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Written submission from Ontario Power Generation Inc.

Mémoire d'Ontario Power Generation Inc.

In the Matter of

À l'égard d'

Ontario Power Generation Inc., Pickering Nuclear Generating Station

Ontario Power Generation Inc., centrale nucléaire de Pickering

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Request for a ten-year renewal of its Nuclear Power Reactor Operating Licence for the Pickering Nuclear Generating Station

Demande de renouvellement, pour une période de dix ans, de son permis d'exploitation d'un réacteur nucléaire de puissance à la centrale nucléaire de Pickering

Commission Public Hearing
Part 1

Audience publique de la Commission
Partie 1

April 4, 2018

Le 4 avril 2018

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OPG Written Submission

in support of the renewal of Pickering's

POWER REACTOR OPERATING LICENCE

Securing Ontario's Clean Power Future

ONTARIO POWER GENERATION

CMD 18-H6.1 PART 1 HEARING April 4, 2018

Table of Contents

Executive Summary **4**

1. Introduction **7**

1.1 The Pickering Nuclear Generating Station 7

1.2 The Licence Renewal Application and Associated Requests 8

1.3 Key Considerations for Licence Renewal 9

1.3.1 Performance Highlights from the Current Licence Term 9

1.3.2 Nuclear Safety Improvements 11

1.3.3 Extended Commercial Operation 12

1.3.4 End of Commercial Operation (ECO) 14

1.4 Format and Organization of this CMD 17

2. The Case for Continued Safe Operation of the Pickering NGS **18**

2.1 Plant Safety Provisions Assure the Protection of the Public and the Environment 18

2.1.1 Defence in Depth 18

2.1.2 Nuclear Safety Analysis 23

2.1.3 Safety Enhancements 26

2.1.4 Emergency Preparedness 29

2.2 Pickering is Fit For Commercial Operation 33

2.2.1 Aging Management 34

2.2.2 Periodic Inspection and Testing 37

2.2.3 Maintenance 38

2.3 Qualified and Competent Staff will be Maintained to Ensure Safe Plant Operation Through to Shut-Down 38

2.3.1 Staffing Management 38

2.3.2 Ensuring a Qualified and Competent Workforce 39

2.3.3 Operational Staffing Policies 41

2.3.4 Safety Culture 41

2.4 Impacts of Pickering NGS Operation on the Public, Workers and the Environment Will Remain Low 44

2.4.1 Environmental Safeguards 45

2.4.2 Conventional Hazards: Environmental Monitoring 47

2.4.3 Environmental Protection: HHRA, EcoRAand Physical Stressors 47

2.4.4 Biodiversity and Wildlife Habitat Protection 49

2.4.5 Waste Management 50

2.4.6 Packaging and Transport of Radioactive Materials 51

2.5 Pickering NGS Will Continue to be Transparent and Engage with the Public and Indigenous Communities 52

2.5.1 Public Information Program 52

2.5.2 Engagement with Indigenous Communities 54

2.6 Continued Investments will Further Improve Pickering Safety, Reliability and Fitness for Service until 2024 56

3. Safety and Control Areas ... 58
3.1 Management System ... 58
3.2 Human Performance Management ... 58
3.3 Operating Performance ... 60
3.4 Safety Analysis ... 60
3.5 Physical Design ... 63
3.6 Fitness for Service ... 63
3.7 Radiation Protection ... 66
3.8 Conventional Health and Safety ... 68
3.9 Environmental Protection ... 69
3.10 Emergency Management and Fire Protection ... 73
3.11 Waste Management ... 74
3.12 Security ... 74
3.13 Safeguards and Non-Proliferation ... 75
3.14 Packaging and Transport ... 76
4. Other Matters of Regulatory Interest ... 77
4.1 Program for Cobalt-60 ... 77
4.2 Financial Guarantee ... 77
4.3 Nuclear Liability ... 77
4.4 Cost Recovery ... 77
5. References ... 78
Addendum A
Pickering Periodic Safety Review (PSR2) ... 79
Addendum B
Assurance of Fuel Channel Fitness For Service ... 98
Addendum C
Pickering Whole-Site Risk Assessment ... 114

Executive Summary

OPG is applying to the Canadian Nuclear Safety Commission (CNSC) for a 10-year renewal of its Power Reactor Operating Licence for the Pickering Nuclear Generating Station (NGS). The current licence expires in August, 2018, and the requested licence renewal would cover continued commercial operation through to the end of 2024, and transition to a safe storage state by 2028.

This Commission Member Document (CMD) summarizes the evidence that demonstrates the Pickering NGS meets all the legal requirements of the Nuclear Safety and Control Act and the associated Regulations, and that OPG is qualified to carry on the licensed activities and makes adequate provisions to protect the health, safety and security of persons and the environment, and maintain national security and measures required to implement international obligations.

OPG is proud of the strong performance and many significant achievements of the Pickering NGS during the current licence term. This track record is a testament to the diligence and passion for excellence that all personnel are committed to, each and every day, in support of the safe and reliable operation of the station. Pickering's longevity has afforded OPG with an abundance of valuable operating experience such that staff are intimately familiar with the plant's operational characteristics. The plant is not the same as it was when it first started to operate – it is better; the design and operation of Pickering NGS has significantly improved over the years, and the plant performance is getting even better. In fact, Pickering NGS heads towards the next licence renewal period with some performance measures that are the best ever in plant history. Following are some highlights of what has been accomplished at the Pickering NGS. These are just a few examples that demonstrate why the Commission and the public can be confident in the continued safe operation of Pickering NGS.

