsequent dispersion of material above the layer. The boundary layer height is important since it effectively determines the volume of air into which the plume of radioactivity can disperse as it moves downwind to a point of being fully mixed vertically. At these distances, the boundary layer height is correlated with the atmospheric stability, with more unstable conditions leading to higher boundary layer heights.

Atmospheric stability

4.40. Atmospheric stability is usually the most important atmospheric dispersion parameter after wind direction and should be considered in modelling. Unstable conditions lead to increased dispersion in both the vertical and crosswind directions and hence lower ground-level concentrations. For elevated releases (e.g. from a stack), unstable conditions increase the vertical dispersion, which causes the plume to reach ground level at shorter downwind distances than would be the case for more stable conditions, and can lead to higher concentration close to the release. For ground-level releases, more stable conditions lead to higher plume centreline concentrations but with lower crosswind spread.

Precipitation

4.41. Precipitation enhances the deposition of activity on the ground by washing material out of the plume. Precipitation can also transfer activity to surface water and/or groundwater systems and should be carefully modelled.

SENSITIVITY STUDY OF THE ANALYSIS OF RADIONUCLIDE DISPERSION IN THE ATMOSPHERE

4.42. Since an assessment involves many assumptions and uncertainties, sensitivity studies should be performed to assess the sensitivity of the overall results to the assumptions or parameter values. Typical sensitivity studies should include the following:

(a) Meteorological data used (for practical reasons, only a subset or sample of the meteorological data may have been used, and the effect of different or larger samples could be investigated);
(b) Source term assumptions, including activity released, possible release heights, energy of release and time profile of release;
(c) Modelling uncertainties;
(d) Representative person assumptions (e.g. age group, location, food consumption);
(e) Parameter value assumptions (e.g. deposition velocities);
(f) Assumptions about protective actions applied.

SCENARIO BASED SIMULATION OF ATMOSPHERIC DISPERSION

4.43. The scenarios simulated for routine or normal discharges should normally assume that the release continues at a constant rate for the lifetime of the nuclear installation, using hourly meteorological data. In addition, short term planned discharges, such as those that occur during maintenance, should also be modelled.

4.44. For radioactive releases from an accident at a nuclear installation, the site specific variability in the meteorological data and exposure scenarios may be accounted for in the deterministic assessment and, if needed, in the probabilistic assessments depending on the off-site consequence criteria to be met (see paras 7.18–7.20).

4.45. Such analyses may also be used to inform emergency planning or for transboundary assessments.

GRADED APPROACH TO ASSESSING THE DISPERSION OF RADIONUCLIDES IN THE ATMOSPHERE

4.46. For nuclear installations with low potential hazard, a graded approach may be used. In a graded approach, the following conservative assumptions could be made:

(a) Conservative source terms are used.
(b) The representative person is directly downwind of the release at a specified distance close to the source (e.g. at the site boundary) or at the point of peak ground-level concentration for elevated releases.

(c) Either typical or conservative combinations of wind speed and atmospheric stability (and possibly precipitation) are used. Conservative assumptions might be stable atmospheric conditions with low wind speed for a ground-level release, and unstable conditions that might lead to higher ground-level concentrations closer to the release point for an elevated release.

4.47. If using such conservative assumptions leads to unacceptable results, some of the assumptions might need to be refined. This is elaborated further in Section 10.

5. ANALYSIS OF THE DISPERSION OF RADIONUCLIDES IN SURFACE WATER

5.1. Radionuclides entering surface water are dispersed by general water movements and sedimentation processes. Liquid radioactive releases can be discharged to freshwater, marine or estuarine environments directly. Radionuclides might also be transferred to surface water bodies through atmospheric release followed by deposition on water, or from the ground surface by surface runoff. The potential exposure scenarios and source terms for each accident scenario should be examined based on the safety assessment, including the quantities and relevant physical and chemical characteristics of the releases to the surface water.

5.2. The hydrological dispersion and transfer of radionuclides should be estimated using relevant models, considering the defined hydrological conditions. The output of atmospheric dispersion models may also be used as input for dispersion in surface water if considered significant. As described in Section 7, all exposure pathways should be listed, and the relevant exposure pathways and the representative person should then be identified. Finally, the estimated dose (and, in some cases, a measure of the risk of health effects based on the estimated doses) should be derived and compared with the applicable established criteria. Possible exposure pathways to the representative person through surface water include those associated with drinking water, fisheries, aquatic food, irrigation and recreational activities.

SELECTION OF RELEASE SCENARIOS FOR DISCHARGES AND ACCIDENTAL RELEASES TO SURFACE WATER

5.3. In discharges, radionuclides are directly released into the water body in liquid form or through atmospheric deposition (mainly aerosol) on the surface water. The composition and quantity of the radionuclides should be determined and the chemical and physical forms (e.g. gas, aerosol, liquid) should also be examined to help assess the environmental dispersion of radionuclides.

5.4. In an accidental release, radionuclides might be transferred to surface water bodies either directly or indirectly by deposition. In addition, some of the radionuclides on the ground surface, either due to deposition from atmospheric releases or direct release to the ground, might enter surface water through surface runoff due to precipitation. Such surface runoff should be considered after an accidental release to the ground surface.

SELECTION OF SOURCE PARAMETERS FOR ANALYSIS OF THE DISPERSION OF RADIONUCLIDES IN SURFACE WATER

5.5. The basic source parameters are the same as those for the dispersion of radionuclides in the atmosphere (see paras 4.15–4.22). Additional parameters should be considered in relation to atmospheric deposition, which may be represented by the scenario based models described in paras 4.43–4.45.

5.6. In respect of the source term and receiving water, there should be representative values for all the parameters that affect the dispersion of radionuclides in surface water, including the following:

(a) The radionuclides and the amounts that could be released (e.g. corrosion products, fission products, activation products).
(b) Chemical properties that control the behaviour of radionuclides in surface water, such as adsorption affinity and biological uptake, and chemical form of radionuclides, whether in dissolved or particulate form. Examples of the chemical properties include:
    (i) Major anion and cation concentrations, which control adsorption of radionuclides.
    (ii) Organic content, which is important for the biological uptake of radionuclides by aquaculture.
    (iii) pH, which controls the behaviour of radionuclides in surface water (dissolution affinity of radionuclides).

(iv) Concentration of dissolved oxygen, conductivity and suspended substances.

(v) Salinity, which is important for the marine environment and estuarine areas where fresh water and sea water mix. The water mass characteristics that control the distribution patterns of radionuclides are determined mainly by salinity and temperature.

(c) Physical properties that determine the distribution, dispersion pattern and concentration of radionuclides in the surface water. Examples of physical properties include:

(i) Temperature at multiple depths, which could define the thermocline and vertical distribution pattern of radionuclides in the water and seasonal temperature profile.

(ii) Density, determined by temperature and salinity and varying with water depth. Radionuclides in water parcels with different densities do not exchange; the distribution of radionuclides in surface water elongates within the zone of equal density (isopycnal water parcel).

(iii) Water flow characteristics, which control the dispersion pattern of radionuclides in the surface water.

(iv) Ice cover, especially for lakes.

(v) Sediment load parameters, which control the removal process of radionuclides from surface water to the bottom sediment.

(d) Sedimentation properties:

(i) Distribution coefficient (K_d), which determines the removal of radionuclides from surface water to the bottom sediment;

(ii) Particle size distribution of sediment or surface area of sediment, as indices for adsorption of radionuclides.

Most of these parameters are based on the data collected as background hydrological data listed in Section 3. Additional parameters can be obtained from literature or from more specialized studies in the laboratory or in the field.

MODELS FOR RADIONUCLIDE DISPERSION IN SURFACE WATER

5.7. There are three basic types of models to estimate radionuclide dispersion in surface water:

(a) Numerical models that usually transform the basic equations describing radionuclide dispersion into finite difference or finite element forms.

(b) Box type models that treat the entire water body or sections of a water body as interconnected homogeneous compartments. These models often include some sediment–radionuclide interactions.
(c) Analytical models that solve the basic radionuclide transfer equations. Simplifying assumptions can be made regarding water body geometry, flow conditions and dispersion processes to obtain analytical solutions to the governing equations.

5.8. Other types of models can be used for assessing radionuclide dispersion in surface water systems (e.g. rivers, human-made impoundments, lakes, estuaries, open shores, oceans). Their selection should be based on the quality of results needed for risk assessment.

Radionuclide dispersion in rivers

5.9. The modelling approach and the level of accuracy of the dispersion modelling depend on the purpose of the model and the accuracy needed for the river under analysis. Simplified models may be developed to represent steady or unsteady flow in one or two dimensions. Detailed modelling typically needs more specific data and more detailed knowledge of the river system. One and/or two dimensional models can be developed in steady or unsteady flow mode using site specific data. For more detailed studies, one or two dimensional models should be used to obtain a preliminary understanding of the behaviour of the hydraulic system and to support a more refined analysis based on three dimensional models.

5.10. The size and length of the river to be modelled dictates the level of modelling. For example, when the length of the river section is much larger than the width and depth, a one dimensional model should be developed. If the flow path of the water is unknown for some of the events, or if it changes significantly during the event, then a one dimensional model is not appropriate.

5.11. The analysis objective (i.e. expected type and accuracy of results) should dictate the selection of the appropriate model. Consequently, the source and level of accuracy of the data should be compatible with the selected model. The availability, source and level of accuracy of data should not be used as a basis for developing a model; on the contrary, an appropriate model should be selected to achieve the expected results and the data should be acquired accordingly.

5.12. Mathematical models, either analytical or numerical, need representative values of the relevant parameters and the boundary conditions, which should

be collected with appropriate accuracy either from literature or from site specific studies.

Radionuclide dispersion in impoundments and lakes

5.13. Appropriate models should be selected for radionuclide dispersion in impoundments and lakes. The typical models for dispersion in lakes, along with their advantages and disadvantages for different situations, are as follows:

(a) Box model: The advantages of this model are that the calculation time is short and that long term prediction is possible. Its disadvantages are that the model is not suitable for stratified lakes, cannot represent the heterogeneity within a box and cannot represent the effects of flow changes.
(b) Vertical one dimensional model: The advantages of this model are that the calculation time is short and that long term prediction is possible. Its disadvantages are that the model cannot represent the distribution within a box and that it is difficult to take into account the effects of flow changes (horizontal variation).
(c) Horizontal two dimensional model: The advantages of this model are that the calculation time is shorter than for three dimensional models and that medium term (1–10 year) prediction is possible. The disadvantage of this model is that it is not suitable for stratified lakes.
(d) Vertical two dimensional model: The advantages of this model are that the calculation time is shorter than for three dimensional models, that medium term (1–10 year) prediction is possible and that stratification is represented. A disadvantage is that transverse variation such as horizontal flow is not represented in this model.
(e) Three dimensional model: The advantages of this model are that it can describe local hydrology and water quality characteristics, that it can take into account flow density and drift current and that it can reproduce complex phenomena in the lake. A disadvantage of the model is that a long calculation time is needed.

Radionuclide dispersion in estuaries

5.14. Estuarine regions are connected at one end to a river and at the other end to the sea. Estuary velocity reverses with the tide, and an estuary can contain fresh or saline water, although estuary water is generally less saline than that of the sea. Any radioactive discharge is assumed to occur from one of the estuary banks. The radionuclide concentration at the banks may be assessed using a methodology that is very similar to that used for rivers, but adjustments should be considered to

take into account tidal effects, salt wedge and estuarine circulation (i.e. freshwater can flow outwards over saline water flowing inwards, impacting circulation and deposition of radionuclides discharged from banks).

5.15. The hydrodynamics of estuaries are complicated since they are affected by many factors. A number of models are available that can be used for simulating one, two or three dimensional flow, transport and biogeochemical processes in surface water systems. These models can be used to simulate the processes of hydrodynamics, sediment transport, water quality behaviour and eutrophication in one, two and three dimensions. However, such models are usually quite complex and difficult to apply if there are limited observational data for calibration and validation.

Radionuclide dispersion in the open shores of seas and oceans

5.16. Appropriate models for radionuclide dispersion in the open shores of seas and oceans should be selected based on careful consideration of the purpose of the assessment and the level of detail needed for the results. If it is determined that an ocean general circulation model will be deployed, three main types of models could be used to model dispersion of radionuclides in the sea, depending on the vertical coordinate system. These models, along with their advantages and disadvantages for different situations, are as follows:

(a) The *z* coordinate model, in which the vertical coordinates are perpendicular to gravity. This model is suitable for long term calculations. The *z* coordinate model utilizes the characteristics of the ocean so that local pressure is expressed as a function of depth by zero-order approximation, which makes implementing the equation of state straightforward. The implementation of bottom topography and drawing of results are also straightforward. This is the most widely used ocean general circulation model because of its versatility. The main disadvantages of this model, however, are that the vertical resolution in shallow seas and near the sea floor tends to be low and that the processes that arise near the coast and the sea floor tend to be poorly reproduced.

(b) The sigma coordinate model, in which the vertical coordinates are the planes along the sea floor. The number of vertical layers to be calculated in shallow water is the same as for deep water. Since the number of vertical grid points is invariable throughout the model domain, sigma models are widely used for coastal ocean simulations. The main disadvantages of this model are that an accurate representation of the horizontal pressure gradient is difficult near steeply sloping bottom topography and that the lateral mixing along

the same vertical layer near the continental slope region might lead to the mixing of the shoreward light water and the seaward dense water.

(c) The isopycnal[7] coordinate model, in which the vertical coordinates of the surfaces are along the isopycnal plane. The development of this class of model is based on the fact that seawater moves along isopycnal surfaces in the interior. Thus, the characteristics of a water mass are well maintained in the ocean interior. Since many theoretical studies of physical oceanography use an isopycnal coordinate framework, isopycnal models have the great advantage of providing good correspondence between theory and numerical models. The main disadvantage of this model is that a surface mixed layer model cannot be incorporated into an isopycnal model.

IDENTIFICATION OF EXPOSURE PATHWAYS FROM SURFACE WATER

5.17. Paragraph 5.27 of GSG-10 [13] lists possible exposure pathways for releases of radionuclides to the atmosphere and surface water in normal operation (typically for nuclear installations such as nuclear power plants). Of these possible exposure pathways, the following are relevant for release to surface water:

— Ingestion of drinking water;
— Ingestion of aquatic food (e.g. freshwater or seawater fish, crustaceans, molluscs);
— External exposure from radionuclides in water and sediments (i.e. from activities on shores, swimming and fishing).

In addition, another pathway to consider is ingestion of food produced using contaminated irrigation water or on land flooded by contaminated rivers, including food produced from animals watered with contaminated water.

5.18. Most accident conditions involve releases to the atmosphere with only indirect releases to surface water. In these situations, assessing only the radiological consequences of the atmospheric release is usually sufficient as these consequences are dominant and any additional impact from indirect releases to surface water is trivial in comparison. Given that the computational effort needed to assess the impact of indirect inputs to surface water is likely to be large (many hundreds of meteorological sequences may need to be considered, taking account of wet and dry deposition in different locations) and that uncertainties in

[7] Isopycnals are layers within the ocean that are stratified based on their densities.

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the atmospheric source term might be far more significant, consideration should be given to whether such calculations are worthwhile in terms of the end points being determined. Situations where assessment might be worthwhile include atmospheric deposition on reservoirs used for drinking water.

5.19. Accident conditions involving a direct release to surface water should be considered if their likelihood or consequences are such that they could make a significant contribution to the overall risk.

DEFINITION AND COLLECTION OF DATA FOR MODELLING RADIONUCLIDE DISPERSION IN SURFACE WATER

5.20. The data necessary for hydrological analysis come from different sources. The existing national hydrometeorological network usually provides sufficient data. These data, however, should be verified before being used, since their reliability varies depending on the location within the network from where they were collected.

5.21. The data listed in paras 5.22–5.27 are needed for standard calculational models. For advanced models, site specific data may be needed. Typical water bodies in the vicinity of a nuclear installation range from rivers, estuaries and open shores of large lakes, seas and oceans to human-made impoundments.

Modelling in rivers

5.22. The following common characteristics are needed to calculate radionuclide concentrations in a river:

(a) Cross-section of the river water body;
(b) Width at the water surface;
(c) Elevation of the deepest point of the riverbed at a representative cross-section;
(d) Elevation of the water surface at a representative cross-section;
(e) Maximum depth;
(f) Mean depth;
(g) Local slope of the riverbed;
(h) Wetted perimeter (wet area per unit length);
(i) Hydraulic radius;
(j) Discharge of water;
(k) Mean flow velocity;
(l) Friction factor;

(m) Turbulent diffusion coefficients;
(n) Coefficient of longitudinal dispersion.

5.23. In addition to these common characteristics, specific characteristics are needed:

(a) For sediment–water interactions:
    (i) Suspended solids;
    (ii) Relative organic carbon content of suspended particles;
    (iii) Sedimentation rate;
    (iv) Porosity of sediments;
    (v) Density of sediment particles;
    (vi) Hydraulic conductivity;
    (vii) Wavelength (horizontal distance) and amplitude of ripples.
(b) For air–water exchange:
    (i) Concentration in the atmosphere;
    (ii) Air–water exchange rate.

Modelling in lakes and impoundments

5.24. The following common characteristics are needed to model the dispersion of radionuclides in a lake or human-made impoundment:

(a) Geology of the lake or impoundment (e.g. volume–area–elevation curve);
(b) Seasonal variation of hydrological parameters;
(c) Longitudinal distance from the release point to a potential receptor location;
(d) Radionuclide decay constant and decay products;
(e) Volume of the water body;
(f) Surface area of the water body;
(g) Mean depth;
(h) Discharge rate;
(i) Total mean concentration;
(j) Total external input of the radionuclide per unit volume and time;
(k) Specific river input and output rates;
(l) Specific rate of constant of air–water exchange;
(m) Specific removal rate by particle settling;
(n) Specific exchange rate between water and the sediment column;
(o) Specific removal rate by water exchange with adjacent box or boxes;
(p) Specific chemical transformation rate;
(q) Specific photochemical transformation rate;
(r) Specific biological transformation rate;
(s) Mean total concentration in inflow;

(t) Atmospheric concentration;
(u) Apparent sediment concentration for input;
(v) Total concentration in adjacent box;
(w) Dissolved fraction of the chemical species;
(x) Solid–water distribution coefficient;
(y) Solid–water phase ratio.

Modelling in estuaries

5.25. The following characteristics, in addition to those listed for lakes and impoundments in para. 5.24, are needed to model the dispersion of radionuclides in an estuary:

(a) Estuary width;
(b) Estuary flow depth;
(c) River width under a mean annual river flow rate upstream of the tidal flow area;
(d) Tidal period.

Modelling in open shores of seas and oceans

5.26. All oceanic phenomena affecting dispersion should be considered. The representative physical factors for developing the oceanic models in terms of their time and spatial scales are given in Table 1. However, using a general circulation model that includes marine areas in the site evaluation does not necessarily provide the information needed for the evaluation.

5.27. The ocean general circulation model considers wind-driven circulation and thermohaline circulation to represent the global scale. Global models are typically used as a boundary condition for the regional model that represents the target ocean. The regional model should represent the relevant physical oceanographic phenomena, such as mesoscale eddies, swells and wind waves, in order to represent the topography and ocean currents specific to the target area. A high resolution model with a grid size of a few kilometres is often used near the coast, and a low resolution model with a grid size of 10–100 km is used in the open ocean.

TABLE 1. REPRESENTATIVE PHYSICAL FACTORS FOR DEVELOPING OCEANIC MODELS

Representative physical factor	Timescale	Spatial scale
Wind waves	1–10 s	1–10 m
Microstructure turbulence	1 s to 1 min	1 cm to 1 m
Boundary layer turbulence	1 min to 1 day	10 cm to 100 m
Swell	1 s to 1 min	100 m
Internal gravity waves	1 hour to 1 day	100 m to 10 km
Submesoscale currents	1 hour to 1 month	100 m to 10 km
Mesoscale eddies	1 day to 1 year	1–100 km
Tides	1 hour to 1 day	1 000–10 000 km
Wind-driven circulation	1 month to 100 years	100–1 000 km
Thermohaline circulation	100–1 000 years	1 000–10 000 km

CALIBRATION OF MODELS AND SENSITIVITY STUDY OF THE ANALYSIS OF RADIONUCLIDE DISPERSION IN SURFACE WATER

5.28. The results from a calculational model should be compared with laboratory data or field data for a specific site. Such validation usually has a limited range of applicability, which should be determined with a full understanding of the model. The model should be calibrated by comparing it with the actual environmental monitoring data set. Calibration of the model can be achieved by selecting some representative (or tuning) parameters measured at the site. Tracer tests can also be conducted in rivers, impoundments, lakes and estuaries, and the dispersion of the tracers can be observed. Tracer tests can also provide determination of some transport parameters such as diffusion and dispersion. It should be verified, for example, that the errors and uncertainties in the model output values are within the error range of the actual observed values.

5.29. As with the atmospheric dispersion model, the assessment involves many assumptions and uncertainties, so a sensitivity study should be performed to assess the sensitivity of the overall results to the assumptions and parameter values. A sensitivity study should include the following:

(a) Hydrological data to be used;
(b) Source term assumptions including radionuclide activity released, potential water depth of release and surface deposition associated with atmospheric fallout;

(c) Representative assumptions (e.g. age group, residence, food consumption, water consumption);
(d) Assumptions about parameter values such as deposition rates;
(e) Assumptions about the measures to be applied.

SCENARIO BASED SIMULATION OF RADIONUCLIDE DISPERSION IN SURFACE WATER

5.30. The scenario for discharge should assume that radionuclides are released to surface water at a constant release rate and that the release continues for the lifetime of the installation. The calibrated model can be run for various scenarios of accidental releases. The scenarios may include different locations of input at various modes of injections (with various amounts of releases, concentrations of radionuclides and time and/or duration of the release). Scenarios should be developed based on the design of the installation as well as the hydrographical setting of the site. Surface water deposition associated with short term planned releases to the atmosphere, such as those that occur during maintenance, can also be simulated.

5.31. In addition, a series of radiological effects can be simulated by reproducing the diffusion of radionuclides in surface water through calculations based on the release of various types and amounts of radionuclides in multiple accidental releases and the corresponding sample times from hydrological data sets.

GRADED APPROACH TO ASSESSING THE DISPERSION OF RADIONUCLIDES IN SURFACE WATER

5.32. The level of complexity of a dispersion model for radionuclides in surface water should be chosen primarily according to the magnitude of the installation's hazard category (see para. 10.5) and the complexity of the hydrological environment. In particular, before developing a detailed model, it is useful to simplify the site characteristics and consider conservative dispersion mechanisms.

5.33. When assessing a river, its size, length and profile, as well as local flow conditions at the discharge point, should be taken into account when determining the level of model complexity. For example, if the river's reach length is much greater than its width or depth, a one dimensional model may be used since complete mixing can be assumed. If the width of a river is so great that discharged water flows over long stretches of the watercourse along one bank and only mixes

slowly over the total width, a one dimensional model is not appropriate and a more sophisticated model should be used. The same is true if discharged water flows via a tributary into another river. When assessing the lateral mixing in the river, different flow conditions, especially low water, should be taken into account. If the water flow path is unknown for certain events or if it changes significantly during an event, a one dimensional model is not appropriate and a more sophisticated model should be used.

5.34. The basic flow phenomena in lakes and human-made impoundments are the flow due to the inflow and outflow of rivers, and the wind-driven flow. The presence or absence of vertical stratification associated with seasonal changes in air and water temperatures is also a criterion for determining whether the model can be simplified. With regard to the spatial scale, a low-dimensional model may be selected when a rough scale such as the average water quality in the lake is sufficient. With regard to the timescale, if the long term variation over a year or more needs to be determined, a low-dimensional model should be considered because a high-dimensional model might not be practical. If a short term phenomenon such as runoff or storm surge needs to be determined, a high-dimensional model would be more appropriate to achieve sufficient accuracy. Section 10 provides further recommendations on the application of a graded approach.

5.35. In the flow field in the ocean, various processes should be considered, such as three dimensional modelling of water mixing associated with temperature, salinity, density, tidal fluctuations, freshwater supply from rivers, the influence of strong currents due to thermohaline circulation in the open ocean, and the presence or absence of eddies. In coastal areas, various processes can be applied to simplify the model depending on the features of the region, such as the presence or absence of large rivers, the seasonal development of vertical stratification and the influence of tidal currents.

6. ANALYSIS OF THE DISPERSION OF RADIONUCLIDES IN GROUNDWATER

6.1. The objectives of conducting a hydrogeological study at a nuclear installation site and in the vicinity of the site are to determine the following:

(a) The estimated concentration of radioactive material in groundwater at the nearest point in the region where groundwater is drawn for human consumption;
(b) The transport paths and travel times for radioactive material to reach the source of consumption from the point of release;
(c) The transport capacity of the surface flow, interflow and groundwater recharge;
(d) The susceptibility to contamination of an aquifer or of aquifers at different levels;
(e) The temporal and spatial distributions of the concentrations of radioactive material in the groundwater resulting from discharges and/or accidental releases from the nuclear installation.

6.2. A graded approach can be applied to the scope of the hydrogeological study in accordance with the hazard category of the installation.

6.3. The hydrosphere is a major medium by which radioactive material that is released from a nuclear installation via discharges or accidental releases could be transferred into the environment and to locations where water is used by or for the population. The dispersion of radionuclides in groundwater is very slow compared with their dispersion in surface water (except in karst topography).

6.4. A detailed investigation of the hydrogeology in the region should be performed. Calculations of the transport and concentrations of radionuclides should be made to show whether the radiological consequences of potential releases of radioactive material to the groundwater (see para. 6.12) are acceptable.

6.5. The results of the hydrogeological investigation should be used for the following purposes:

(a) To confirm the suitability of the site;
(b) To select and calibrate an appropriate flow and transport model for the site;
(c) To establish limits for radioactive discharges to pathways that ultimately reach the groundwater;

(d) To assess the radiological consequences of releases;
(e) To assist in evaluating the feasibility of planning effective emergency response actions;
(f) To develop a monitoring programme and a sampling strategy for use in normal operating conditions and also in the event of an accidental radioactive release.

6.6. The information necessary to perform dose assessment relating to exposure pathways in the hydrogeological system includes the following:

(a) The source term from radioactive material released to the groundwater system;
(b) Hydrological, physical, physicochemical and biological characteristics governing the dispersion, diffusion and retention of radioactive material;
(c) Relevant food chains leading to humans.

6.7. The direction of groundwater movement and of radionuclide transport in isotropic media is orthogonal to the contours at the hydraulic head. In this case, the standard calculational models may be applied. If the aquifers are strongly anisotropic, however, and the water and transported effluents can move over a limited domain through fractures and/or karstic conduits, most calculational models are not valid. In this case, field studies including tracer tests may be necessary and should be considered. The level of complexity of the model should primarily be selected on the basis of the level of risk of the installation and complexity of the hydrogeological configuration.

6.8. The objectives outlined in para. 6.1 may be achieved primarily by mathematical models that produce groundwater flow velocity vectors in the flow domain. These models should then be coupled with transport models to assess the spatial and temporal variations in the concentrations of radionuclides. Computer codes that are capable of evaluation of groundwater by combining flow and transport can be used.

6.9. The calculational model should also be selected on the basis of the objective of the study. Considering the objectives listed in para. 6.1, preference should be given to process based deterministic models. The models selected should be suitable for simulating the transport, dispersion, dilution and accumulation of radionuclides, and their decay or other removal mechanisms, as necessary. The mode of the releases expected during normal operation of the installation as well as potential exposures should be taken into account (see also GSG-9 [20]).

6.10. When it is appropriate to use analytical models, a detailed analysis of appropriateness in terms of the boundary conditions and assumptions that satisfy the physical conditions at the study site should be conducted. Consequently, the analytical model used should be validated for each specific application.

6.11. Considering their characteristics, analytical models for groundwater flow and radionuclide transport should be applied as an initial prediction because, in some cases, they may involve a high level of simplification of the real system. Additionally, the assumptions in these models limit their application to relatively simple systems. Therefore, careful consideration should be given in selecting analytical models for groundwater flow and radionuclide transport.

SELECTION OF RELEASE SCENARIOS FROM DISCHARGES AND POTENTIAL EXPOSURE RELEASES TO GROUNDWATER

6.12. A release of radioactive substances from a nuclear installation might contaminate the groundwater system in the region either directly or indirectly, via soil, atmospheric fallout or surface water, in the following ways:

(a) Indirect discharge to groundwater through seepage and infiltration of surface water that has been contaminated by radioactive substances discharged from the nuclear installation;
(b) Infiltration into groundwater of radioactive liquids from a storage tank or reservoir;
(c) Infiltration into groundwater of any airborne radioactive material deposited on the ground surface or on surface water;
(d) Direct release from a nuclear installation as a result of an accident.

6.13. The potential for indirect contamination of surface water and possible contamination of groundwater from the surface should be assessed.

6.14. The protection of aquifers from accidents should be considered in the safety analysis for postulated accident conditions, taking into consideration geological barriers. As a result of safety analysis, the building of a protective barrier might be necessary.

SELECTION OF SOURCE PARAMETERS FOR ANALYSIS OF THE DISPERSION OF RADIONUCLIDES IN GROUNDWATER

6.15. The following properties and parameters should be estimated for radioactive releases:

(a) Radioactivity:
  (i) Rate of release of each important radionuclide;
  (ii) Location, duration and concentration of the release.
(b) Chemical properties, including the following:
  (i) Concentrations of important anions and cations, and their oxidation states and complexing states (e.g. Ca^{2+}, K^{+}, Mg^{2+}, Na^{+}, NH_4^{+}, HCO_3^{-}, Cl^{-}, SO_4^{2-}, NO_2^{-}, NO_3^{-}, PO_4^{-});
  (ii) Organic content;
  (iii) pH and Eh value (redox potential);
  (iv) CO_2 partial pressures;
  (v) Chelating agents;
  (vi) Concentration of dissolved oxygen, and electrical conductivity and concentrations of associated pollutants.
(c) Physical properties of the liquid effluents discharged, including:
  (i) Temperature;
  (ii) Density;
  (iii) Loads and granulometry of suspended solids.
(d) Flow rates for continuous discharges, or volume and frequency for batch discharges.
(e) Variation of the source term over the duration of the discharge.
(f) Geometry and mechanics of discharges.
(g) Sorption/desorption characteristics of the specific radionuclide onto sediments and/or rock matrix.
(h) Distribution coefficient(s) (K_d) between the liquid phase and the solid phase.
(i) Physical, chemical and geological factors that can influence K_d.
(j) Diffusion parameters.

CONCEPTUAL MODEL DEVELOPMENT

6.16. A variety of models and data are necessary to predict the dispersion of radionuclides through environmental media and transfer to the representative person. The processes that are more relevant to dose estimation should be identified and a conceptual model should be elaborated in the form of a representation that captures the key elements or components of a complex system,

such as the relationship between the released radionuclides and the environment. The conceptual model should represent the identified relevant exposure pathways (see para. 2.9).

6.17. A conceptual model that provides a working description of the characteristics and dynamics of the hydrogeological system is essential for any analysis of the water flow and dispersion of radionuclides. It should be regarded as the fundamental step of hydrogeological assessment for a nuclear installation site.

6.18. Conceptualization and characterization of the hydrogeological system are essential and form the most important part of the predictive flow and dispersion modelling. By nature, conceptual models are a simplification of a real system. However, the degree of simplification should be decided in accordance with the type of nuclear installation and the stage of reporting. (See Section 10 for more details on a graded approach.)

6.19. Inadequate conceptualization is one of the main sources of uncertainty and might result in unreliable models for the dispersion of radionuclides. Inadequate consideration of spatial variations of hydrogeological parameters might also adversely affect the results. Simple hydrogeological models that might not produce a conservative assessment of the system behaviour should be used with caution.

6.20. It is possible to construct a preliminary hydrogeological conceptual model for a nuclear installation site on the basis of geological and hydrological information available for the site itself and/or its near vicinity. Properties of similar geological materials elsewhere and generic data from similar geographical and geological regions can also be used in preliminary conceptualization. However, each site is unique in its hydrogeological features, properties and behaviour, so it is not possible to fully represent the hydrogeological setting using a generic conceptual model. Therefore, site specific conceptualization and characterization should be the ultimate objective of the hydrogeological data acquisition.

6.21. To decide the extent of the study area, first the hydrogeological domain to which the nuclear installation site belongs should be defined. A model area should then be determined for hydrogeological conceptualization and characterization. The conceptual model should extend to natural boundaries (e.g. topography such as topographical divide, geological structure or lithological contact, or surface water features such as streams, rivers or lakes). The model should also consider the extent of the potential impact of stress generated at the site. To reduce the impact of boundary conditions on the model, the extent of the hydrogeological domain to be studied should be larger than the model domain.

6.22. Alternative conceptual models can be constructed based on the available data, and any reasonable alternative conceptualizations should be evaluated. Further studies should be performed in order to reduce model bias and uncertainty and thus ensure the most appropriate and/or representative conceptual model.

6.23. An iterative approach should be used in the process of construction of a hydrogeological conceptual model. The preliminary conceptual model should be tested by an appropriate mathematical model (see paras 6.24–6.33) using the monitored data and refined until improvements in the predictive capability of the model are, practically, not necessary. Prediction refers to mainly the flow (head distribution). Monitoring the temporal variation of groundwater levels provides the time series needed to check the capability of the model by comparing the predicted head with the monitored data.

DEFINITION AND COLLECTION OF DATA FOR MODELLING RADIONUCLIDE DISPERSION IN GROUNDWATER

6.24. Hydrogeological investigation in the framework of site evaluation for a nuclear installation involves regional and local investigations using comparatively standard hydrogeological mapping, surface geophysical surveys and borehole drilling programmes for hydrogeological characterization studies such as packer tests, single well tests, pumping tests, geophysical studies and tracer tests.

6.25. Both regional and local information should be collected to identify the hydrogeological system and determine whether preferential flow paths are present. The information to be collected should include the following:

(a) Meteorological data: In regions where precipitation (e.g. rain, snow) makes a substantial contribution to groundwater, long term meteorological data on annual, monthly and, if available, daily precipitation and on corresponding air temperature (to calculate potential evapotranspiration) should be analysed for as long a period as there are data available. The average precipitation should be calculated using appropriate interpolation techniques from precipitation data recorded at meteorological stations in and around the watershed where the installation is situated. The effect of topography may need to be considered where there is a large difference in elevation. Meteorological data analyses should also be performed for the groundwater recharge at an acceptable level of certainty. Alternatively, tracers (chemical or isotopic) of the water cycle as well as satellite technologies could be introduced to calculate groundwater recharge.

(b) Surface runoff: Another component of the water balance should be either estimated or measured at the outlet of the basin. Long term records of flow of the stream draining the basin may be used to assess the surface runoff. If there is no flow record, empirical relationships or satellite technologies may be used to estimate the surface runoff. The construction of weirs or flumes to measure the flow rate for at least one water year[8] should be considered. This would help with making adjustments to the empirical assessment of the runoff coefficient and the surface runoff. The baseflow component of the measured streamflow may need to be considered and calculated.

(c) Discharge data of significant springs: Springs with significant discharge should be identified, including their type, and their discharge should be measured on at least a monthly basis for a minimum of one water year.

(d) Surface drainage system or standing water body: Any surface drainage system or standing water body accessible from a potential release point in an accident should be identified. Areas from which contaminated surface water can directly enter an aquifer (e.g. sinkholes) should be determined. In karstic areas, the recharge to the aquifer may be either concentrated or diffused. Concentrated recharge implies that the source of the recharge is surface water directly above the aquifer. Diffused aquifer recharge implies that the recharge source is not directly above, but rather that the aquifer recharges through hydraulic communication at depth. The karstic features (e.g. ponors, swallow holes, sinkholes) that allow direct input to the aquifer should be mapped and considered in characterization of the groundwater system. The relevant hydrogeological information for surface or near surface discharges includes information on soil moisture properties, infiltration rates, configuration of unsaturated zones and chemical retention properties under unsaturated conditions. In addition, records of level fluctuation of standing water bodies such as lakes and wetlands are needed for a complete water balance calculation. Bathymetry should be mapped for establishing the elevation–area–volume relationship.