During the current licence term, Pickering NGS has continued to demonstrate strong conventional safety performance that is in the industry's top quartile. For instance, in 2014, Pickering reached 11 million hours without a single lost-time accident; and, in 2017, Pickering had its best-ever All Injury Rate with a remarkable value of 0.06. In November 2016, OPG received the Canadian Electricity Association's President's Gold Award of Excellence for Employee Safety in recognition of the company-wide All Injury Rate and Accident Severity Rate performance for 2013, 2014 and 2015. Furthermore, in each of 2015 and 2016, the station received the CNSC integrated plant rating of Fully Satisfactory (the highest rating from the regulator) based on the CNSC's evaluation of the 14 Safety and Control Areas.

Station reliability has improved significantly due to investments and improvements made over the licensing period. As a result, two of Pickering's units have had record operational runs - Unit 5 at 632 days and Unit 1 at 622 days. This can only happen because the plant is being maintained well. Combined with its best forced loss rate performance in site history (average of 4% over 2015 to 2017), Pickering NGS is continuing to achieve improved and more reliable operation, which in turn improves nuclear safety at the station.

Comprehensive safety analyses, both deterministic and probabilistic, confirm that the Pickering NGS design is robust and very safe. These analyses are within all safety analysis criteria and limits as well as below OPG's probabilistic safety assessment safety goals (severe core damage frequency and large release frequency for individual reactors). Moreover, in collaboration with industry, a first-of-a-kind whole-site risk assessment was performed to support that the overall risk of the entire Pickering site is low; this pilot work is at the forefront of international progress on probabilistic safety assessment.

As safe as Pickering NGS has been, nuclear safety has been enhanced over the current licence term with a number of significant safety improvements that OPG implemented, including physical plant improvements to safety systems, substantial investments to put in place emergency mitigating equipment (EME) Phase 1 and 2, and procedure improvements. The EME was utilized during a recent large scale emergency exercise, Exercise Unified Control (December 2017), which demonstrated the robustness of both on-site and off-site emergency preparedness measures.

Furthermore, an extensive Periodic Safety Review (PSR) was conducted in concert with the licence renewal application, and it has concluded that Pickering NGS has in place effective programs and processes for continued safe operation through 2024. Through OPG's Integrated Aging Management Program, appropriate maintenance, testing and monitoring are ongoing at Pickering NGS, with particular attention to major components such as fuel channels, assuring that the plant is fit-for-service and safe throughout the continued operating period. In addition, OPG is pursuing a number of plant modifications identified via the PSR process to further enhance the safety of the plant. Pickering NGS is safer today than it has ever been, and with the PSR modifications, Pickering NGS will be even safer during the next licence term.

OPG is particularly mindful of its social licence and the need to ensure protection of the public and the environment. OPG has an extremely strong track record in this area. OPG continues to demonstrate that the radiological releases into air and water from Pickering reactor operations are at levels that are far below regulatory limits and hence are protective of public health and the environment. The environmental monitoring program regularly samples water, air, and soil to ensure that both radiological and non- radiological emissions remain at safe levels. OPG posts the environmental monitoring results on its external website so that local communities and interested members of the public can verify the plant's safety. As a major achievement, Pickering NGS was recently issued a fish authorization by Fisheries and Oceans Canada, in recognition of the protective measures which OPG has undertaken for aquatic life and the participation in biodiversity and wildlife habitat programs. OPG will continue to show environmental stewardship in biodiversity and wildlife habitat programs. Pickering's performance will continue to improve, with the station priorities focusing on safety, reliability and human performance.

OPG also maintains strong relationships with local communities and with Indigenous groups. OPG recognizes that members of the public, stakeholder groups, and local communities have a legitimate interest in the operations of the Pickering NGS; the way in which it is operated and managed; and the means by which OPG keeps the risks to human health and safety, and to the environment, at a low level. OPG therefore shares information on facility operations and performance with members of the public, to enable interested individuals to monitor the safety of the plant and OPG's management record. OPG also works to develop positive relationships with local communities, including those in the vicinity of the Pickering facility and Indigenous communities, as well as with stakeholder groups that have a longstanding interest in the safety of nuclear power.

The transitioning of the station from commercial operation, at the end of 2024, to a safe storage state is being carefully planned. OPG has proven its ability to undertake such a transition with the successful safe storage of Units 2 and 3. Well-established procedures exist for the associated activities of reactor defueling and dewatering, as Pickering NGS utilizes these procedures during unit outages.

In its Licence Application submitted to the CNSC, Pickering made a set of six major commitments related to the continued safe and reliable operation of the plant through the requested licence term. These are:

- Nuclear safety will be assured such that plant personnel, the public and the environment are protected;
- Systems, structures and components at the plant are fit to continue commercial operation to the end of 2024, and inspection programs will ensure fitness for service during the next licence period;
- Staff are qualified and competent to operate the plant, and this will be maintained through the next licence period, including sufficient staffing numbers;
- Impacts of plant operation to the public, workers, and the environment will continue to be of low risk and adequately mitigated, while continuing to provide the various societal and environmental benefits of plant operation;

- Transparency and appropriate public and Indigenous engagement will continue; and
- OPG will continue to invest in Pickering to support the above objectives, including to improve equipment reliability, to assure fitness for service until the end of commercial operations, and to further enhance nuclear safety.