(e) Description and mapping of major hydrogeological units: Data should be obtained on the various types of geological formations in the region and their stratigraphical distribution in order to characterize the regional system. The hydrostratigraphical units should be described on the basis of hydrogeological properties of the lithological units in the region. For consideration of the transport potential of seepage and groundwater in the region of the site, data on types of aquifers, aquitards and aquicludes, their

[8] A water year is a 12-month period over which precipitation totals are measured, not normally corresponding to a calendar year. Normally the year begins on the first day of the month in which a dry period ends and precipitation increases.

interconnections and the flow velocities and mean transit times should be investigated. The extent and thickness of major hydrostratigraphical units, in particular of the aquifer units, should be mapped and depicted on cross-sections. Three dimensional visualization should be provided. Karstic features such as sinkholes, dolines, poljes and similar closed depressions, caves and underground rivers should be mapped.

(f) Hydraulic head distribution: Potentiometric maps should be prepared for each aquifer (if the flow domain is a multiaquifer system), for at least one dry and one wet period. The potentiometric map should be produced from the groundwater levels measured in a sufficient number of piezometers. Heterogeneity should be considered in deciding on the number and locations of the piezometers. Such data permit the regional flow pattern and its relation to the local flow pattern of seepage and groundwater to be characterized. Dye tracing tests should be designed and conducted in karstic aquifers to delineate the groundwater catchment area and assess the direction and velocity of groundwater flow.

(g) Description of natural recharge and discharge areas: Potentiometric maps can also be used to delineate recharge and discharge areas, and to define hydraulic boundaries and boundary conditions of the flow domain. Environmental isotopes (stable and radioactive) should be considered a useful tool in assessment of recharge–discharge relationships. Stable isotope characteristics of local and regional precipitation should be obtained to establish the relationship between elevation and ^{18}O. This relationship can be obtained by analysing seasonal springs issuing at different altitudes.

(h) Ages, transit time or mean turnover times of groundwater: Artificial or environmental tracers such as tritium, the ratio of helium to tritium (where tritium is close to the natural background), or other appropriate tracers should be used to obtain the average apparent age, transit time and turnover time of groundwater. In complex systems, a vertical profile of groundwater age should be determined. Environmental isotopes and hydraulic heads should be used to investigate interconnections between aquifers, and interactions between groundwater and surface water.

(i) Hydrochemical data: Water samples from groundwater (e.g. springs, wells) and surface water bodies should be collected properly and analysed for major ion content at least on a seasonal basis. In situ measurements of temperature, electrical conductivity, pH, redox potential and dissolved oxygen should accompany the sampling.

(j) Hydraulic characteristics and transport parameters: A sufficient number of laboratory and/or field tests should be performed to obtain representative values of the hydraulic characteristics of each aquifer material, such as porosity, hydraulic conductivity, transmissivity, storativity (i.e. storage

coefficient), specific yield, bulk density of aquifer material and dispersivity (i.e. hydrodynamic dispersion coefficient). Batch, column experiments and/or in situ tracer tests should be performed to determine the sorption characteristics (e.g. distribution coefficients) for radionuclides of interest.

MODELS FOR RADIONUCLIDE DISPERSION IN GROUNDWATER

6.26. Interpretive (also known as informative) and predictive models can be used to model radionuclide dispersion in groundwater. Interpretive models are used to obtain a thorough understanding of the hydrogeological system dynamics. They help to construct and to test the hydrogeological conceptual model of the site. Interpretive models do not necessarily need to be calibrated but predictive models do. Calibration mainly refers to flow models, with the assumption that a calibrated flow model will provide a substantial basis for a useful transport model. Calibration of transport models can be achieved by tracer tests, considering advective and dispersive transport only.

6.27. Activity concentrations in the subsurface environment resulting from the postulated discharge of radioactive material should be estimated by means of mathematical models. A number of models have been developed to calculate the dispersion and retention of radionuclides released into groundwater. Standard calculational models are generally satisfactory and should be used in most cases. The complexity of the model chosen should reflect the complexity of the hydrogeological system at a particular site. The objective of modelling should also be taken into consideration during the selection of the model. Further recommendations on the selection of the appropriate level of complexity of the model to be used are provided in Section 10.

6.28. Two possible approaches can be taken to the use of models and data for the assessment of radionuclide dispersion in groundwater. A generic and simple methodology can be followed, which takes account of the dilution, dispersion and transfer of radioactive material in the environment with conservative assumptions. Alternatively, a specific, more detailed methodology can be followed, using site specific data to estimate activity concentrations in different environmental media, with more realistic assumptions. In some situations, a combination of generic models with site specific data could also be suitable for the assessment. In all cases, the models selected should be suitable for estimating the spatial distribution and temporal variation of activity concentrations in the environment. The complexity of the model used should be commensurate with the likely level of environmental impact from the installation.

6.29. The models that can be used for nuclear installations are diverse and can be categorized according to the problem being addressed. Deterministic models and stochastic models are the main two categories commonly used by States. The most appropriate approach should be chosen on the basis of the hydrogeological setting (conceptualization and characterization), and the level of accuracy sought at the reporting stage of interest (e.g. site characterization stage, construction stage, operation stage, closure of the installation).

6.30. Stochastic models may be used to consider strong heterogeneity and occurrence of preferential flow paths. Stochastic models are used when there are significant sources of uncertainty. Occurrence of preferential flow paths may also be considered as one of the sources of heterogeneity. Geostatistical methods are useful in producing the spatial variability of parameters that is needed in a stochastic approach. Monte Carlo simulation is the most commonly applied stochastic approach to predict groundwater flow and radionuclide transport on the basis of geostatistical inputs. This approach can also be used to reduce and quantify the predicted uncertainty.

6.31. Deterministic models can be subcategorized as lumped (also referred to as black box or grey box) models or distributed parameter (also referred to as process based) models. Mathematical (partial differential) equations simulating groundwater flow and solute (radionuclide) transport are the most used distributed parameter models. These equations are solved either analytically (i.e. with exact solutions) or numerically (i.e. with approximate solutions, commonly known as mathematical models).

6.32. Analytical models are solutions that satisfy certain geometry and specific boundary conditions of the flow domain, and are generally limited in their consideration of heterogeneity and anisotropy. Significant uncertainties may be associated with these models when the assumptions are not totally satisfied at the site under study. When the hydrogeological conceptual model partly meets the boundary conditions and the assumptions of the selected analytical model, they can be used as a first approximation and the result should be evaluated with caution.

6.33. Numerical flow and transport models can be applied with different levels of simplification. Flow and solute transport phenomena in the subsurface environment might involve various processes. In particular, the transport models are commonly known by the process or processes involved, such as advective, dispersive, sorptive, reactive or radioactive, or a combination of some or all of these processes.

6.34. The vadose zone in general has a retarding and attenuating role in contaminant fate and transport behaviour. However, characterizing the transport properties of the vadose zone can be difficult. Ignoring the effects of the vadose zone in modelling can lead to higher concentrations and faster movement of the contaminants in saturated zone groundwater. Such a modelling decision allows for making conservative predictions at the first stage of site evaluation. Conservative assumptions and sensitivity tests can help to inform the need to model the vadose zone. If the site is determined to be acceptable without vadose zone modelling, characterization of the vadose zone may be omitted. Experience has shown that the following affect the level of complexity of the hydrogeological model:

(a) Ignoring the role of the unsaturated zone;
(b) Considering a conservative contaminant;
(c) Assuming a homogeneous and isotropic flow domain.

6.35. Modelling should start with the simplest model — advective — which assumes that the dispersion is governed only by the mean velocity of groundwater flow. Therefore, descriptions of dispersion parameters and variables are not needed.

6.36. In order to use more complicated models (e.g. combining all processes), more hydraulic and dispersion parameters need to be determined, such as dispersivity, diffusion coefficients, distribution coefficients, kinetic reaction rates and half-lives. Recommendations on the application of a graded approach for different reporting stages are provided in Section 10 and in the Appendix.

IDENTIFICATION OF EXPOSURE PATHWAYS FROM GROUNDWATER

6.37. The following can serve as the starting point for possible exposure pathways from groundwater during normal operation of nuclear installations:

(a) Boreholes, wells and galleries used to abstract water for drinking;
(b) Springs captured for drinking water;
(c) Groundwater used for agriculture;
(d) Groundwater base flow to streams, rivers, lakes or wetlands (that can lead to internal exposure through ingestion of drinking water and/or aquatic food such as fish, crustaceans and molluscs);
(e) Groundwater flow into the sea and estuaries (that can lead to internal exposure through ingestion of aquatic food and external exposure through activities such as swimming and fishing).

CALIBRATION OF MODELS AND SENSITIVITY STUDY OF THE ANALYSIS OF RADIONUCLIDE DISPERSION IN GROUNDWATER

6.38. Models always have limitations because they are simplifications of the complex real world and do not provide a unique representation of reality. However, properly constructed models can provide reliable results within the uncertainty limits. Therefore, the level of uncertainty of a model should be evaluated and reported.

6.39. The calibration of a model provides the means to test and/or compare the selected conceptual models. Calibration involves observation of the actual site conditions and thus the monitoring of data sets. To ensure that the model simulates the real system with an acceptable degree of error and uncertainty, the calibration should be done for both steady state and transient conditions.

6.40. Consideration should be given to uncertainties that might arise from (a) deficiencies in understanding and conceptualization of the hydrogeological system; (b) spatial and temporal variations in variables and parameters; and (c) definition of the boundary conditions of the flow domain. Different types of uncertainty (e.g. conceptual model uncertainty, numerical model uncertainty, parameter uncertainty, exposure scenario uncertainty, exposure parameter uncertainty) should be considered.

6.41. A sensitivity study should be conducted to identify the parameters and locations to which the system behaviour is sensitive. Performing additional site characterization to better estimate parameters at these locations reduces model uncertainty. Further monitoring should be performed where the system is most sensitive to model parameters.

SCENARIO BASED SIMULATION OF RADIONUCLIDE DISPERSION IN GROUNDWATER

6.42. To achieve the objectives described in para. 6.1, a predictive model should be run to simulate different scenarios. A properly constructed and calibrated model provides a tool to forecast the response of the groundwater system to future conditions.

6.43. Two sources of uncertainty should be considered in scenario based simulations[9]. The model itself is one source of uncertainty (see para. 6.38) and the other is associated with the scenario. The accuracy of specification of the future conditions should be considered as a significant source of uncertainty in the forecast.

6.44. Primarily, simulation under normal conditions (continuous discharge) should be run for different scenarios. Scenarios should be based on the expected future changes in natural conditions and on the design of the installation. Changes in the meteorological and hydrological conditions during the lifetime of the installation and the release of radionuclides during normal operation should be simulated for a period covering at least the lifetime of the installation. Changes in meteorological parameters such as precipitation, temperature and land use, which affect surface runoff and evapotranspiration, should be taken into account. The exposure pathways defined in para. 6.37 should also be considered.

6.45. Similarly, different scenarios defining possible types and locations of an accidental release of radionuclides should also be simulated to forecast the pathways, distribution of concentration, activity and velocity of the radionuclides in the groundwater system. Interactions with surface water bodies should be considered, where applicable.

GRADED APPROACH TO ASSESSING THE DISPERSION OF RADIONUCLIDES IN GROUNDWATER

6.46. Detailed recommendations for determining the most appropriate level of complexity for modelling radionuclide dispersion in groundwater are provided in the Appendix.

[9] In a scenario based simulation, the calibrated model is run to simulate different plausible release scenarios for discharges and accidental releases.

7. ASSESSMENT OF THE OVERALL RADIOLOGICAL IMPACT OF A NUCLEAR INSTALLATION

SUMMARY OF THE NUCLEAR INSTALLATION SITE CHARACTERISTICS USED FOR RADIOLOGICAL IMPACT ASSESSMENT

7.1. Recommendations on the characteristics of a nuclear installation site that form the basis for radiological impact assessment are provided in Section 3. These characteristics primarily relate to meteorological and hydrological conditions, topography, population distribution and habits, land and water use, natural background radioactivity and food production and consumption in the vicinity of the site. These site characteristics and where they are used in radiological impact assessments for a nuclear installation are shown in Table 2 and Fig. 1.

7.2. External hazards at the site might affect the installation and this should be considered in the analyses for determining the types of safety features that are incorporated into the design of a nuclear installation and the frequency of potential accident scenarios during the operation of the installation. Therefore, these design characteristics also affect the radiological impact of nuclear installations either by altering the source terms (i.e. quantities, physical and chemical form and timing of radionuclides released to the environment during an accident) or by changing the frequency of potential accident scenarios. Source terms have a strong influence on the potential doses from individual accident scenarios and the frequency of accidents has a direct effect on the total radiological risk from a nuclear installation (see paras 7.27–7.30).

TABLE 2. OVERVIEW OF SITE CHARACTERISTICS AND THEIR USE IN RADIOLOGICAL IMPACT ASSESSMENTS FOR NUCLEAR INSTALLATIONS

Site characteristic	Use in radiological impact assessment				
	Atmospheric dispersion	Surface water dispersion	Groundwater dispersion	Public dose estimation	Biota dose estimation
Meteorology:					
Wind speed and direction, temperature, humidity and atmospheric stability	X		X		
Precipitation	X	X	X		
Surface water hydrology:					
Physical characteristics		X			
Flow and interconnections		X			
Sedimentation		X			
Interaction with groundwater		X	X		
Groundwater hydrology:					
Site hydrogeology (i.e. description and mapping of major hydrogeological units)			X		
Groundwater flow, including recharge and discharge			X		
Hydraulic head distribution and hydraulic characteristics[a] of aquifers		X	X		
Surface features, topography	X	X	X		

TABLE 2. OVERVIEW OF SITE CHARACTERISTICS AND THEIR USE IN RADIOLOGICAL IMPACT ASSESSMENTS FOR NUCLEAR INSTALLATIONS (cont.)

Site characteristic	Use in radiological impact assessment				
	Atmospheric dispersion	Surface water dispersion	Groundwater dispersion	Public dose estimation	Biota dose estimation
Population distribution and habits				X	
Habitats for biota[b]					X
Land use		X	X	X	
Water use		X	X	X	
Food production and consumption				X	

[a] Examples include porosity, conductivity, transmissivity and dispersivity.
[b] See annex 1 to GSG-10 [13] for an example of a generic methodology.

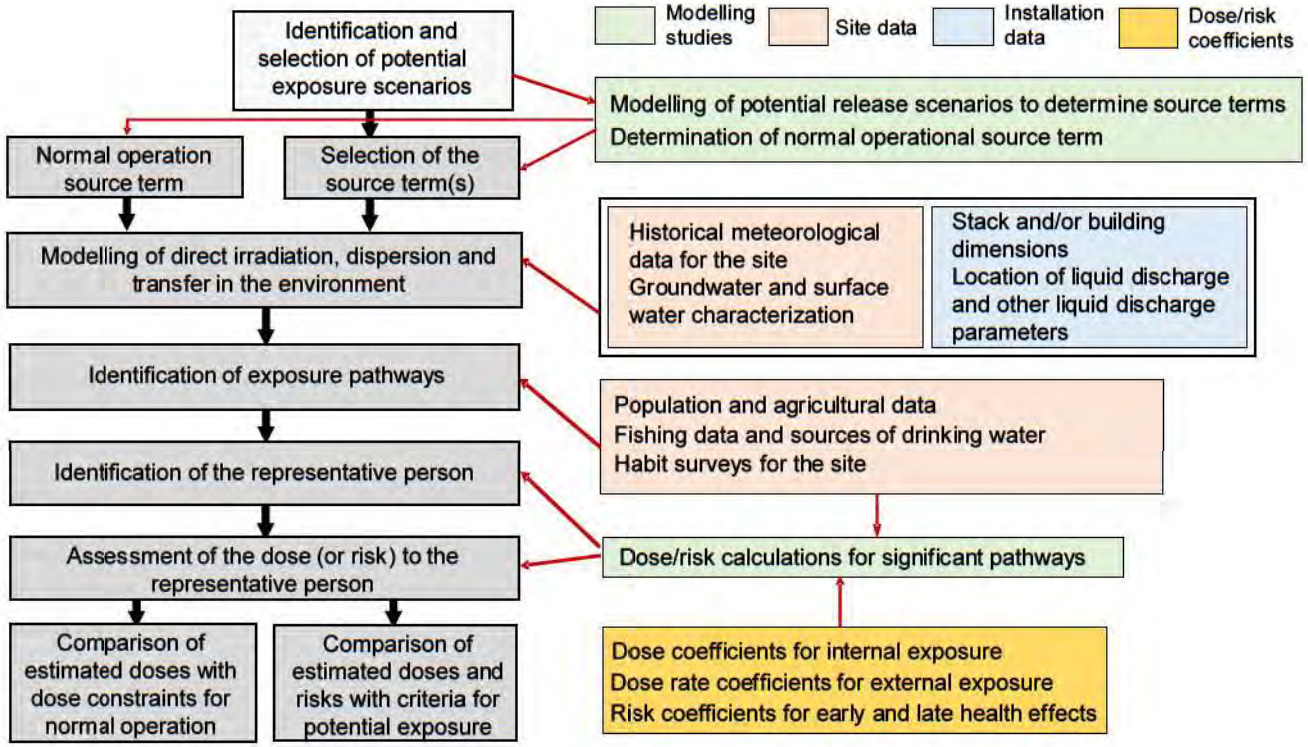


FIG. 1. Data used and modelling performed at the various stages of the radiological environmental impact assessment for operational states and accident conditions.

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COMPILATION OF RADIOLOGICAL IMPACT ASSESSMENT RESULTS

7.3. The end points for analysis of the dispersion of radionuclides in the atmosphere, groundwater and/or surface water should be activity concentrations of radionuclides in environmental media that could lead to exposure of people and biota.