This CMD contains and references the information necessary for the Commission to make its decision associated with the licence renewal application. Following the Introduction, Section 2 explains the evidence that OPG is qualified to operate Pickering NGS with adequate attention to protection of the public, workers, and the environment, through management systems and programs that ensure that safety is the overriding priority in all activities at the station. This evidence is presented in terms of OPG's six commitments for safe and reliable operations through the licence term, listed above.

Section 3 consists of a brief description of each of the CNSC's Safety and Control Areas (SCAs), highlights strengths and noteworthy achievements in these areas, and updates information contained in the Licence Application to reflect 2017 results. Section 4 reviews some additional regulatory matters including the Cobalt-60 program and the Nuclear Liability Act.

Finally, further technical details on the Pickering Periodic Safety Review (PSR2), assurance of fuel channel fitness for service, and Pickering whole-site risk assessment are provided in three Addenda to the CMD.

1. Introduction

Ontario Power Generation (OPG) is applying to the Canadian Nuclear Safety Commission (CNSC) for a ten-year licence renewal to operate the Pickering Nuclear Generating Station (NGS), including continued commercial operation to 2024 and post-shutdown activities leading to a safe storage state. OPG is confident that Pickering NGS will remain fit for service and that Pickering Nuclear staff are qualified to continue to operate the plant with adequate provision for human health and safety as well as environmental, security and international obligation considerations over the next licence term.

OPG is pleased to present the evidence in support of its Licence Application in this Commission Member Document (CMD). The CMD summarizes and explains the science-based case for the relicensing of Pickering NGS. It reviews the various physical, operational, and programmatic provisions that together assure the safe operation of the station throughout the entire licence renewal period, while meeting or exceeding the applicable regulatory requirements, codes, and standards as well as respecting social concerns and expectations for safety and transparency. As such, this CMD contains and references the information necessary for the Commission to make its decisions associated with the licence renewal application.

1.1 The Pickering Nuclear Generating Station

The Pickering NGS is located on the north shore of Lake Ontario in the City of Pickering in Ontario. The station generates approximately 14% of the electricity needs of the province of Ontario, at low operating costs and with virtually no greenhouse gas (GHG) emissions. Under the Long Term Energy Plan of the Province of Ontario, the continued commercial operation of the Pickering NGS will ensure that Ontario has a reliable source of GHG-free baseload electricity to carry it through the refurbishment of the Darlington NGS and the initial Bruce NGS units.

As shown in the site map below, Pickering NGS has eight CANDU nuclear reactors that are arranged on two sides of the station, with separate control rooms on each side of the station. Six of these units, Units 1 and 4 and Units 5 -8, are operating and generating electricity. Another two (Units 2 and 3) are no longer operating and have been in the safe storage state since 2010. The operating reactor buildings are connected to a common vacuum building, a major component of the Pickering NGS safety systems.

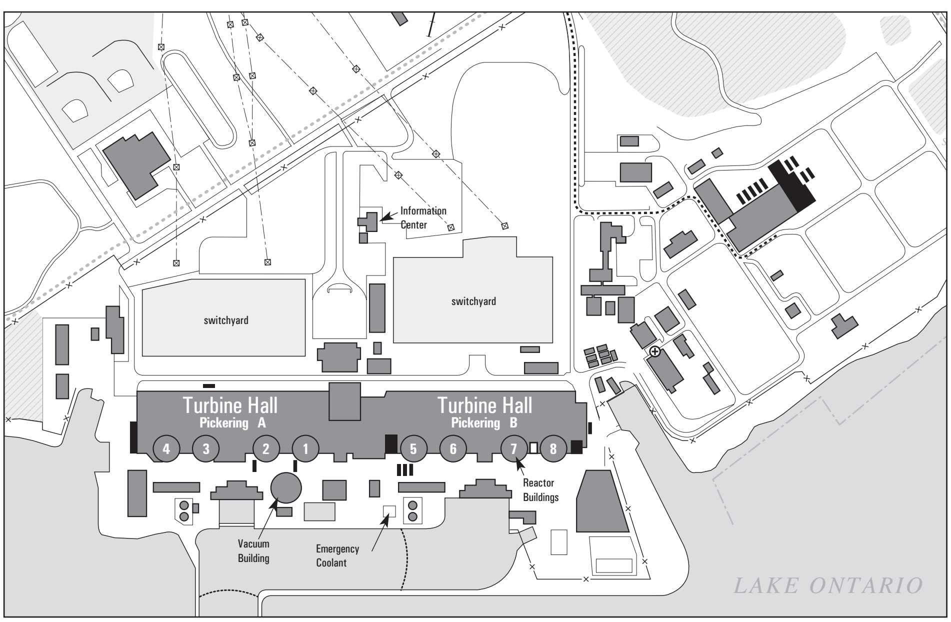


Figure 1 - Site map illustrates the main structures of the Pickering nuclear station

1.2 The Licence Renewal Application and Associated Requests

The current Pickering Power Reactor Operating Licence expires on August 31, 2018. As requested by the Province of Ontario in January 2016, OPG is pursuing the extension of Pickering NGS operations past 2020 to 2024 subject to the regulatory approval process. The requested ten-year licence renewal would encompass commercial operation to the end of 2024 as well as the operation of transitioning the reactors to a safe storage state by 2028.