7.4. The inhalation dose for an individual at a particular location should be determined by combining the following:

(a) The time-integrated air concentrations for each radionuclide at that location derived from the atmospheric dispersion modelling.
(b) The breathing rate of an individual at that location. This could be taken from standard data for a given age group (e.g. from Ref. [25]), or it could be determined from habit surveys that record the typical daily hours of performing various activities (e.g. a farmer working outdoors probably has a higher than average breathing rate for the time of exposure).
(c) Any location factors applied (e.g. being indoors effectively reduces the activity inhaled).
(d) Age-dependent inhalation dose coefficients for each radionuclide for effective dose and organ dose such as the thyroid (e.g. from Ref. [26]).

7.5. The ingestion dose of an individual consumer of a particular food type should be determined by combining the following:

(a) The activity concentration of each nuclide in that food type (as a function of time if long term exposure is being evaluated) determined by the dispersion and transfer modelling and food chain models;
(b) The ingestion rate for an individual food consumer, usually determined from habit surveys and considering various age groups;
(c) Age-dependent ingestion dose coefficients for each radionuclide (e.g. from Ref. [26]).

7.6. External exposure of an individual at a particular location should be calculated using the following:

(a) The activity concentrations in the air, on the ground or in the water (as a function of time if long term exposure is being evaluated);
(b) The time the individual is exposed, which is determined from habit data;

(c) The geometry of the exposure and distance from sources of radioactivity (e.g. deposited activity on the ground, a plume in the air);
(d) Any factors applied for shielding (e.g. being indoors);
(e) The dose rate coefficients for each radionuclide (e.g. from Ref. [27], which provide values for typical environmental geometries and shielding situations for exposure from air, soil and water).

7.7. The total dose for any given individual is the sum of all dose contributions listed in paras 7.4–7.6 (i.e. inhalation, ingestion and external exposure).

7.8. To meet any regulatory criteria for individual dose or risk, a representative person should be identified (see paras 7.14–7.17).

7.9. For normal operation of a nuclear installation, a criterion for a single source or site can be a dose constraint that is a fraction of the dose limit for public exposure, which is an effective dose of 1 mSv in a year (see para. III.3 of GSR Part 3 [4]).

7.10. The radiological impact assessment should consider the whole lifetime of the nuclear installation so that the effects of accumulation of longer lived radionuclides in the environment can be assessed.

7.11. For all accident conditions considered, the individual doses from the various release routes (i.e. atmosphere, surface water, groundwater) and exposure pathways should be summed for comparison with either reference levels or dose constraints and dose limits, as appropriate.

7.12. For public exposure from accidental releases from nuclear power plants or other types of nuclear installation, it may be sufficient to only consider atmospheric releases, since the atmosphere is likely to be the release route for most accident situations unless there are accident scenarios involving a direct release to surface water or groundwater. Compared with an atmospheric release, the impact from a release to surface water or groundwater is less immediate: dilution in large bodies of water can occur and the water provides some shielding (see para. 2.28), reducing the exposure of any people in the vicinity. Where there is any uncertainty regarding the proportion of a release to the atmosphere and to water bodies, the conservative assumption would usually be that the entire release is to the atmosphere.

7.13. If multiple release routes for a single accident scenario are considered (which might be necessary if the same groups of people could be significantly affected as

a result of each release route), then the results from each separate modelling study should be combined to determine the dose to the representative person.

IDENTIFICATION OF THE REPRESENTATIVE PERSON AND REFERENCE ANIMALS AND PLANTS

7.14. Reference [19] provides guidance on selecting representative persons and determining their habits (e.g. location, time spent outdoors, breathing rate, food consumption rate) so that their overall radiological exposure can be determined. The selection should be reasonable, sustainable and homogeneous. In other words, the selection should not be overly conservative by combining a set of extreme habits or describing one-off events but should instead consider situations likely to continue over the lifetime of the nuclear installation and applying to more than a single individual.

7.15. The representative person may be different for operational states and accident conditions at the same site or installation. Possible representative persons for an accidental release from a nuclear installation could be as follows:

(a) An adult spending most of the time in a location leading to a higher likelihood of exposure, for example in the prevailing wind direction close to the site boundary/exclusion area boundary or close to sediment in surface waters that have accumulated radioactivity;
(b) An adult consuming a high rate of local food and living in the nearest population centre;
(c) A child or infant consuming supermarket food or non-locally produced food and living in the nearest population centre;
(d) An adult not resident in the nearest population centre, but who spends a significant fraction of the day working outdoors close to the release point (e.g. in an agricultural occupation on an adjacent site);
(e) A pregnant woman's fetus.

7.16. Several conservative assumptions should not be combined in selecting the representative person. For example, an infant living in the most exposed location and consuming only local food should not be selected.

7.17. To assess the total risk from a nuclear installation, the risks to the representative person and/or the societal consequences from each accident scenario, and the respective scenario frequency, should be considered.

7.18. For an atmospheric release, the radiological consequences are strongly dependent on the meteorological conditions at the time of the release. For example, the number of people exposed and the level of exposure for individuals are very different for various wind directions and other meteorological conditions. Different approaches may be applied, from a deterministic assessment using reasonably bounding meteorological conditions to statistical methods accounting for the many variabilities (e.g. meteorological conditions, exposure scenarios). One such option is a Level 3 probabilistic safety assessment[10], but the choice of an adequate option depends on the risk criteria to be met. With a lower risk installation, a proportional approach with simpler modelling conditions (e.g. a single set of bounding meteorological conditions) may be acceptable.

7.19. Statistical methods usually sample from a data set of hourly historic data measured or calculated for the site, as described in Section 4. Since the accident scenario considered in the assessment might extend over many hours or days, the meteorological data for each hour of the release or for discrete phases should be used; this is termed a meteorological sequence. Sufficient meteorological sequences should be sampled to represent the range of meteorological conditions that a given site might experience. For random meteorological sampling, the relative likelihoods of each sequence are unity; if other sampling schemes are used to obtain more examples of particular types of weather (e.g. heavy rainfall), then the relative likelihoods should be adjusted accordingly. This procedure should be repeated for every accident scenario considered, whether it is a part of a deterministic assessment or part of a probabilistic assessment. In this latter case, the conditional risks for each scenario are multiplied by their respective frequencies (derived from the Level 1 and/or Level 2 probabilistic safety assessment [18, 23]) to give the risk for each scenario. An analogous procedure could be followed for aquatic releases, if deemed necessary.

7.20. Computer codes used for statistical methods may combine several aspects such as atmospheric dispersion modelling and dose and risk calculations using meteorological data, demographic data and food production data for the nuclear installation site and surrounding area. When using such codes or specific models developed for different environments, care should be taken to ensure they are applicable to the environment being assessed. For example, such codes might use food chain models developed for agricultural practices in temperate climates that might not be suitable for use in tropical climates.

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[10] See footnote 6 on p. 39.

7.21. Where exposure of animals and plants is considered, this is usually only for normal operation. Care should be taken to protect the more highly exposed population groups of a species rather than individual members of species within those groups.

7.22. Animals and plants might occupy different habitats to those occupied by humans and might be exposed to radionuclides that accumulate over time in those habitats. A region around the discharge locations of the nuclear installation (e.g. with an area of around 100–400 km^2) should be considered, in which population groups of animal and plant species that might be exposed are identified. A set of reference animals and plants is defined in Ref. [28]. A generic methodology for assessing exposures of flora and fauna is provided in annex I of GSG-10 [13].

ASSESSMENT OF DOSE AND/OR RISK TO THE REPRESENTATIVE PERSON AND TO REFERENCE ANIMALS AND PLANTS

7.23. The radiological impact to the public from normal operation should be assessed on the basis of the individual effective dose to the representative person. Whether a quantitative assessment of the radiological impact on fauna and flora from normal operation is also needed is a matter for individual States. With regard to this, para. 1.33 of GSR Part 3 [4] states:

> "Trends also indicate the need to be able to demonstrate (rather than to assume) that the environment is being protected against effects of industrial pollutants, including radionuclides, in a wider range of environmental situations, irrespective of any human connection. This is usually accomplished by means of a prospective environmental assessment to identify impacts on the environment, to define the appropriate criteria for protection of the environment, to assess the impacts and to compare the expected results of the available options for protection. Methods and criteria for such assessments are being developed and will continue to evolve."

7.24. The components of the radiological impact on the public from accidental releases is shown in fig. 3 of GSG-10 [13].

7.25. The framework for radiation protection of members of the public and protection of the environment in planned exposure situations, emergency exposure situations and existing exposure situations and its application are provided in IAEA Safety Standards Series No. GSG-8, Radiation Protection of the Public and

the Environment [29]. Recommendations on the application of the principles of justification, optimization of protection and dose limits, where appropriate, are provided in GSG-8 [29].

DETERMINATION OF THE ACCEPTABILITY OF RADIOLOGICAL IMPACTS

7.26. For operational states (i.e. normal operation and anticipated operational occurrences), recommendations on setting dose limits and constraints are provided in GSG-9 [20].

7.27. For potential exposures, para. 3.15(e) of GSR Part 3 [4] requires that the likelihood and magnitude of such exposures, their likely consequences and the number of individuals who may be affected be assessed, while para. 3.120 of GSR Part 3 [4] requires that constraints on dose and constraints on risk be established but no criteria are specified. It is the responsibility of the government or the national regulatory body to either approve or establish dose constraints. International guidance on determining the acceptability of impacts is provided in Refs [15, 30].

7.28. Impacts on neighbouring States from both operational states and accident conditions should be considered. Paragraph 3.124 of GSR Part 3 [4] states:

> "When a source within a practice could cause public exposure outside the territory or other area under the jurisdiction or control of the State in which the source is located, the government or the regulatory body:
>
> (a) Shall ensure that the assessment for radiological impacts includes those impacts outside the territory or other area under the jurisdiction or control of the State;
>
> .....
>
> (c) Shall arrange with the affected State the means for the exchange of information and consultations, as appropriate."

7.29. For nuclear power plants, since it is difficult to exclude the possibility of any public exposure in neighbouring States, a transboundary assessment should be performed. For nuclear installations other than nuclear power plants,

a transboundary assessment should be conducted if a facility has the potential to affect an area across borders.

7.30. When considering transboundary impacts, the criteria used for the assessment of the level of protection for operational states or for the consideration of potential exposures in other States should be in line with the criteria set out in GSG-10 [13] and should be the same as those used for the State in which the installation is located.

7.31. GSR Part 3 [4] establishes general requirements on environmental protection from radiation but does not have specific requirements on the assessment of exposure (and hence the level of protection) for flora and fauna. GSR Part 3 [4] notes the importance of assessing environmental impacts, while allowing decision flexibility commensurate with radiation risks associated with the facility or activity. If regulations require a flora and fauna exposure assessment, typical environmental monitoring programmes for public protection, as detailed in GSG-10 [13] and GSG-19 [14], are generally sufficient to validate the exposure assessment. The IAEA follows (to the extent applicable) ICRP recommendations in publications 103, 108, 114, 124 and 136 [28, 31–34], which use 12 reference animals and plants to assess radiological impacts on non-human species. This approach, aligned with human protection principles, includes derived consideration reference levels and has been incorporated into GSG-10 [13] for planned exposure situations.

7.32. As part of the application for a licence for a new nuclear installation project, the applicant prepares, and the regulatory body reviews, an environmental management plan, which is a comprehensive document that identifies, among other things, the actions to be taken (including any mitigation measures that are included in the environmental impact assessment report and licensing conditions imposed by the regulatory body), responsibilities, reporting and processes for implementing corrective actions if needed. The purpose of the environmental management plan is to ensure that potential project interactions with the environment are considered during the site preparation, construction, operation and decommissioning stages of the nuclear installation, to minimize or prevent potential negative impacts and to enhance the positive impacts. Some States might not require such a combined document but instead might require individual plans for specific issues. The environmental monitoring programme, which is presented in Section 8 of this Safety Guide, should be a part of the environmental management plan. That monitoring programme may need adjustment during the decommissioning process owing to the changing nature of activities at the site.

8. MONITORING OF RADIOACTIVITY IN THE ENVIRONMENT AROUND A NUCLEAR INSTALLATION

8.1. Requirement 28 of SSR-1 [1] states that "**All natural and human induced external hazards and site conditions that are relevant to the licensing and safe operation of the nuclear installation shall be monitored over the lifetime of the nuclear installation.**"

ENVIRONMENTAL MONITORING PROGRAMME DURING THE SITE CHARACTERIZATION AND PRE-OPERATIONAL STAGES OF A NUCLEAR INSTALLATION

8.2. Recommendations on the measurement of the background radioactivity as part of the establishment of baseline environmental conditions at the site and in the vicinity of the site for a nuclear installation are provided in Section 3. Sampling programmes should be developed for measuring background radiation and other parameters used to estimate radiation doses due to direct radiation from radioactive material inside the installation and from radioactive material released from the installation to the air, surface water, groundwater and the ground surface during the site characterization and pre-operational stages. These sampling programmes can serve as the basis for the monitoring programmes that will be established during the operation of the proposed nuclear installation. The locations and the media chosen for measuring the radioactivity and other parameters should be those that are likely to be relevant to the exposure of representative persons when the nuclear installation starts to operate.

8.3. The environmental monitoring programme should commence well before the start of construction of the installation and sufficiently before operation to be able to identify any trends in the background levels of radioactivity. For example, if the levels of a particular radionuclide are falling prior to the start of operation, then they would be expected to continue to fall in the absence of any new releases from the installation.

8.4. The environmental monitoring programme should continue for the lifetime of the installation.

Monitoring of radioactivity in the atmosphere

8.5. Monitoring stations should be set up at several key locations on the site, on the site perimeter and away from the site to measure external radiation and the radioactivity in materials suspended in the air. These stations should initially be used to establish the background radiation and meteorological conditions in the area. Their operation should continue after the installation starts operating, to determine changes in radioactivity in the air due to the operation of the installation and to record any changes in the meteorological conditions at the site and in its vicinity.

Monitoring of radioactivity in surface water and groundwater

8.6. A monitoring programme should be established for both surface water and groundwater. The purposes of such a programme during the site characterization and pre-operational stages are to establish the baseline conditions and to determine whether there are any trends that result in changing the characteristics of the region before the commencement of operation of the nuclear installation. Recommendations on the selection of sampling locations for monitoring of surface water and groundwater are provided in GSG-19 [14].

8.7. All surface water and groundwater in the vicinity of the site should be sampled regularly. For surface water bodies, sediments should be sampled as well as the water itself.

8.8. Groundwater should be monitored by means of samples taken from boreholes and wells. The samples can also be taken from groundwater reaching the surface in springs or in natural depressions. Boreholes and wells should be kept in an operable state.

8.9. The monitoring programme for groundwater should be initiated at least two years before the start of construction of the installation. The site area should be monitored before the foundation work is begun in order to verify possible changes in the groundwater regime. Monitoring should continue after construction has finished.

Monitoring of radioactivity in soils and biota

8.10. Soil samples should be taken and analysed to determine the baseline radionuclide concentrations in the soils before the start of operation of the nuclear installation (see Section 3). The sampling locations should include areas on the

site, in particular those that will not be covered by buildings or paved over by roads and parking lots, as well as areas off the site that are residential, industrial, commercial, agricultural, recreational or for wildlife.

8.11. Samples should also be taken and analysed to determine the baseline concentrations of radionuclides in biota in the vicinity of the nuclear installation. Biota samples should include the following:

(a) Foodstuffs grown (e.g. vegetables, fruits, grains) and animals reared in the region for human consumption;
(b) Biota consumed by domesticated and wild animals (e.g. grass, leaves on bushes, shrubs, low tree branches);
(c) Wild animals in the region (e.g. birds, rabbits).

Guidelines on soil and vegetation sampling for radiological monitoring are given in Ref. [35].

Monitoring of population data and other parameters

8.12. The monitoring programmes started during the pre-operational stages of a nuclear installation and continued during operation and decommissioning should focus on those radionuclides that are important contributors to the total dose of the representative person. In addition, those parameters that are identified as important to this dose calculation through modelling studies and sensitivity analyses should be sampled more frequently and in more locations than other parameters to which the results are less sensitive. The distance of the sampling locations from the nuclear installation should be determined by the results of the pathway analyses. If the results indicate that an individual could receive a substantial dose through a pathway at some distance, the environmental samples should be extended to that distance. These distances vary for different types of nuclear installations depending on the source terms and site environmental factors. The control locations (see para. 3.36) that are outside the region of influence of the nuclear installation should continue to be sampled regardless of their distance from the installation.

8.13. Arrangements for emergency preparedness should be considered carefully for any conceivable emergency when implementing the monitoring programmes during the pre-operational stage (see GSG-19 [14]). The basic intervention levels should be understood by all responsible persons and organizations, and operational intervention levels should be established on a site specific basis. The operational intervention levels should refer to parameters that can be easily

measured (e.g. dose rate in air, deposition density of radionuclides) so that an interpretation can be made rapidly if intervention is needed.

MONITORING PROGRAMME DURING THE OPERATION OF A NUCLEAR INSTALLATION

8.14. Requirements for monitoring during operation of a facility are established in Requirements 14, 20 and 32 of GSR Part 3 [4]. GSG-19 [14] provides supporting recommendations and Ref. [36] provides detailed descriptions of the monitoring programmes employed during the operation of a nuclear installation, including information about the objectives, conduct and use of monitoring both during operational states and in accident conditions.

8.15. During the operation of a nuclear installation, monitoring programmes should be used for the following purposes:

— To verify compliance with regulatory limits such as dose constraints;
— To confirm that the levels of radionuclides in the environment are consistent with the discharges reported by the operating organization;
— To confirm the results of the impact study;
— To check the predictions of environmental models;
— To provide a warning of unusual or unforeseen conditions.

In an emergency, additional monitoring activities should be established.