A ten-year licence term is desirable and appropriate, for the following reasons:

- It would allow OPG to expedite the post-shutdown activities and ensure an efficient and smooth transition to safe storage;
- It would provide regulatory certainty for OPG's shareholder, the Province of Ontario, and rate payers;
- It is consistent with the ten-year time frame that is normally associated with a Periodic Safety Review in Canada (as this CMD discusses in more detail later, the Pickering NGS licence renewal request is supported by a comprehensive Periodic Safety Review, which is an internationally recognized process that is systematically performed in concert with licence renewals);
- It does not impact the effectiveness of the compliance program established by CNSC staff or the authority of the Commission to suspend, revoke or replace the licence, including establishing new licence conditions; and
- It does not preclude reviews and ongoing public scrutiny of plant performance before the Commission.

With the end of commercial operation on December 31, 2024, all units will be shut down, and the fuel and heavy water will be removed from the reactors to begin the safe storage phase, in preparation for eventual decommissioning. The continued commercial operation of approximately six years will be achieved with additional safety enhancements to further reduce the already low risk of plant operation, and with ongoing inspection, maintenance and investments to assure fitness for service. The timeline for the activities planned for the licence term is shown in Figure 2 below.

OPG submitted a full Pickering Nuclear Generating Station Power Reactor Operating Licence Application to the CNSC in August, 2017 (Reference 1) and is requesting a ten-year licence renewal from September 1, 2018 to August 31, 2028. OPG has also submitted supplementary Licence Application information to the CNSC in December, 2017 (Reference 2), in response to CNSC staff requests for further information on some parts of the Licence Application. These documents demonstrate that Pickering will continue to be operated safely through the requested licence renewal term, providing detailed evidence that OPG is qualified to carry out the licensed activities and make adequate provisions to protect the health, safety and security of persons, and the environment and maintain national security and international obligations. The Licence Application and supplementary information to the Application are available to the public on OPG's website, **www.opg.com**.

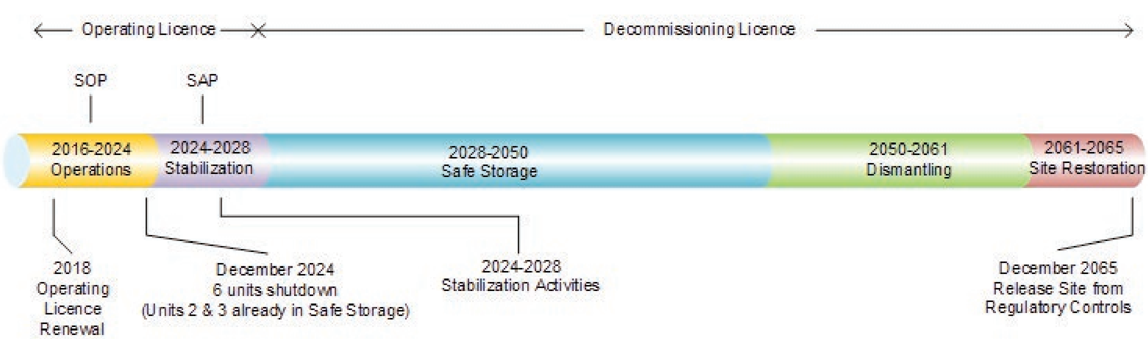


Figure 2 - Pickering long-term plan showing the Sustainable Operations Plan (SOP) and the Stabilization Activity Plan (SAP) within an extended timeframe

Associated with the Licence Application is a request for the Commission to approve the operation of the fuel channels in Pickering Units 5-8 beyond their current limit of 247,000 Effective Full Power Hours (EFPH) to 295,000 EFPH for the lead unit.

> EFPH is a measure of the age of the fuel channels. It captures only those times when the fuel is undergoing fission, i.e., the nuclear chain reaction process which changes the characteristics of the fuel channel.

This extended operational period corresponds approximately to the intended end of commercial operation (December 31, 2024).

The activities that OPG is requesting be licensed under the new licence term are noted in Appendix A of the Licence Application.

OPG is also requesting that the list of activities authorized under the renewed licence include the import and export of nuclear substances consisting primarily of contaminated laundry (See Reference 2). These activities were the subject of a previous licence amendment, which was approved in October, 2017.

1.3 Key Considerations for Licence Renewal

The use of nuclear energy and substances is regulated under the Nuclear Safety and Control Act (NSCA) to ensure the safe operation of nuclear power plants, through preventing unreasonable risk to workers, the public and the environment. The systems, structures and components, as well as the managed systems, are in place at Pickering NGS to ensure that safety is the focus and overriding priority of all operations at the plant. OPG is committed to safe and reliable operation of the Pickering NGS and continues to meet or exceed all of the legal requirements of the Nuclear Safety and Control Act and the associated regulations.

OPG Nuclear and Pickering staff recognize that they are accountable to manage the facilities in a way that ensures that Ontarians benefit from the electricity the plant produces, at minimal risk to public health and safety and to the environment.

OPG takes seriously its responsibility to protect against the risks that are associated with nuclear power, including risks to workers from routine plant operations, risks to the environment from leaks or other emissions, and risks to the public from an accident. OPG is proud of the excellent safety record of its nuclear power reactors, including Pickering, and continues to work hard every day to maintain and improve that record.

The rest of this Section summarizes the key factors that ensure the safe and reliable operation of Pickering NGS, and outlines important considerations related to the scope of the Pickering NGS licence renewal request. More detailed and additional supporting discussions are provided in Section 2 as well as the addenda to this CMD.

1.3.1 Performance Highlights from the Current Licence Term

During the current licence term, Pickering NGS has continued to demonstrate strong safety performance with a conventional safety performance rating that is in the industry's top quartile. In 2014, Pickering reached 11 million hours without a lost-time accident, and achieved its best-ever All Injury Rate of 0.06 in 2017. In November 2016, OPG received the Canadian Electricity Association's President's Gold Award of Excellence for Employee Safety in recognition of the company-wide All Injury Rate and Accident Severity Rate performance for 2013, 2014 and 2015.