Environmental monitoring during normal operation

8.16. The environmental monitoring programme established during the site characterization and pre-operational stages of a nuclear installation should be continued during the operation of the installation. Samples of environmental media should be taken and analysed on a schedule that depends on the half-lives of the radionuclides that could potentially be discharged from the installation, their discharge route and also corresponding to the objective of the analysis to be made. However, the frequency and the number of samples taken during the early stages of operation of the installation should be relatively high to confirm the predictions made by modelling conducted during the site characterization and pre-operational stages. As experience is gained, the scale of routine monitoring could be reduced and the locations amended to reflect actual discharge patterns identified during monitoring activities.

8.17. Environmental monitoring in the context of this Safety Guide refers to the measurement of external dose rates in the environment and radionuclide activity concentrations in air, water, soil, sediments, vegetation, foodstuffs and the bodies of animals. A key feature in designing environmental monitoring programmes for major sources is the identification of potentially critical radionuclides, pathways and groups. Once identified and assessed, it is possible to select those radionuclides and pathways that make the biggest contribution to individual doses so that the monitoring programmes can be focused accordingly.

Environmental monitoring during a nuclear or radiological emergency

8.18. Environmental monitoring takes on special significance during an emergency because it often provides important information about the severity of impacts from the accident. GSR Part 7 [5] requires prompt monitoring and assessment of areas that could be or are known to have been contaminated during a nuclear or radiological emergency. GSG-19 [14] provides recommendations on environmental monitoring in an emergency.

Source monitoring

8.19. Source monitoring is the monitoring of a particular source of radiation or discharges of radionuclides to the environment arising from a nuclear installation. Source monitoring programmes are usually designed to measure dose rates at the source and/or the discharge rates of radionuclides, which may be in the form of gases, aerosols or liquids. The results from source monitoring can be used to verify compliance with the authorized limits on discharges and/or as a basis for estimating environmental radiation levels and activity concentrations in environmental media using predictive modelling. The results of source monitoring can also provide an early warning of any deviations from normal operation.

8.20. In accordance with GSG-19 [14], there should be coordination between the source monitoring programme and the environmental monitoring programme. In the case of discharges where the activity concentrations in environmental monitoring are below detection limits, the dose calculations can be based on source monitoring data and appropriate modelling.

8.21. Further recommendations on source monitoring are provided in GSG-19 [14].

Individual monitoring

8.22. Individual monitoring relates to measurements taken directly on people. It includes measurements of external doses with personal dosimeters carried by individuals and/or measurements of the quantities of radioactive substances in the body or in excreta, and the interpretation of such measurements in terms of individual dose. Workers who are exposed to radiation at varying levels in different parts of the nuclear installation site are routinely monitored.[11] Members of the public who visit the site may also be monitored. However, members of the public off the site are not normally monitored individually.

8.23. Paragraph 5.52 of GSR Part 7 [5] states:

> "The operating organization and response organizations shall ensure that arrangements are in place for the protection of emergency workers and protection of helpers in an emergency for the range of anticipated hazardous conditions in which they might have to perform response functions. These arrangements, as a minimum, shall include:
>
> .....
>
> (c) Managing, controlling and recording the doses received".

8.24. Requirement 12 of GSR Part 7 [5] states:

> "**The government shall ensure that arrangements are in place for the provision of appropriate medical screening and triage, medical treatment and longer term medical actions for those people who could be affected in a nuclear or radiological emergency.**"

8.25. Recommendations on individual monitoring in an emergency exposure situation are provided in GSG-19 [14].

[11] Recommendations on the monitoring of workers and the workplace are provided in IAEA Safety Standards Series No. GSG-7, Occupational Radiation Protection [37], and further information is provided in Ref. [38]).

Other monitoring situations

8.26. Paragraph 3.137 of GSR Part 3 [4] states:

> "Registrants and licensees shall, as appropriate:
>
> (a) Establish and implement monitoring programmes to ensure that public exposure due to sources under their responsibility is adequately assessed and that the assessment is sufficient to verify and demonstrate compliance with the authorization. These programmes shall include monitoring of the following, as appropriate:
> (i) External exposure due to such sources;
> (ii) Discharges;
> (iii) Radioactivity in the environment;
> (iv) Other parameters important for the assessment of public exposure."

8.27. For a nuclear installation, the 'other parameters' mentioned in the quotation in para. 8.26 should include the following:

(a) Population distribution (resident and transient) and characteristics (e.g. age, gender);
(b) Population habits (e.g. food consumption rates, proportion of time that people spend indoors and outdoors);
(c) Agricultural activity in the region (e.g. types and quantities of food grown);
(d) Types and numbers of animals raised for food in the region;
(e) Wildlife in the region;
(f) The proportion of locally grown food that is consumed in the region compared with that exported outside the region.

8.28. If the operating organization of the nuclear installation included any mitigation measures in its assessment of the radiological impacts when applying for authorization, or if the regulatory body granting authorization imposed any conditions, the parameters needed to verify and document those measures or conditions should also be addressed in the monitoring programme.

8.29. Certain non-radiological impacts of a nuclear installation are usually included in the environmental impact assessment as part of the authorization process. These include the impact on people and the environment from releases of hazardous chemicals and heated water, the impact from the construction of the installation, the impact on places of societal significance (e.g. historical

monuments, cultural places), the impact on endangered species and the impact on the landscape, as well as other societal and economic factors. Such impacts are normally considered by the regulatory body, taking into account regulatory requirements. It may be cost effective and beneficial to coordinate any monitoring activities that are necessary as part of the non-radiological impact assessment with the activities undertaken in the radiological monitoring programme.

MONITORING PROGRAMME FOLLOWING PERMANENT SHUTDOWN

8.30. Paragraph 9.3 of IAEA Safety Standards Series No. GSR Part 6, Decommissioning of Facilities [39], states:

> "If the approved decommissioning end state is release from regulatory control with restrictions on the future use of the remaining structures, appropriate controls and programmes for monitoring and surveillance shall be established and maintained for the optimization of protection and safety, and protection of the environment."

8.31. With regard to nuclear fuel cycle facilities, para. 5.13 of SSR-4 [3] states:

> "The operating organization shall establish a programme of monitoring throughout the lifetime of the facility to evaluate natural and human-made changes in the area, including changes in demographics. The programme of monitoring shall be in place no later than the start of construction and shall continue through to decommissioning until termination of the authorization."

8.32. When a nuclear installation ceases to operate and before the start of decommissioning, and in accordance with the decommissioning plan, the monitoring programme should be re-evaluated and modified as appropriate for the decommissioning stage and for the stage from the end of decommissioning to release from regulatory control. Further recommendations are provided in GSG-19 [14] and IAEA Safety Standards Series No. SSG-47, Decommissioning of Nuclear Power Plants, Research Reactors and Other Nuclear Fuel Cycle Facilities [40], and additional information is provided in Ref. [41].

9. CONSIDERATION OF THE FEASIBILITY OF PLANNING EFFECTIVE EMERGENCY RESPONSE ACTIONS

9.1. Requirement 13 of SSR-1 [1] states:

> "**The feasibility of planning effective emergency response actions on the site and in the external zone shall be evaluated, with account taken of the characteristics of the site and the external zone as well as any external events that could hinder the establishment of complete emergency arrangements prior to operation.**"

9.2. Any adverse conditions surrounding the site that could hinder off-site emergency response actions, such as the sheltering or evacuation of the population in the region or the access of external services needed to deal with an emergency, should be identified and evaluated (e.g. by performing a transport analysis; see para. 9.9) and it should be confirmed that planning effective emergency response actions remains feasible.

9.3. The area to consider should be large enough to encompass any possible future emergency planning zone or distance (see para. 5.38 of GSR Part 7 [5] and appendix II of IAEA Safety Standards Series No. GS-G-2.1, Arrangements for Preparedness for a Nuclear or Radiological Emergency [42]).

9.4. Geographical features of the landscape that might make off-site protective actions difficult to implement include physical barriers such as rivers or mountains that lack infrastructure for facilitating a response. Feeder roads (e.g. frontage roads, spurs, secondary roads) that offer single points of access are not barriers to response as they lead to major evacuation routes. If evacuation is likely to be necessary, then, as a high level principle, there should be at least two major evacuation routes in different directions to offer various itinerary options for the implementation of precautionary urgent protective actions or urgent protective actions that involve road transportation during a nuclear or radiological emergency. If this is not possible owing to geographical features, administrative restrictions or other reasons, the site should be considered unsuitable for a nuclear installation unless measures are identified that would, when implemented, mitigate or eliminate the barriers to response. Examples of unsuitable sites are provided in Figs 2 and 3, while an example of a suitable site is provided in Fig. 4.

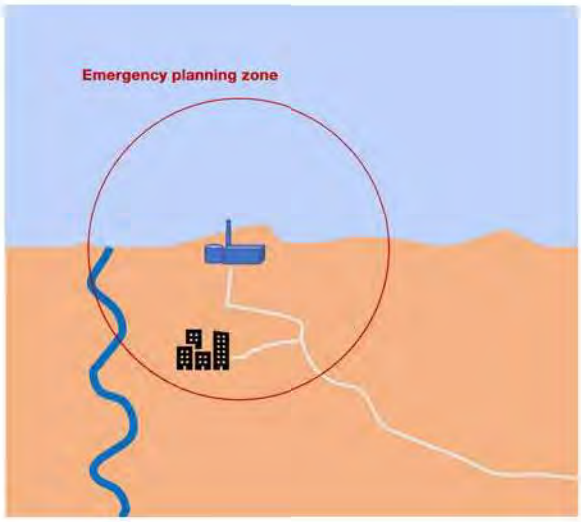


FIG. 2. Example of a site with a physical barrier (river) preventing construction of an alternative evacuation route in another direction. The site is unsuitable unless a bridge is constructed or an alternative evacuation route is made available.

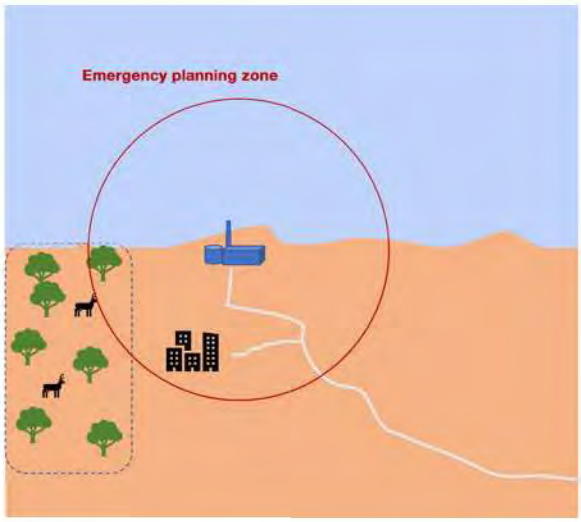


FIG. 3. Example of a site with an administrative barrier (national park or special area) preventing construction of an alternative evacuation route in another direction. The site is unsuitable.

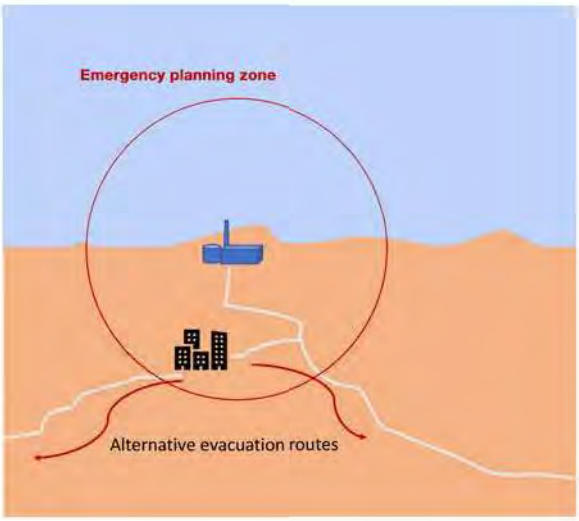


FIG. 4. Example of a suitable site. Two major evacuation routes (with sufficient capacity) in different directions exist or can be constructed.

9.5. In preparedness for a nuclear or radiological emergency, effective arrangements for sheltering should include the identification in advance of large and closed buildings that can be easily accessed by the public. These buildings, particularly in warmer climates, should be assessed for their effectiveness as shelters, considering that contamination can pass through even small openings.

9.6. As indicated in appendix V to GS-G-2.1 [42], iodine thyroid blocking tablets should be provided to the local population before or shortly after an intake of radioiodine. If iodine thyroid blocking tablets have not been pre-distributed and an order to administer the tablets is issued during a nuclear emergency, an absence of infrastructure (e.g. insufficient access options by road) might hinder access to iodine thyroid blocking tablets for the local population. However, if the site is suitable for evacuation, it can be assumed that the infrastructure also supports the distribution of tablets.

9.7. Restrictions may need to be placed on the consumption of food and water that can become contaminated from a release. Although these might need to be established in the hours or days following a release, such restrictions have no implications for site suitability.

9.8. The feasibility of planning effective emergency response actions for the nuclear installation site should be evaluated on the basis of the specific natural

and infrastructural conditions in the region. In this context, infrastructure means transport and communications networks, industrial activities and anything that might influence the rapid movement of people and vehicles in the vicinity of the site. Other information on the region, such as the availability of sheltering, systems for the collection and distribution of milk and other agricultural products, special population groups (e.g. people in hospitals and prisons, nomadic groups), industrial and other important facilities and environmental conditions (e.g. the range of weather conditions), should be collected for evaluating the feasibility of planning effective emergency response actions.

9.9. If evacuation is likely to be necessary, a transport analysis (e.g. road, rail) should be performed to demonstrate that the transport infrastructure for multiple evacuation routes is sufficient to evacuate the necessary number of people — taking special population groups into consideration — in the necessary amount of time to avoid significant exposures. The factors that should be taken into account for the transport analysis of each alternative route include the following:

(a) Number of people to evacuate;
(b) Available vehicles;
(c) Transport needs and arrangements for any special population groups;
(d) Time to alert people and to prepare to evacuate, taking into consideration any special population groups;
(e) Typical traffic volumes;
(f) Typical road capacity;
(g) Traffic bottlenecks such as bridges.

9.10. When planning for an evacuation, the transport infrastructure does not need to be present at the time of the site evaluation, but it should be practicable to improve the infrastructure so that the off-site emergency plan can be made feasible before operation.

9.11. Many site related aspects should be considered in assessing the feasibility of planning effective emergency response actions. The most important aspects are:

(a) Population density and distribution in the region;
(b) Distance of the site from population centres;
(c) Special population groups;
(d) Particular geographical features, such as islands, mountains and rivers;
(e) Characteristics of local transport and communications networks;
(f) Industrial facilities where potentially hazardous activities are conducted;

(g) Agricultural activities that are sensitive to possible discharges of radionuclides;
(h) Possible combinations of hazards from external events (e.g. earthquake with flooding).

9.12. The presence of large populations in the region or the proximity of a city to the nuclear installation should be carefully considered in the hazard assessment to develop effective off-site emergency arrangements. The specific circumstances of any special population groups should be recognized and taken into account.

9.13. External events might have consequences that limit the effectiveness of the response to an emergency at a nuclear installation. For example, an external event might result in a problem with the infrastructure or in damage to sheltering facilities. In order to ensure that the population in the region can be sheltered and evacuated effectively, consideration should be given to the provision of backup facilities and alternative routes. External events such as earthquakes might damage key transport infrastructure such as bridges; this may need to be considered when assessing alternative transport scenarios.

9.14. If it is determined that no effective response actions can be established, then the proposed site should be considered unsuitable.

9.15. The conditions assessed for the approval of the site and design may change over time. The site characteristics considered in the off-site emergency plan, such as infrastructural developments, should therefore be reviewed periodically during the operational stage of the nuclear installation.

10. APPLICATION OF A GRADED APPROACH TO RADIOLOGICAL ENVIRONMENTAL IMPACT ASSESSMENT FOR NUCLEAR INSTALLATIONS

10.1. A graded approach[12] should be applied to radiological environmental impact assessment for nuclear installations, on the basis of the following:

(a) The stage in the lifetime of the nuclear installation;
(b) The level of complexity of the site and the radionuclide transfer mechanisms;
(c) The hazard category of the installation (see para. 10.5).

10.2. The advantages of applying a graded approach include the following:

(a) It allows conservative calculations to be made, reducing the time and cost of data acquisition.
(b) It avoids the construction of models more complicated than needed to make sufficiently useful and accurate predictions.
(c) It provides a guideline for selecting a suitable level of complexity for reporting appropriate to the specific stage of site evaluation.

10.3. Radiological environmental impact assessment is required to be performed using site specific data and site specific design parameters (if the technology is known; otherwise a plant parameter envelope can be used in the interim and updated at a later stage) during site characterization (see para. 4.44 of SSR-1 [1]). During further stages of site evaluation over the lifetime of the nuclear installation, it may be necessary to update the assessments, depending on the availability of data or results of the monitoring programmes. The radiological environmental impact during construction and operation should be confirmed by the environmental monitoring programme. If the impacts deviate from those expected, a process should be initiated to determine the cause of the discrepancies and implement remedial measures if necessary.

10.4. The level of complexity incorporated in a model should be commensurate with the purpose, hazard category (see para. 10.5) and stage of site evaluation

[12] The use of a graded approach is intended to ensure that the necessary levels of analysis, documentation and actions are commensurate with, for example, the magnitudes of any radiological hazards and non-radiological hazards, the nature and the particular characteristics of a facility, and the stage in the lifetime of a facility [6].

for the installation. The radionuclide transfer mechanisms included should be based on the complexity of the system to achieve acceptable accuracy. The system may be simplified to make a first approximation, or complexities may be incorporated implicitly if their effect on transfer is deemed less relevant. Simplifications might decrease the accuracy of the model and do not necessarily mean that the results are conservative. The modelling may be in one, two or three dimensions, assuming steady state or transient flow conditions. One and two dimensional modelling assuming steady state conditions is much easier than three dimensional modelling and should be performed for low hazard installations and for exploratory purposes for high hazard installations to determine the level of complexity that should be applied in the subsequent stages. Analytical models may be used for low to intermediate hazard installations. For intermediate and high hazard installations, a stepwise strategy may be followed. Modelling with some simplifications of the site characteristics and use of the most conservative transfer mechanisms may precede more detailed modelling that takes into account site complexities (e.g. stratification in lakes, uniform or non-uniform geometry in rivers, heterogeneity and anisotropy in groundwater systems, complex surface topography for dispersion in the atmosphere) and known mechanisms (e.g. dispersion, sorption and first-order reaction in groundwater systems, sedimentation or resuspension in rivers and lakes).

10.5. The radiological environmental impact assessment for nuclear installations should be commensurate with the radiological hazards and with the hazards due to other materials present on the site. In general, the criteria for categorization should be based on the radiological consequences of the release of radioactivity from the installation, ranging from very low radiological consequences to potentially severe radiological consequences. As an alternative, the categorization may range from radiological consequences within the installation itself, to radiological consequences within the site boundary, to radiological consequences to the public and the environment outside the site. Three or more categories of nuclear installation may be defined (e.g. those presenting high, medium or low hazards) on the basis of national practice. The analysis process may be performed iteratively, where complexity is sequentially added until no more complexity in the analysis is necessary. For the application of a graded approach, the hazard categorization of a nuclear installation can be based on the same characteristics as listed in para. 9.5 of SSG-9 (Rev. 1) [8], as follows:

(a) The amount, type and status of the radioactive inventory at the site (e.g. whether solid, liquid and/or gaseous, whether the radioactive material is being processed or only stored);

(b) The intrinsic hazard associated with the physical processes (e.g. nuclear chain reactions) and chemical processes (e.g. for fuel processing purposes) that take place at the installation;
(c) The thermal power of the nuclear installation, if applicable;
(d) The configuration of the installation for different kinds of activity (depending on the design and accident management, there might be considerable time before a major release of radioactive material is initiated);
(e) The distribution of radioactive sources in the installation (for research reactors, most of the radioactive inventory is in the reactor core and the fuel storage pool, whereas for fuel processing and storage facilities it might be distributed throughout the installation);
(f) The changing nature of the configuration and layout of installations designed for experiments (such activities have an associated intrinsic unpredictability);
(g) The need for active safety systems and/or operator actions for the prevention of accidents and for mitigation of the consequences of accidents, and the characteristics of engineered safety features for the prevention of accidents and for mitigation of the consequences of accidents (e.g. the containment and containment systems);
(h) The characteristics of the structures of the nuclear installations and the means of confinement of radioactive material;
(i) The characteristics of the processes or of the engineering features that might show a cliff edge effect[13] in the event of an accident;
(j) The characteristics of the site that are relevant to the consequences of the transfer of radioactive material to the atmosphere and the hydrosphere (e.g. size and demographics of the region);
(k) The potential for on-site and off-site contamination.

10.6. The application of a graded approach may allow certain simplifications and a less detailed approach in the following areas:

(a) Source term (e.g. radionuclide quantity, activity, mass and/or volume, form, chemical and physical composition, geometry, height of release, potential for release, release start time and time profile of the release, novelty of design or activity);

[13] In a nuclear power plant or nuclear fuel cycle facility, a cliff edge effect is an instance of severely abnormal facility behaviour caused by an abrupt transition from one facility status to another following a small deviation in a facility parameter, and thus a sudden large variation in facility conditions in response to a small variation in an input [6].

(b) Complexity of environmental characteristics of the site and its region: characteristics of the site and its region relating to dispersion of radionuclides in the environment (e.g. hydrogeology, hydrology, meteorology, morphology, biophysical characteristics), presence and characteristics of receptors (e.g. demography, population habits and living conditions, flora and fauna, exposure pathways), land use and other activities (e.g. agriculture, food processing, other industries) and characteristics of other installations in the vicinity;
(c) Dimensionality of model (i.e. one, two or three dimensional);
(d) Steady state and transient transfer mode;
(e) Type of model (i.e. analytical, numerical or statistical);
(f) Source of information;
(g) Transfer phenomena.

10.7. An example of the application of a graded approach to the analysis of radionuclide dispersion in groundwater is given in the Appendix.

11. APPLICATION OF THE MANAGEMENT SYSTEM TO THE INVESTIGATION OF SITE CHARACTERISTICS AND EVALUATION OF RADIATION RISKS FROM A NUCLEAR INSTALLATION

11.1. A management system is required to be established, applied and sustained by senior management (see Requirement 3 of IAEA Safety Standards Series No. GSR Part 2, Leadership and Management for Safety [43]). This applies to all facilities and activities and should be implemented for the activities that are performed for the investigation of site characteristics and evaluation of radiation risks to the public and the environment in site evaluation for nuclear installations.

PROJECT MANAGEMENT APPROACH

11.2. A project work plan for the investigation of site characteristics and evaluation of radiation risks from a nuclear installation should be established that, at a minimum, addresses the following topics:

(a) The objectives and scope of the project;
(b) Applicable regulations and standards;
(c) Organization of the roles and responsibilities for management of the project;
(d) Work breakdown, processes, tasks, schedule and milestones;
(e) Interfaces among the different types of tasks (e.g. data collection tasks, analysis tasks) and disciplines involved, especially the various specialists needed for the different aspects of the investigation of site characteristics and evaluation of radiation risks to the public and the environment with all necessary inputs and outputs;
(f) Project deliverables and reporting.

11.3. The project scope should identify all aspects of the investigation of site characteristics and evaluation of radiation risks that are relevant to the impact of the nuclear installation on the public and the environment and that are investigated within the framework of the project.

11.4. The project work plan should include a description of all requirements that are relevant for the project, including applicable regulatory requirements in relation to the investigation of site characteristics and evaluation of radiation risks to the public and the environment. The applicability of the set of regulatory requirements should be reviewed by the regulatory body prior to conducting the project activities.

11.5. All approaches and methodologies that reference lower tier legislation (e.g. regulatory guidance documents, industry codes and standards) should be clearly identified and described. The details of the approaches and methodologies to be used should be clearly stated in the project work plan.

11.6. At a minimum, the following generic processes should be included in the management system to ensure quality of the project:

(a) Document control;
(b) Control of products;
(c) Controls for measuring and testing equipment;
(d) Control of records;

(e) Control of analyses;
(f) Purchasing (procurement);
(g) Validation and verification of software;
(h) Validity and quality of data;
(i) Audits (self-assessment, independent assessments and review);
(j) Control of non-conformances;
(k) Corrective actions;
(l) Preventive actions.

Processes covering field investigations, laboratory testing, data collection and the analysis and evaluation of observed data, as well as communication processes for interaction among the experts involved in the project, should also be applied.

11.7. The project work plan should ensure that there is adequate provision, in terms of resources and in the schedule, for collecting and analysing new data that might be important for the conduct of the investigation of site characteristics and evaluation of radiation risks to the public and the environment.

11.8. To make the investigation of site characteristics and evaluation of radiation risks to the public and the environment traceable and transparent to users (e.g. peer reviewers, the operating organization, the regulatory body), the documentation for the analysis should provide a description of all elements of the process and include the following information:

(a) A description of the study participants and their roles;
(b) Background material that includes documentation on the data collected and analysed;
(c) A description of the computer software used, and the input and output files;
(d) Reference documents;
(e) All documents supporting the treatment of uncertainties and related discussions;
(f) Results of intermediate calculations and sensitivity studies.

This documentation should be maintained in an accessible, usable and auditable form by the operating organization.

11.9. The documentation should include references to all sources of information used in the investigation of site characteristics and evaluation of radiation risks to the public and the environment, including information on the sources of important citations that might be difficult to trace.

ENGINEERING USES AND OUTPUT SPECIFICATION

11.10. The investigation of site characteristics and evaluation of radiation risks to the public and the environment should be conducted in order to develop the site evaluation report and environmental impact assessment report. From the beginning, the work plan for the investigation of site characteristics and evaluation of radiation risks to the public and the environment should identify the intended engineering uses and objectives and should incorporate an output specification that describes all the results necessary for the intended engineering uses and objectives of the project.

DOCUMENTATION OF THE INVESTIGATION OF SITE CHARACTERISTICS AND EVALUATION OF RADIATION RISKS TO THE PUBLIC AND THE ENVIRONMENT

11.11. The project for the investigation of site characteristics and evaluation of radiation risks to the public and the environment should be well documented, with a clearly defined scope and objectives. The conceptual models used for numerical modelling should be described in detail. The code selected and the reasons for its selection should be described. The steps of model construction should be documented, including grid construction, assignment of parameters, boundary conditions, steady state and transient calibration, and sensitivity analysis, if applicable. Simulation runs should be documented. The scenarios should be well described, and the results should be discussed, taking into consideration the uncertainties. An electronic copy of a ready-to-run model should be provided as an appendix to the documentation. The electronic copy should include the inputs and outputs of each run and a description of the version of software used and the operating system it was used on.

INDEPENDENT PEER REVIEW OF THE INVESTIGATION OF SITE CHARACTERISTICS AND EVALUATION OF RADIATION RISKS TO THE PUBLIC AND THE ENVIRONMENT

11.12. An independent peer review should be conducted to provide assurance of the following:

(a) That a proper process has been duly followed in conducting the investigation of site characteristics and evaluation of radiation risks to the public and the environment;

(b) That the analysis addresses the uncertainties involved;
(c) That the documentation is complete and traceable.

11.13. The independent peer review team should possess the multidisciplinary expertise needed to address all technical and process related aspects of the investigation of site characteristics and evaluation of radiation risks to the public and the environment. The team members should not have been involved in other aspects of the project and should not have a vested interest in the outcome.

11.14. Two methods of peer review should be used: participatory peer review and late-stage peer review. The participatory peer review should be conducted during the implementation of the project, allowing most of the comments of the reviewers to be resolved before the end of the project. The late-stage (follow-up) peer review should be conducted towards the end of the project. Participatory peer review decreases the likelihood that the results of the investigation of site characteristics and evaluation of radiation risks from the nuclear installation are found to be unsuitable at a later stage.

Appendix

APPLICATION OF A GRADED APPROACH TO MODELLING RADIONUCLIDE DISPERSION IN GROUNDWATER

A.1. This Appendix provides recommendations for determining the most appropriate level of complexity for modelling radionuclide dispersion in groundwater. Since different nuclear installations pose different levels of hazard, the suggested method uses a graded approach based on the level of hazard and the stage of reporting.

A.2. In addition to the level of hazard and the stage of reporting, several other factors may need to be taken into account in applying a graded approach. These factors include the complexity of the hydrogeological setting of the site; the type of the model; the type of solution provided by the mathematical model; the dimensionality of the model; the modes of flow and transport; the type of flow and transport domain; the availability, sources, reliability and representativeness of data needed for the selected model; the source and reliability of information on boundary conditions; and consideration of the processes that affect the transport and fate of radionuclides.

A.3. As described in para. 10.5, three or more levels of hazard categorization for nuclear installations may be defined. In this Appendix, three levels are assumed, based on the type and capacity of the nuclear installation.

A.4. Three reporting stages are assumed in this Appendix. Reporting Stage 1 relates to the site characterization stage, which involves a detailed study of the hydrogeological domain. Site specific data for hydrogeological conceptualization, characterization and modelling should be collected, evaluated and reported during this stage. Reporting Stage 2 relates to the construction and operation stages. For conformity of the analysis, this stage should include validation of the predictive model constructed for the site, using well established monitored observations of flow, hydraulic heads and concentrations. Validation is used here to mean a post-audit to assess the predictive accuracy of a site specific model based on long term monitoring data. Reporting Stage 3 relates to the closure of the installation. If there might be a new source term, its dispersion in groundwater should be simulated by a validated model.

A.5. The complexity of the hydrogeological configuration refers to the variety and contact relations of hydrostratigraphical units. Factors such as dual porosity,

fracture and/or karst permeability, heterogeneity and anisotropy significantly complicate the hydrogeological setting and should be considered. The ease of construction of a representative hydrogeological conceptual model without oversimplification should also be considered during the evaluation stage.

A.6. Depending on the objective defined for the groundwater modelling study, the mathematical model should be selected to simulate different flow domains: saturated or a combination of saturated and unsaturated. The vadose zone has a significant role in the transport and fate of the radionuclides, in terms of retardation and attenuation. Therefore, it has a reductive effect on the contaminant transport. For a conservative prediction, this reductive effect should be omitted at the first stage of site selection and site evaluation. Simulating the flow and transport in the saturated flow domain could be sufficient to achieve the objectives. A simulation including the unsaturated flow domain is more complicated and needs data that are more difficult to acquire. A graded approach, as depicted in Figs 5–9, can be used to determine the conditions involving consideration of the vadose zone in the hydrogeological characterization.

A.7. The groundwater modelling can be achieved by using different techniques to solve the flow and transport equations. Partial differential equations simulating the groundwater flow and solute (radionuclide) transport are solved either analytically or numerically. The advantages and disadvantages of the different techniques are presented in detail in paras 6.26–6.34. It should be kept in mind that natural systems often do not exhibit configurations that closely match the geometries defined in specific analytical solutions. Therefore, analytical models should be used when the natural hydrogeological setting can be simplified with certain confidence to fit the assumptions of the analytical solution.

A.8. The objective and the level of hazard category may necessitate groundwater modelling in one, two or three dimensions. One dimensional models simulate flow and transport in the mean flow direction and should be used only for the low hazard category. For higher hazard categories, more detailed two or three dimensional models should be employed, particularly for the screening stage, to better capture spatial variability and potential impacts. Dimensionality should be selected on the basis of the objective, expected impact and level of hazard. The higher the hazard category and the higher the accuracy needed for the investigation, the more dimensions the model should have.

A.9. The selected model should then be run and calibrated for steady state (independent of time) and transient (time dependent) flow and transport modes. Calibration is achieved by the reproduction of observed heads and/or

concentrations by the model. The model can be run only for steady flow and transport for the screening stage and/or for low hazard category installations. Transient flow and transport need to be simulated to make predictions. Therefore, the selected model (analytical or numerical) should be verified by checking the results against an independent set of data.

A.10. The application of a graded approach also involves the collection and use of different levels of data. For low hazard category installations and/or for the screening stage, data from literature, regional studies and information based on expert qualitative observations can be used if site specific data are not available. For higher levels of hazard category and at Reporting Stage 1, site specific representative data are needed. These data should include hydraulic parameters that represent all hydrostratigraphical units, the hydraulic head distribution at the flow domain and the hydraulic head, and concentration or fluxes at the boundaries of the hydrogeological domain.

A.11. A mathematical model to simulate the flow and transport processes should be selected on the basis of the level of hazard of the installation and the expected impact. The transport and fate of radionuclides in groundwater are primarily affected by advection, diffusion, sorption and radioactive decay, but processes such as dispersion should also be included if the results of groundwater modelling show that the site is not suitable for a nuclear installation. In some cases, transport models that include a reactive term may be selected.

A.12. There are several freeware and commercial computer codes that can be used in modelling studies. The model used should be verified to ensure that its numerical algorithm has been implemented correctly. In general, this is achieved by comparing the results of a numerical model with an analytical solution.

A.13. The following factors should be considered in selecting the model complexity:

(a) Level of hazard;
(b) Reporting stage;
(c) Complexity of hydrogeological configuration;
(d) Saturated or unsaturated media;
(e) Dimensionality of the model;
(f) Steady or transient flow mode;
(g) Technique for solving the equations (i.e. analytical or numerical);
(h) Source of data for parameters;
(i) Source of information for boundary conditions;
(j) Transport and fate processes.

A.14. The details of the application of a graded approach to groundwater modelling are illustrated in the flow charts in Figs 5–7 for Reporting Stage 1. Figures 8 and 9 illustrate the steps for Reporting Stages 2 and 3, respectively. The low and medium hazard categories are graded in three levels of complexity for the hydrogeological configuration of the site, while the high hazard category is graded in four levels.

A.15. The symbols and abbreviations used in the flow charts in Figs 5–9 are explained in Table 3.

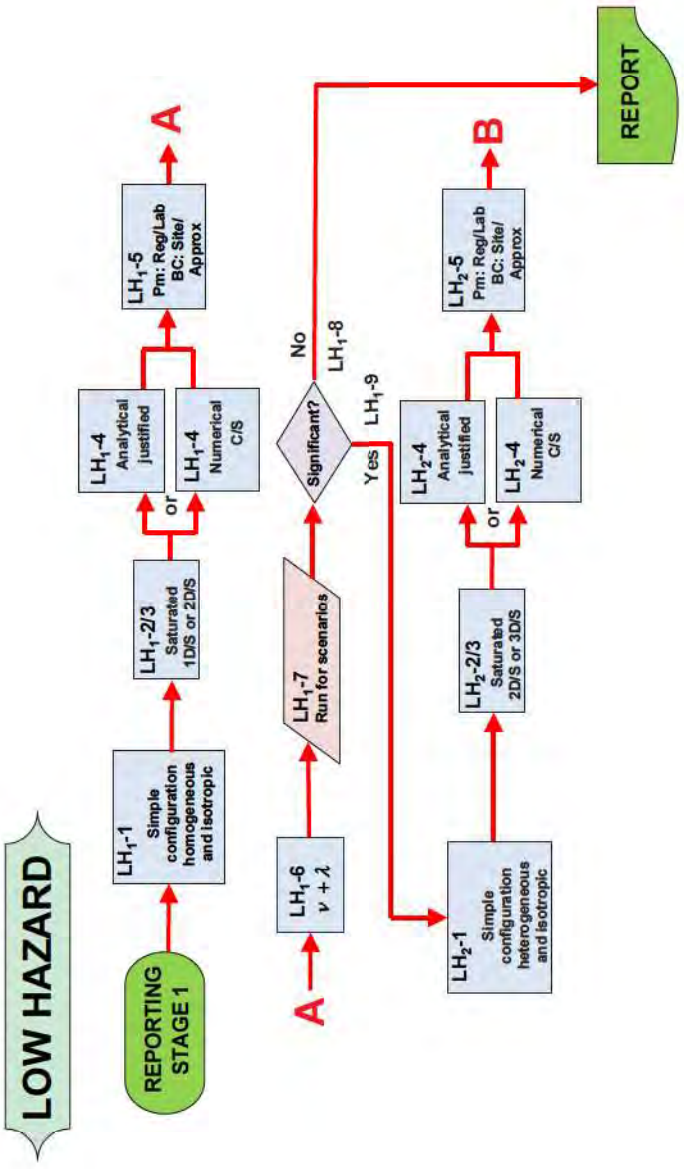
A.16. A more detailed explanation for each step illustrated in Figs 5–9 is provided under paras A.17–A.19.