Pickering has received a CNSC integrated plant rating of Fully Satisfactory (the highest rating possible) in 2015 and 2016, through CNSC's evaluation of the 14 Safety and Control Areas. Probabilistic safety assessments have demonstrated that the risk of operating Pickering reactors is low, and below safety goals with respect to severe core damage frequency and large release frequency. In addition, OPG completed a first-of-a-kind whole-site risk assessment of Pickering with the overall conclusion that the risk of the whole Pickering site is low.

In the last three years, using the "As Low As Reasonably Achievable (ALARA)" principles, the Pickering collective radiation exposure (the aggregate doses received by all workers) has been reduced despite an increase in the amount of radiological work being performed.

Operational reliability has improved significantly as a result of investments and improvements made over the licensing period, with Pickering's Units 5 and 1 having record operational runs at 632 days and 622 days, respectively, and with Unit 4 on the way to its longest operational run. Combined with its best forced loss rate performance in site history (average of 4% in last three years), Pickering NGS is continuing to achieve improved and more reliable operation. This demonstrates that the station is well maintained.

Human performance over the licensing period has also improved as a result of initiatives implemented under the human performance strategic plan (e.g., focus on fundamentals, proficiency, and the use of error reduction tools) and the ability of the Station Leadership Team to recognize weaknesses and address them.

Pickering leadership recognizes the need to strive for continual improvement and engagement of the work force. Pickering's mission is improved performance year after year, so that the station's best day of operation is its last day of operation. Pickering's vision for 2018 is to "work with a passion for excellence founded on safety and quality". Station priorities are focused on supporting Pickering's performance goals to continue to improve safety, reliability and human performance.

Pickering's leadership team has actively promoted and enabled innovation in safety and reliability during the current licensing period and will continue to do so in the future. OPG is confident that many more applications will be developed in the next few years. Improved station performance will be driven by these innovations, which include:

- The use of a robot to complete repair work, avoiding worker radiation exposure; and avoiding a forced outage;
- A Wireless Battery Monitoring System which provides on-demand information through a smart phone application, taking the place of existing battery-related preventive maintenance tasks.
- A technology lab has been established, making available innovative tools including 3-D printers and scanners, water jet cutters, virtual reality and augmented reality technology. The results include hardware improvements, such as 3-D printed parts for use in trouble-shooting, and models of parts for use in design drawings and to support more effective design improvements in the plant, and thus enhance safety. New computer programs have been developed to locate and discharge suspect fuel bundles more quickly and efficiently. This provides a radiation dose benefit to staff. In the area of radiation protection of staff, collective radiation exposure has been reduced through innovative shielding and the use of an industry-first gamma spectrometry camera that allows real-time data collection and thus early awareness of changing radiation fields and their source.

OPG's environment program continues to demonstrate that the radiological releases into air and water from Pickering reactor operations are at levels that are far below regulatory limits, and hence are protective of public health and the environment. The environmental monitoring program regularly samples water, air, and soil to ensure that both radiological and non-radiological emissions remain at safe levels. OPG posts the environmental monitoring results on its website so that local communities and interested members of the public can verify the plant's safety.

OPG has successfully operated a fish diversion system at Pickering Nuclear since October 2009 to protect aquatic species. In recognition of this system and OPG's habitat improvement projects that are underway, Fisheries and Oceans Canada recently issued a fish authorization for Pickering NGS in January, 2018 (Reference 3). This is a major achievement that speaks to OPG's responsibilities to protect the environment.

Furthermore, Pickering Nuclear has updated its Environmental Risk Assessment (ERA) which confirmed that human and ecological risks due to exposure to contaminants and physical stressors associated with Pickering NGS and its activities are low.

This supports the overall conclusion that the Pickering site operates in a manner that is protective of the environment and the public. The ERA is being updated to incorporate review comments from CNSC staff. The updated Pickering ERA will be posted on OPG's external website.

Regarding emergency preparedness, OPG distributed potassium iodide pills to the entire population in the primary zone (10 km radius) around Pickering NGS. OPG is partnering in the Durham Regional NextGen public safety radio system and has installed new radio system infrastructure at the site. This allows seamless integration and interoperable communications with City of Pickering Fire Service responders using their own radios in the powerhouse. Most recently, OPG (Pickering) completed Exercise Unified Control to further assess the emergency preparedness of OPG, as well as emergency response agencies at the local, municipal, provincial and federal levels. The exercise successfully demonstrated a number of new initiatives including a new dose assessment software, web access to plant emergency information, and the new radio system.

Pickering maintains healthy, open relationships and partnerships with stakeholders, including government, media, business leaders, educational institutions, interest groups, and community organizations. OPG also meets regularly with Indigenous communities to provide details of nuclear operations and reports, and discuss interests and concerns over current and future operations of the Pickering NGS.

In summary, Pickering NGS has a strong track record of safe and reliable operation over the current licence term, demonstrating the abilities and qualifications of OPG to carry on the licensed activities and make adequate provisions to protect the public, workers, and the environment.

1.3.2 Nuclear Safety Improvements

Thanks to its CANDU design, the accident mitigation capability of Pickering NGS has always been robust. Nevertheless, OPG has continuously looked for ways to enhance nuclear safety, including implementing improvements to the physical plant.