TABLE 3. SYMBOLS AND ABBREVIATIONS USED IN THE FLOW CHARTS IN FIGS 5–9

Symbol/abbreviation	Definition
Hazard category of nuclear installations	
LH_n	Low hazard category (complexity level n)
MH_n	Medium hazard category (complexity level n)
HH_n	High hazard category (complexity level n)
Stage of site evaluation	
Reporting Stage 1	Site characterization
Reporting Stage 2	Construction and operation
Reporting Stage 3	Decommissioning
Transfer mechanism	
v	Advective transfer constant
λ	Radioactive decay constant
α	Dispersive transfer constant
R_f	Sorption constant
r	First-order reaction constant

TABLE 3. SYMBOLS AND ABBREVIATIONS USED IN THE FLOW CHARTS IN FIGS 5–9 (cont.)

Symbol/abbreviation	Definition
Dimensionality and flow conditions	
1D/S	One dimensional and steady
2D/S	Two dimensional and steady
2D/ST	Two dimensional, steady and transient
3D/S	Three dimensional and steady
3D/ST	Three dimensional, steady and transient
Source of information	
Approx	Approximation based on site observations
BC	Source of boundary conditions
Lab	Data from tests at laboratory
Obs	From site observation
Pm	Source of parameter value
Reg	Data from literature in the close vicinity of the installation site
Site	Site specific representative data/field test
Model status	
C/S	Calibrated for steady state conditions
C/ST	Calibrated for steady state and transient conditions


LOW HAZARD
REPORTING STAGE 1
LH1-1 Simple configuration homogeneous and isotropic
LH1-2/3 Saturated 1D/S or 2D/S
LH1-4 Analytical justified
or
LH1-4 Numerical C/S
LH1-5 Pm: Reg/Lab BC: Site/ Approx
A
A
LH1-6 ν + λ
LH1-7 Run for scenarios
Significant?
No
LH1-8
Yes
LH1-9
LH2-1 Simple configuration heterogeneous and isotropic
LH2-2/3 Saturated 2D/S or 3D/S
LH2-4 Analytical justified
or
LH2-4 Numerical C/S
LH2-5 Pm: Reg/Lab BC: Site/ Approx
B
REPORT

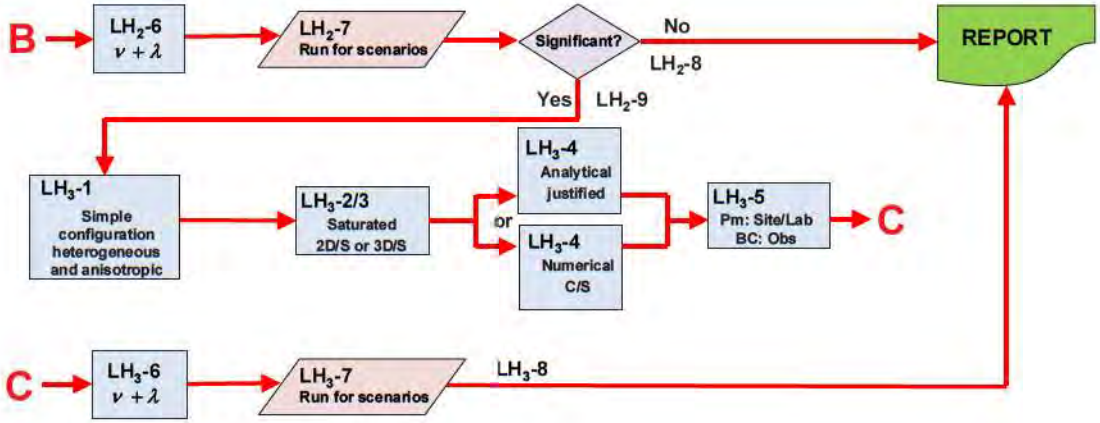
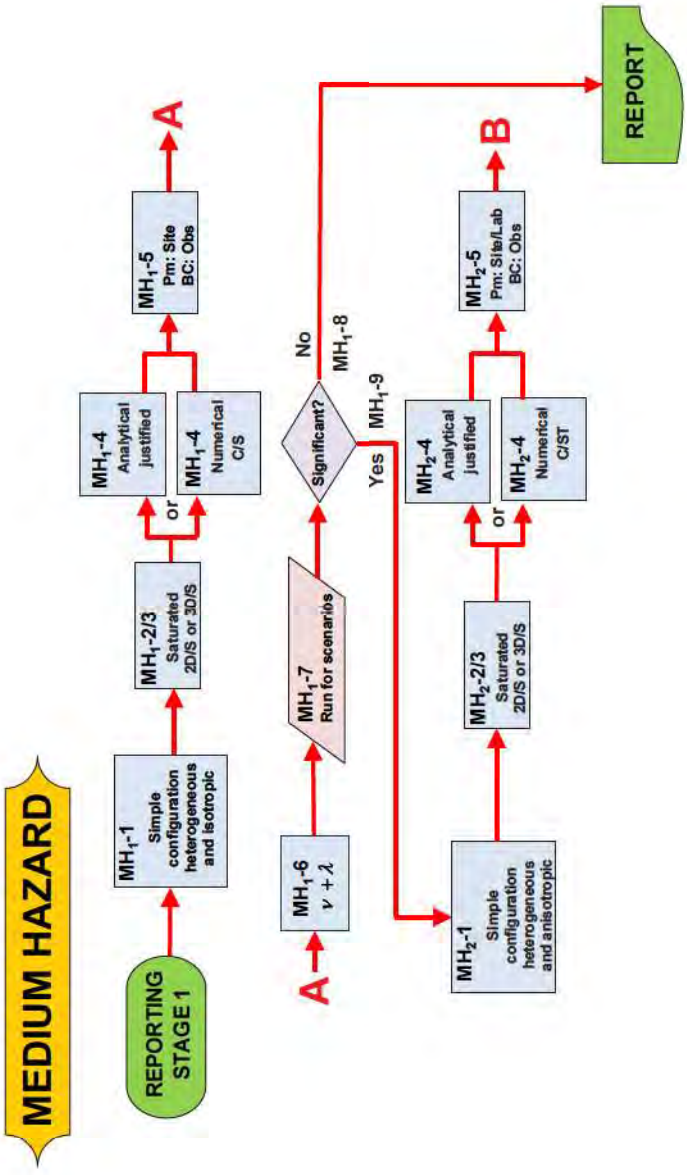


FIG. 5. Flow chart showing a graded approach to modelling radionuclide dispersion in groundwater in Reporting Stage 1 of site evaluation for low hazard category nuclear installations. (See Table 3 for definitions of the symbols and abbreviations.)

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MEDIUM HAZARD
REPORTING STAGE 1
MH1-1 Simple configuration heterogeneous and isotropic
MH1-2/3 Saturated 2D/S or 3D/S
or
MH1-4 Analytical justified
MH1-4 Numerical C/S
MH1-5 Pm: Site BC: Obs
A
A
MH1-6 ν + λ
MH1-7 Run for scenarios
Significant?
No
MH1-8
REPORT
Yes
MH1-9
MH2-1 Simple configuration heterogeneous and anisotropic
MH2-2/3 Saturated 2D/S or 3D/S
or
MH2-4 Analytical justified
MH2-4 Numerical C/ST
MH2-5 Pm: Site/Lab BC: Obs
B

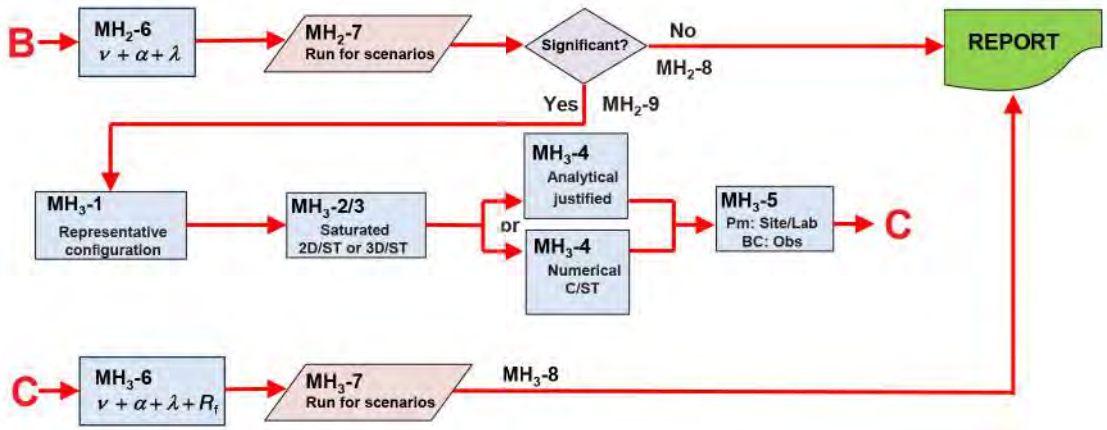
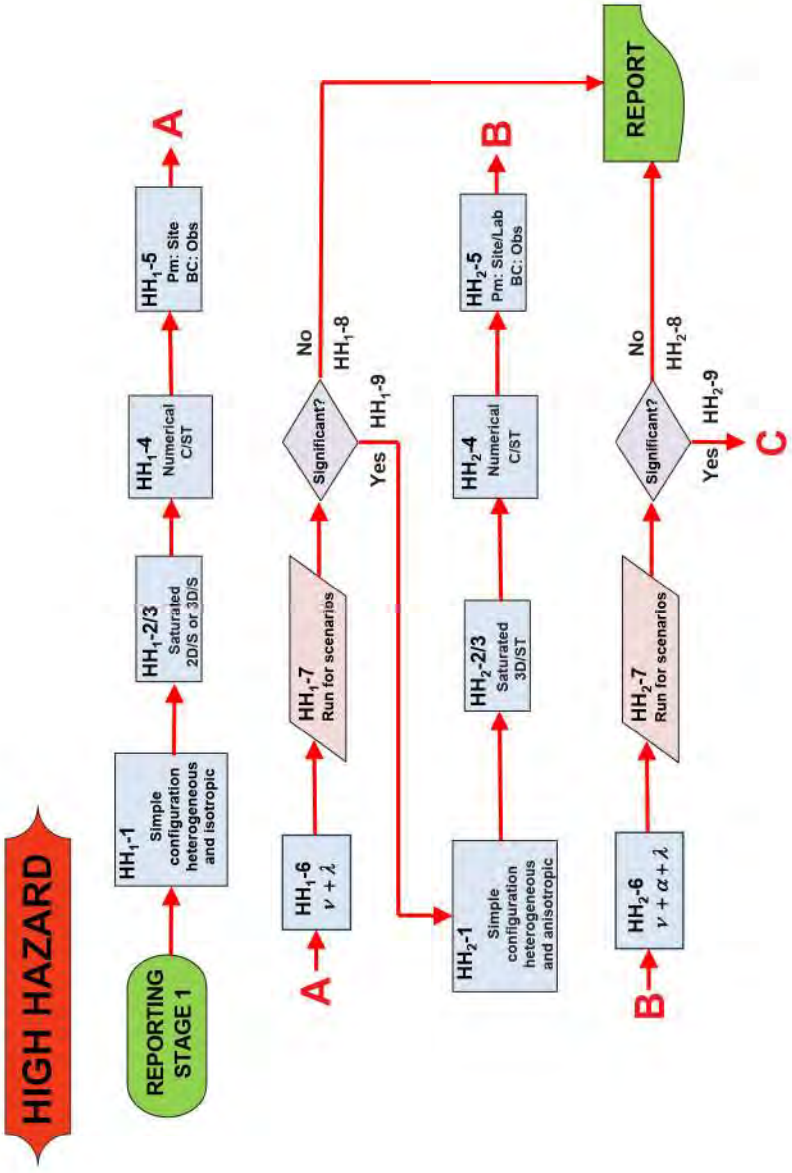


FIG. 6. Flow chart showing a graded approach to modelling radionuclide dispersion in groundwater in Reporting Stage 1 of site evaluation for medium hazard category nuclear installations. (See Table 3 for definitions of the symbols and abbreviations.)

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HIGH HAZARD
REPORTING STAGE 1
HH1-1 Simple configuration heterogeneous and isotropic
HH1-2/3 Saturated 2D/S or 3D/S
HH1-4 Numerical C/ST
HH1-5 Pm: Site BC: Obs
A
A
HH1-6 ν + λ
HH1-7 Run for scenarios
Significant?
No
HH1-8
Yes
HH1-9
HH2-1 Simple configuration heterogeneous and anisotropic
HH2-2/3 Saturated 3D/ST
HH2-4 Numerical C/ST
HH2-5 Pm: Site/Lab BC: Obs
B
B
HH2-6 ν + α + λ
HH2-7 Run for scenarios
Significant?
No
HH2-8
Yes
HH2-9
C
REPORT

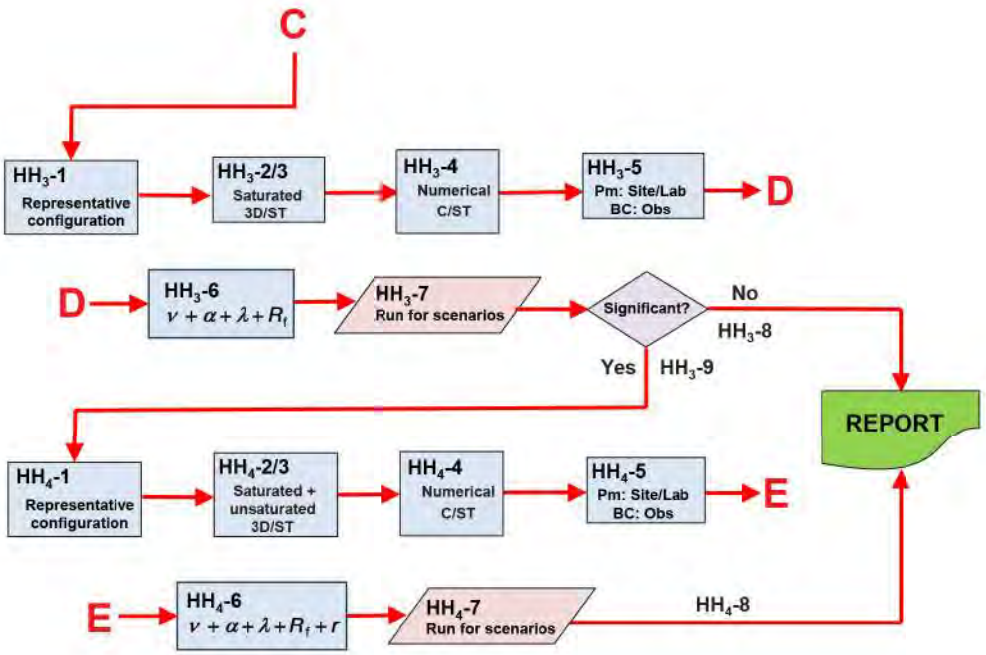


FIG. 7. Flow chart showing a graded approach to modelling radionuclide dispersion in groundwater in Reporting Stage 1 of site evaluation for high hazard category nuclear installations. (See Table 3 for definitions of the symbols and abbreviations.)

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FIG. 8. Flow chart showing steps of modelling radionuclide dispersion in groundwater in Reporting Stage 2 of site evaluation for low, medium and high hazard category nuclear installations. (See Table 3 for definitions of the symbols and abbreviations.)

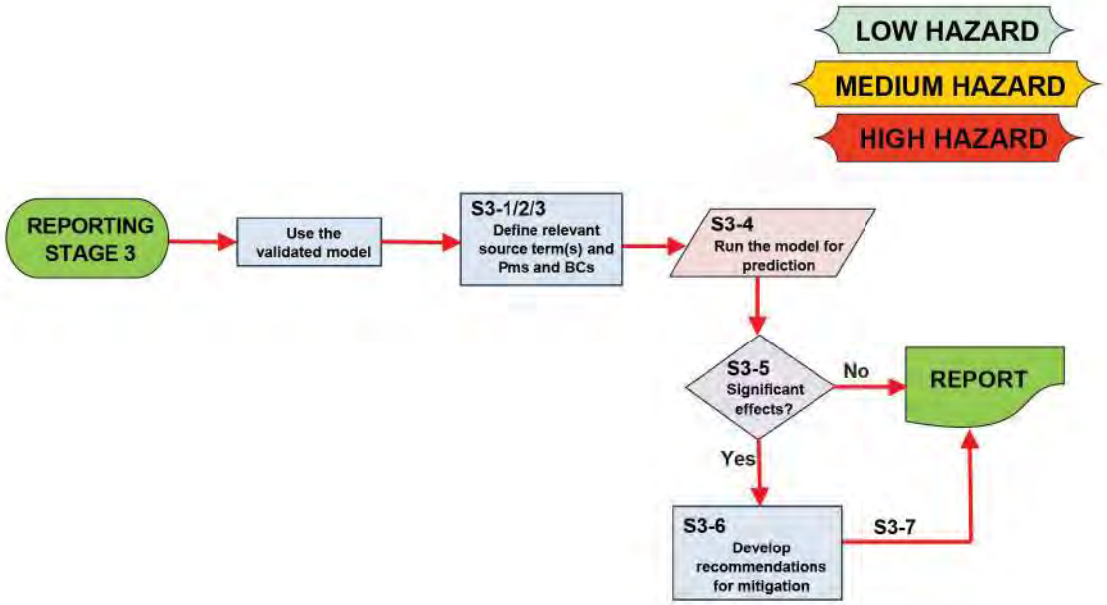


FIG. 9. Flow chart showing steps of modelling radionuclide dispersion in groundwater in Reporting Stage 3 of site evaluation for low, medium and high hazard category nuclear installations. (See Table 3 for definitions of the symbols and abbreviations.)