For example, an integrated safety review for Pickering Units 5-8 was completed in 2009 for continued operation of the station (Reference 4); as part of this review OPG committed to carry out safety enhancements and reliability improvements, and has completed them all.

More recently, following the events that occurred at the Fukushima Daiichi nuclear plant in 2011, OPG engaged with the international nuclear community and undertook comprehensive studies to consider the lessons learned from that accident. While these studies confirmed the robustness of the Pickering NGS design for the types of hazards that are characteristic of the site vicinity, they also led to important risk insights and to the implementation of further safety measures at Pickering NGS. Additionally, in 2014 OPG committed to a risk improvement plan that encompassed a combination of physical improvements, changes to operating procedures, and improvements to analysis methodology for Pickering, focusing on Pickering Units 1 and 4. Pickering has provided an annual update to the CNSC on the risk improvement plan, and significant risk reductions have been shown (Reference 5).

Some of the more notable enhancements to the Pickering NGS to improve nuclear safety include the following items:

- Improvements to safety significant equipment (e.g., Units 1, 4 standby generator protective relay upgrades and reliability improvements, and stack monitor replacements);
- Emergency mitigating equipment (Phase 1) consisting of portable pumps and generators for responding to an extended loss of all AC power;
- Emergency mitigating equipment (Phase 2) including the provision of large electrical generators to provide power to restore key equipment such as the Emergency Filtered Air Discharge System (EFADS) for containment filtered venting, containment air cooling units, and hydrogen igniters following a total loss of AC power;
- Establishment of Severe Accident Management Guidelines to support the response to a severe accident;

- Supply of emergency makeup water to refill the emergency coolant injection storage tank, for gravity feed into the Pickering NGS units' heat transport systems;
- Passive autocatalytic recombiners for enhanced post-accident hydrogen mitigation in containment;
- Installation of removable flood barriers (at the Pickering Units 1 and 4 Standby Generator Fuel Forwarding Building), to provide additional protection following an external flood; and
- On-line refueling of the auxiliary power system, to maintain its capability to continuously provide power in an accident; and
- Procedural updates to enhance containment venting capability through the EFADS in situations without electrical power.

In summary, while safety analyses demonstrate that the Pickering NGS design is safe, robust and that accident risk is very low, Pickering has strengthened its accident mitigation capability by continuing to incorporate nuclear safety improvements and the lessons learned from the Fukushima event. Upgraded equipment and procedures are in place, and have been incorporated into periodic drills and exercises for emergency response.

Moreover, additional nuclear safety enhancements, which will further reduce the already low risk of Pickering NGS, are planned for implementation as part of the Periodic Safety Review process (PSR, described further below). The additional physical plant enhancements include:

- Piping modifications on Pickering NGS Units 1 and 4 to provide make-up water to Units 1 and 4 calandria vessels, heat transport systems and steam generators to ensure continuous post-accident fuel cooling and protection of containment; and
- Changes to the existing firewater system to allow the firewater from Pickering NGS Units 1 and 4 diesel driven firewater pumps to supply Pickering NGS Units 5-8 through station interconnection to provide an independent source of water supply.

Pickering NGS has always been safe. With the currently implemented nuclear safety improvements (EME, etc.), Pickering NGS is better prepared to deal with emergency events thereby further reducing the risk to the public. With the planned PSR modifications, the Pickering NGS will be even safer.

1.3.3 Extended Commercial Operation

Periodic Safety Review

In support of plans to extend commercial operation of Pickering NGS to the end of 2024, OPG has conducted a Periodic Safety Review (PSR). A PSR is an internationally recognized process that is defined by the International Atomic Energy Agency and regulated in Canada by the CNSC. Periodic Safety Reviews are typically performed in concert with, and in support of, the licence renewal of a nuclear power plant; the PSR is highlighted here as a major element in support of Pickering NGS relicensing.

The objective of Pickering's PSR, referred to as PSR2 as it builds on previous assessments, was to confirm that the design, operation, structures, systems, and components (SSCs) support continued operation to 2024. The PSR2 is thus a forward-looking assessment, which focuses on changes to requirements since the last applicable assessment. The PSR2 also recommends reasonable and practicable safety enhancements to further reduce the already low risk of the plant.

In the PSR2 for Pickering, fifteen safety factors and two complementary reviews have been conducted, covering all factors that are important to the continued safe operation of the plant. It concluded that there are no fundamental safety issues and that OPG has in place effective programs and processes for continued safe operation of the Pickering NGS through to the end of 2024. The results have been summarized in Safety Factor Reports that have been submitted to the CNSC. The safety factor reviews also identify enhancements to OPG programs based on new CNSC Regulatory Documents and Canadian Standards Association (CSA) standards.

The enhancements identified in these safety factor reviews have been consolidated with proposed resolutions that were then prioritized and ranked based on safety significance.

The results have been addressed, reviewed by CNSC staff, and documented in the latest Global Assessment Report (GAR) that was submitted to the CNSC in February, 2018 (Reference 12). The GAR concludes that the current Pickering NGS design, operation, processes and management system will ensure continued safe operation of Units 1 and 4 and 5-8, both in the short term, and for operation to 2024. The GAR also recommends reasonable and practical resolutions that further enhance nuclear safety.

As the final step in the PSR process, the actions that support the resolutions in the global assessment, with target completion dates, are documented in an Integrated Implementation Plan (IIP) (Reference 13). The Pickering NGS IIP actions include the PSR2-related plant modifications, mentioned above, to further improve nuclear safety. The IIP also includes administrative, change control, and reporting requirements to ensure that the IIP actions are well managed at Pickering NGS. The Pickering PSR2 IIP was submitted to CNSC staff, for review and acceptance, on November 30, 2017 (Reference 13). CNSC review comments on this IIP have been received. The comments have been addressed by OPG, and the revised IIP was submitted to the CNSC in March 2018 (Reference 14). The revised IIP was subsequently accepted by the CNSC (Reference 15) and is being posted on **www.opg.com**.

The IIP represents OPG's commitment to continued improvement for safe and reliable operation of Pickering NGS.

In summary, the Pickering PSR2 has acknowledged and credited many actions that were already in progress to enhance safety and reliability. The PSR2 review found that managed systems and programs are strong, and confirms that there are no safety issues that would preclude continued safe operation of Pickering NGS through 2024. Additional initiatives under existing programs have been identified that will ensure safety and reliability are maintained and enhanced throughout the extended operations period to the end of 2024, and the actions within the IIP will further enhance nuclear safety. Addendum A to this CMD provides a more detailed description of the PSR2 process, results, and actions planned for Pickering NGS. Key PSR2 documents have been posted on OPG's external website.

Fitness for Service

The plant components at Pickering NGS are subject to gradual changes in condition as they age. For both safe and reliable operation of the plant, it is important to ensure that key components can continue to fulfill their intended functions and remain fit for service throughout the extended operating period. This is particularly true for the fuel channels, which contain the fuel bundles and ensure fuel cooling.

OPG has in place well established Fitness for Service (FFS) programs for major components that will ensure fitness for service is demonstrated until the end of commercial operation. OPG is confident that these programs demonstrate the continued fitness for service of major components and systems, structures and components important to safety. The life cycle management plans (LCMP) for the major components document the strategies and actions planned to facilitate demonstration of fitness for service of the components throughout the planned operating period.

Fuel Channels

OPG has assessed the operation of the fuel channels on all units and the assessment has shown there is a sufficient margin of safety on fuel channel fitness for service limits to assure safe operation beyond the current operating limit of 247,000 Effective Full Power Hours (EFPH), for the lead reactor unit. Fuel channel fitness for service was also assessed as part of the Pickering NGS PSR2, and associated IIP actions have been identified for implementation. Specifically, OPG assures the fitness for service of all units to the new target service life of December 2024 on the basis of sound technical reviews, the established programmatic controls within OPG for managing fuel channel aging, and the availability of mitigating measures where required. In terms of EFPH, fitness for service of the Pickering fuel channels is assured up to 295,000 EFPH for the lead unit, corresponding approximately to the end of 2024.

The condition of the fuel channel components is regularly monitored via inspection programs, consistent with the life cycle management approach used for all major components, ensuring that the fuel channel component conditions remain within the licensing basis and fitness-for-service criteria of the applicable standards (CSA N285.4 and N285.8). OPG has robust processes in place for responding to inspection or surveillance results should they not satisfy the prescribed acceptance criteria, and to address relevant operational experience that could impact fuel channel fitness for service, plant safety or operability. Should inspection results identify that a component cannot be demonstrated to be fit for service, that component will not be placed back in service.

Addendum B to this CMD provides more technical details on OPG's management of the aging mechanisms relevant to the Pickering fuel channels, as well as the ongoing and planned research and development (R&D) that provides the science-based evidence in support of the assurance of fuel channel fitness for service through 2024. In collaboration with the Canadian nuclear industry, OPG will continue to discuss fuel channel-related issues with CNSC staff to ensure regulatory expectations are met.

In summary, OPG is confident that the Pickering fuel channels will remain fit for service for continued commercial operation up to 295,000 EFPH for the lead Pickering unit, corresponding approximately to the intended end of commercial operation on December 31, 2024. The associated PSR2 action plan for the fuel channels as documented in the IIP will ensure the required actions are taken for continued fitness for service through to the end of 2024.

1.3.4 End of Commercial Operation (ECO)

With the end of commercial operation (ECO) part way through the requested licence term for Pickering NGS, OPG understands the need for various activities to be carefully planned in order to support not only the post-shutdown phase, but also the transition in the years before the plant is shut down; see Figure 3 below. These considerations are discussed in the Sustainable Operations Plan (SOP) and the Stabilization Activity Plan (SAP).

Sustainable Operations

OPG will continue to ensure safe, reliable operation of Pickering to the end of commercial operation. While processes will remain in place to ensure Pickering NGS is operated and maintained using sound nuclear safety practices, it is recognized that new challenges might be faced due to the transition from an operating station to the End of Commercial Operation. The SOP is pro-actively developed to address these challenges in advance of ECO.

The SOP is based on all of the 14 Safety and Control Areas (SCAs) as defined by the CNSC. OPG recognizes that safe operation is based on the maintenance of both a healthy safety culture and the programs associated with each of the 14 SCAs. The SOP documents actions and defines stand-alone supplemental measures to existing programs (arrangements, activities or actions) which will be implemented.

The SOP will be submitted to the CNSC five years before the permanent shutdown of the first unit at the Pickering NGS. A progress update will then be provided annually, in December of each year.

In 2016, OPG submitted a SOP to the CNSC based on an assumed end of commercial operations date of 2020. There are currently standalone supplemental measures in three SCAs with plans in development. These are in the areas of Organizational Change, Human Performance, and Maintenance and Reliability.