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EXPLANATION OF EACH STEP FOR REPORTING STAGE 1

A.17. This section describes in detail the process depicted in Figs 5–7 for Reporting Stage 1, for different levels of hazard and for different levels of site complexity.

Reporting Stage 1: Low hazard

Low hazard — Complexity level 1

LH_1-1: Conceptualize the hydrogeological system assuming that the aquifer is homogeneous and isotropic. Delineate the boundaries of the flow domain to be modelled using the available data and geological map of the site at an appropriate scale. The boundaries should be set either at a hydrostratigraphical unit (i.e. aquiclude) or a hydrological element (i.e. river, lake or measured head).

LH_1-2: Consider only the saturated part of the flow domain and ignore the role of the unsaturated zone.

LH_1-3: Construct a simple conceptual hydrogeological model in one dimension (along the main flow path) or two dimensions (cross-section and/or plane).

LH_1-4: Select one or more analytical models for flow and solute transport and justify that any model used fits the constructed conceptual model in terms of geometry of the flow domain, processes considered, parameters and boundary conditions. Alternatively, select numerical model codes that simulate one dimensional or two dimensional flow and transport. The models should be calibrated and suitable for steady state conditions.

LH_1-5: The hydraulic parameters (i.e. hydraulic conductivity, effective porosity) and transport parameters (e.g. dispersivity) may be taken from previous work at the site and vicinity and from laboratory tests. The hydraulic and concentration boundary conditions can be defined or estimated by expert approximation and observations at the site.

LH_1-6: Choose models that simulate the advective transport and radioactive decay of specific radionuclides expected to be released from the installation.

LH_1-7: Run the calibrated model for scenarios.

LH_1-8: Document whether contaminant concentrations are acceptable.

LH_1-9: If the results show that the concentrations of contaminants are significant, move to a higher complexity level of investigation and modelling (LH_2).

Low hazard — Complexity level 2

LH_2-1: Conceptualize the hydrogeological system considering the heterogeneity of the flow domain. Assume the flow domain is isotropic. Delineate the boundaries of the flow domain to be modelled using the available data and geological map of the site at an appropriate scale. The boundaries should be set either at a hydrostratigraphical unit (i.e. aquiclude) or a hydrological element (i.e. river, lake or measured head).

LH_2-2: Consider only the saturated part of the flow domain and ignore the role of the unsaturated zone.

LH_2-3: Construct a simple conceptual hydrogeological model in two dimensions (cross-section and/or plane) or three dimensions (e.g. block or fence diagram).

LH_2-4: Select one or more analytical model for flow and solute transport and justify that any model used fits the constructed conceptual model in terms of geometry of the flow domain, processes considered, parameters and boundary conditions. Alternatively, select numerical model codes that simulate one dimensional and/or two dimensional flow and transport. The models should be calibrated and suitable for steady state conditions.

LH_2-5: The hydraulic parameters (i.e. hydraulic conductivity, effective porosity) may be taken from previous work at the site and vicinity and from laboratory tests. The dispersivity (or hydrodynamic dispersion coefficient) can be taken from literature for similar types of hydrogeological units. The hydraulic and concentration boundary conditions can be defined or estimated by expert approximation and observations at the site.

LH_2-6: Choose models that simulate the advective and dispersive transport and radioactive decay of specific radionuclides expected to be released from the installation.

LH_2-7: Run the calibrated model for scenarios.

LH_2-8: Document whether contaminant concentrations are acceptable.

LH_2-9: If the results show that the concentrations of contaminants are significant, move to a higher complexity level of investigation and modelling (LH_3).

Low hazard — Complexity level 3

LH_3-1: Conceptualize the hydrogeological system considering the heterogeneity and anisotropy of the flow domain. When site data are lacking, the anisotropy can be assumed such that horizontal hydraulic conductivity is ten times higher than vertical hydraulic conductivity. Delineate the boundaries of the flow domain to be modelled using the available data and geological map of the site at an appropriate scale. The boundaries should be set either at a hydrostratigraphical unit (i.e. aquiclude) or a hydrological element (i.e. river, lake or measured head).

LH_3-2: Consider only the saturated part of the flow domain and ignore the role of the unsaturated zone.

LH_3-3: Construct a simple conceptual hydrogeological model in two dimensions (cross-section and/or plane) or three dimensions (e.g. block or fence diagram).

LH_3-4: Select one or more analytical models for flow and solute transport and justify that any model used fits the constructed conceptual model in terms of geometry of the flow domain, processes considered, parameters and boundary conditions. Alternatively, select numerical model codes that simulate two dimensional or three dimensional flow and transport. The models should be calibrated and suitable for steady state conditions.

LH_3-5: The hydraulic parameters (i.e. hydraulic conductivity, effective porosity) may be taken from previous work at the site and from laboratory tests. The dispersivity (or hydrodynamic dispersion coefficient) should be obtained from laboratory or in situ tests. The hydraulic and concentration boundary conditions can be defined on the basis of observations at the site.

LH_3-6: Choose models that simulate the advective and dispersive transport and radioactive decay of specific radionuclides expected to be released from the installation.

LH_3-7: Run the calibrated model for scenarios.

LH_3-8: Document the results.

Reporting Stage 1: Medium hazard

Medium hazard — Complexity level 1

MH_1-1: Conceptualize the hydrogeological system considering the heterogeneity of the medium and assuming that the aquifer is isotropic. Delineate the boundaries of the flow domain to be modelled using the available data and geological map of the site at an appropriate scale. The boundaries should be set either at a hydrostratigraphical unit (i.e. aquiclude) or a hydrological element (i.e. river, lake or measured head).

MH_1-2: Consider only the saturated part of the flow domain and ignore the role of the unsaturated zone.

MH_1-3: Construct a simple conceptual hydrogeological model in two dimensions (cross-section and/or plane) or three dimensions (e.g. block or fence diagram).

MH_1-4: Select one or more analytical models for flow and solute transport and justify that any model used fits the constructed conceptual model, in terms of geometry of the flow domain, processes considered, parameters and boundary conditions. Alternatively, select numerical model codes that simulate two dimensional or three dimensional flow and transport. The models should be calibrated and suitable for steady state conditions.

MH_1-5: The hydraulic characteristics (e.g. transmissivity, storativity) should be obtained from tests at the site and previous work (if any) at the site. The hydraulic and concentration boundary conditions should be defined on the basis of observations at the site.

MH_1-6: Choose models that simulate the advective transport and radioactive decay of specific radionuclides expected to be released from the installation.

MH_1-7: Run the calibrated model for scenarios.

MH_1-8: Document whether contaminant concentrations are acceptable.

MH_1-9: If the results show that the concentrations of contaminants are significant, move to a higher complexity level of investigation and modelling (MH_2).

Medium hazard — Complexity level 2

MH_2-1: Conceptualize the hydrogeological system considering the heterogeneity and anisotropy of the flow domain. When site data are lacking, the anisotropy can be assumed such that horizontal hydraulic conductivity is ten times higher than vertical hydraulic conductivity. Delineate the boundaries of the flow domain to be modelled using the available data and geological map of the site at an appropriate scale. The boundaries should be set either at a hydrostratigraphical unit (i.e. aquiclude) or a hydrological element (i.e. river, lake or measured head).

MH_2-2: Consider only the saturated part of the flow domain and ignore the role of the unsaturated zone.

MH_2-3: Construct a simple conceptual hydrogeological model in two dimensions (cross-section and/or plane) or three dimensions (e.g. block or fence diagram). Oversimplification of the real conditions should be avoided.

MH_2-4: Select analytical models for flow and solute transport and justify that they fit the constructed conceptual model in terms of geometry of the flow domain, processes considered, parameters and boundary conditions. Alternatively, select numerical model codes that simulate two dimensional or three dimensional flow and transport. The models should be calibrated and suitable for steady state and transient conditions.

MH_2-5: The hydraulic characteristics (e.g. transmissivity, storativity) should be obtained from tests at the site and previous work (if any) at the site. The dispersivity (or hydrodynamic dispersion coefficient) should be obtained from the laboratory or in situ tests. The hydraulic and concentration boundary conditions should be defined on the basis of observations at the site.

MH_2-6: Choose models that simulate the advective and dispersive transport and radioactive decay of specific radionuclides expected to be released from the installation.

MH_2-7: Run the calibrated model for scenarios.

MH_2-8: Document whether contaminant concentrations are acceptable.

MH_2-9: If the results show that the concentrations of contaminants are significant, move to a higher complexity level of investigation and modelling (MH_3).

Medium hazard — Complexity level 3

MH_3-1: Conceptualize the hydrogeological system considering the heterogeneity and anisotropy of the flow domain. Special care should be taken to avoid oversimplification to ensure that the constructed conceptual hydrogeological model represents the real conditions. Delineate the boundaries of the flow domain to be modelled using the detailed geological mapping of the site at an appropriate scale. The boundaries should be set either at a hydrostratigraphical unit (i.e. aquiclude) or a hydrological element (i.e. river, lake or measured head). The boundary type should be defined and quantified from observations using appropriate techniques (e.g. piezometers) at the site.

MH_3-2: Consider only the saturated part of the flow domain and ignore the role of the unsaturated zone.

MH_3-3: Construct a detailed and representative conceptual hydrogeological model in two dimensions (cross-section and/or plane) or three dimensions (e.g. block or fence diagram). Oversimplification of the real conditions should be avoided.

MH_3-4: Use analytical models for flow and solute transport and justify that they fit the constructed conceptual model in terms of geometry of the flow domain, processes considered, parameters and boundary conditions. Alternatively, select numerical model codes that simulate two dimensional or three dimensional flow and transport. The models should be calibrated and suitable for steady state and/or transient conditions.

MH_3-5: The hydraulic characteristics (e.g. transmissivity, storativity) should be obtained from tests at the site and previous work (if any) at the site and/or from laboratory tests. The dispersivity (or hydrodynamic dispersion coefficient) and distribution coefficient should be obtained from the laboratory or in situ tests. The hydraulic and concentration boundary conditions can be defined on the basis of observations at the site.

MH_3-6: Choose models that simulate the advective, dispersive and sorptive (with retardation) transport and radioactive decay of specific radionuclides expected to be released from the installation.

MH_3-7: Run the calibrated model for scenarios.

MH_3-8: Document the results.

Reporting Stage 1: High hazard

High hazard — Complexity level 1

HH_1-1: Conceptualize the hydrogeological system considering the heterogeneity of the medium and assuming that the aquifer is isotropic. Delineate the boundaries of the flow domain to be modelled using the available data and geological map of the site at an appropriate scale. The boundaries should be set either at a hydrostratigraphical unit (i.e. aquiclude) or a hydrological element (i.e. river, lake or measured head).

HH_1-2: Consider only the saturated part of the flow domain and ignore the role of the unsaturated zone.

HH_1-3: Construct a simple conceptual hydrogeological model in two dimensions (cross-section and/or plane) or three dimensions (e.g. block or fence diagram). Oversimplification of the real conditions should be avoided.

HH_1-4: Select numerical model codes that simulate two dimensional or three dimensional flow and transport. The models should be calibrated and suitable for steady state and transient conditions.

HH_1-5: The hydraulic characteristics (e.g. transmissivity, storativity) should be obtained from tests at the site and previous work (if any) at the site. The hydraulic and concentration boundary conditions should be defined on the basis of observations at the site.

HH_1-6: Choose models that simulate the advective transport and radioactive decay of specific radionuclides expected to be released from the installation.

HH_1-7: Run the calibrated model for scenarios.

HH_1-8: Document whether contaminant concentrations are acceptable.

HH_1-9: If the results show that the concentrations of contaminants are significant, move to a higher complexity level of investigation and modelling (HH_2)

High hazard — Complexity level 2

HH_2-1: Conceptualize the hydrogeological system considering the heterogeneity and anisotropy of the flow domain. When site data are lacking, the anisotropy can be assumed such that horizontal hydraulic conductivity is ten times higher than vertical hydraulic conductivity. Delineate the boundaries of the flow domain to be modelled using the available data and geological map of the site at an appropriate scale. The boundaries should be set either at a hydrostratigraphical unit (i.e. aquiclude) or a hydrological element (i.e. river, lake or measured head).

HH_2-2: Consider only the saturated part of the flow domain and ignore the role of the unsaturated zone.

HH_2-3: Construct a conceptual hydrogeological model in three dimensions (e.g. block or fence diagram). Oversimplification of the real conditions should be avoided.

HH_2-4: Select numerical model codes that simulate three dimensional flow and transport. The models should be calibrated and suitable for steady state and transient conditions.

HH_2-5: The hydraulic characteristics (e.g. transmissivity, storativity) should be obtained from tests at the site and previous work (if any) at the site. The dispersivity (or hydrodynamic dispersion coefficient) should be obtained from the laboratory or in situ tests. The hydraulic and concentration boundary conditions should be defined on the basis of observations at the site.

HH_2-6: Choose models that simulate the advective and dispersive transport and radioactive decay of specific radionuclides expected to be released from the installation.

HH_2-7: Run the calibrated model for scenarios.

HH_2-8: Document whether contaminant concentrations are acceptable.

HH_2-9: If the results show that the concentrations of contaminants are significant, move to a higher complexity level of investigation and modelling (HH_3).

High hazard — Complexity level 3

HH_3-1: Conceptualize the hydrogeological system considering the heterogeneity and anisotropy of the flow domain. Special care should be taken to avoid oversimplification to ensure that the constructed conceptual hydrogeological model represents the real conditions. Delineate the boundaries of the flow domain to be modelled using the detailed geological mapping of the site at an appropriate scale. The boundaries should be set either at a hydrostratigraphical unit (i.e. aquiclude) or a hydrological element (i.e. river, lake or measured head). The boundary type should be defined and quantified from observations using appropriate techniques (e.g. piezometers) at the site.

HH_3-2: Consider only the saturated part of the flow domain and ignore the role of the unsaturated zone.

HH_3-3: Construct a detailed and representative conceptual hydrogeological model in three dimensions (e.g. block or fence diagram).

HH_3-4: Select numerical model codes that simulate three dimensional flow and transport. The model should be calibrated and suitable for steady state and transient conditions.

HH_3-5: The hydraulic characteristics (e.g. transmissivity, storativity) should be obtained from tests at the site and previous work (if any) at the site and/or from laboratory tests. The dispersivity (or hydrodynamic dispersion coefficient) and distribution coefficient should be obtained from the laboratory and/or in situ tests. The hydraulic and concentration boundary conditions can be defined on the basis of observations at the site.

HH_3-6: Choose models that simulate the advective, dispersive and sorptive (with retardation) transport and radioactive decay of specific radionuclides expected to be released from the installation.

HH_3-7: Run the calibrated model for scenarios.

HH_3-8: Document whether contaminant concentrations are acceptable.

HH_3-9: If the results show that the concentrations of contaminants are significant, go to a higher complexity level of investigation and modelling (HH_4).

High hazard — Complexity level 4

HH_4-1: Conceptualize the hydrogeological system considering the heterogeneity and anisotropy of the flow domain. Special care should be taken to avoid oversimplification to ensure that the constructed conceptual hydrogeological model represents the real conditions. Delineate the boundaries of the flow domain to be modelled using the detailed geological mapping of the site at an appropriate scale. The boundaries should be set either at a hydrostratigraphical unit (i.e. aquiclude) or a hydrological element (i.e. river, lake or measured head). The boundary type should be defined and quantified from observations using appropriate techniques (e.g. piezometers) at the site.

HH_4-2: Consider the saturated and the unsaturated zone of the flow domain.

HH_4-3: Construct a detailed and representative conceptual hydrogeological model in three dimensions (e.g. block or fence diagram) including the unsaturated zone.

HH_4-4: Select numerical model codes that simulate three dimensional saturated or unsaturated flow and transport. The model(s) should be calibrated and suitable for steady state and transient conditions.

HH_4-5: The hydraulic characteristics (e.g. transmissivity, storativity) should be obtained from tests at the site. Data from previous work (if any) at the site and/or from laboratory tests may also be used if consistent. The dispersivity (or hydrodynamic dispersion coefficient) and distribution coefficient should be obtained from in situ tests and laboratory tests. Reaction rate coefficients can be taken from literature or from laboratory tests. The hydraulic and concentration boundary conditions can be defined on the basis of observations at the site.

HH_4-6: Choose models that simulate the advective, dispersive, sorptive (with retardation) and reactive (if found significant) transport and radioactive decay of specific radionuclides expected to be released from the installation.

HH_4-7: Run the calibrated model for scenarios.

HH_4-8: Document the results.

EXPLANATION OF STEPS FOR REPORTING STAGE 2

A.18. This section describes the process depicted in Fig. 8 for Reporting Stage 2. This reporting stage includes the periodic validation of the models using the data obtained from the monitoring network and the revision of the conceptual model if necessary.

Reporting Stage 2: All hazard categories

S2-1: Collect the flow, head and quality data from the monitoring network at the site.

S2-2: Compare the observed data with those calculated by the models run to predict the future conditions.

S2-3: Document whether the model predictions are satisfactory.

S2-4: If the predictions are poor, revise the conceptual model.

S2-5: Check and revise the parameters and boundary conditions.

S2-6: Calibrate and run the model for steady state and transient conditions.

S2-7: Report and continue monitoring until the next period of validation.

EXPLANATION OF STEPS FOR REPORTING STAGE 3

A.19. This section describes the process depicted in Fig. 9 for Reporting Stage 3. This reporting stage includes the use of the validated model to predict the impacts during decommissioning, which may assist in developing suggestions for mitigating adverse effects, if any.

Reporting Stage 3: All hazard categories

S3-1: Identify and define any new source terms created by decommissioning activities.

S3-2: Identify and define any new boundary conditions created by decommissioning activities.

S3-3: Identify and quantify any alterations of hydraulic parameters.

S3-4: Run the validated model.

S3-5: Identify any adverse effects on water resources.

S3-6: Develop potential mitigation measures for any adverse effects and model their performance.

S3-7: Report the results.

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