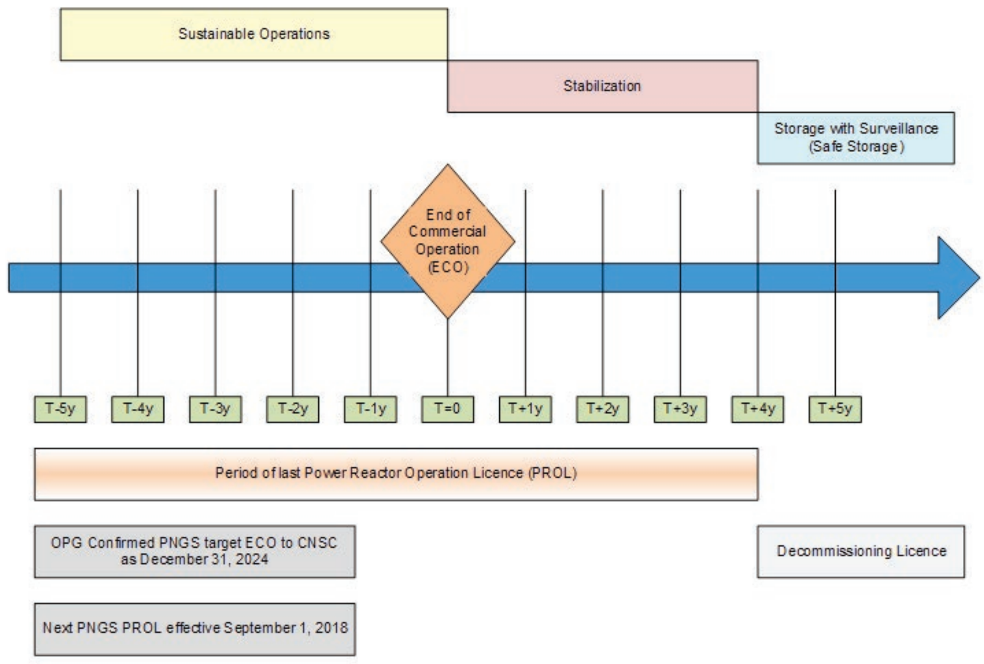


Figure 3 - Pickering ECO Life Cycle Overview

For Organizational Change, OPG will develop a plan to ensure that capable, competent staff remains at Pickering NGS through the transition to ECO, safe storage and decommissioning. This plan will include a change management plan which will look at the impacts of the Pickering shut-down on both Pickering operations and on the broader Nuclear and OPG organizations and staff. It will cover activities related to leadership alignment, engagement of staff, internal and external communications, training and development, assessing and managing impact on people, business policies, processes and practices, and business readiness. Oversight will be provided to monitor performance of the transition to the new organization and ensure continued safe operations.

The Human Performance Initiative involves maintaining continuous monitoring and improvement of human performance to minimize the likelihood of nuclear safety events throughout the transition to ECO. This will be achieved by systematically identifying and addressing situations that are likely to lead to errors, reducing organization vulnerability and by challenging the integrity of defenses. Initiatives within the program also include communications, field presence and surveillance to promote human performance improvement, as well as utilizing benchmarking of similar plants and internal operating experience to maintain or improve human performance while in transition to ECO.

The Maintenance and Reliability Strategy involves determining the maintenance plans and activities to be performed prior to and after the shutdown of the units. In order to ensure safe and reliable operation of each unit at Pickering, existing programs and procedures will be used for equipment maintenance and reliability strategies during the transition to ECO. Procedures and processes will ensure that all of the maintenance necessary to ensure safe and reliable operation up to the shutdown of each unit is identified, as well as the maintenance necessary to sustain the systems that will be relied upon during the stabilization and safe storage phases.

The SOP will point to existing programs and the results of these programs to demonstrate fitness for service while approaching the End of Commercial Operation. The SOP will include specific supplemental FFS actions to augment existing programs where it is determined that programmatic changes or stand-alone actions within existing programs are required to resolve unique challenges while approaching ECO. Any supplementary actions which are not covered under these three areas will be addressed in the SOP in order to support safe and reliable operation of Pickering.

In summary, nuclear safety will be assured through to the end of commercial operation and staffing levels and competency will be appropriately maintained, while maintaining reliable plant operation and protecting the public, workers and the environment. OPG understands the special considerations that need to be addressed as Pickering NGS approaches the end of commercial operation and is confident that the transition will be carried out safely and effectively.

Stabilization Activity

Preparation for Safe Storage includes the period leading up to the end of commercial operations as planning activities are carried out, as well as the execution of stabilization activities which will safely transition the Pickering NGS from its current electricity generating state to its Safe Storage State (SSS). The SAP documents OPG's planning efforts for the stabilization of the station and the SSS.

Stabilization involves defueling the reactors of spent fuel, dewatering systems containing heavy water, and removing from service the systems that are no longer required to support commercial operation of the station. Although the station will no longer generate power, an operational footprint will be required to continue to support operational and regulatory requirements, such as the storage and removal of fuel from the irradiated fuel bays, storage of heavy water, and ongoing monitoring and security activities.

The stabilization of the station from its current electricity generating state to its SSS will follow a phased approach, where the phases will be characterized by milestones in hazard reduction. The operational need for structures, systems and components (SSCs) at each phase will be determined by a thorough and systematic review process, considering both regulatory and system requirements across all 14 CNSC Safety and Control Areas.

The SSCs not required for the operation of the station in the SSS will be placed in a passive safe state. Fitness for service of the required SSCs will continue to be managed during the post-shutdown phase (e.g,. for the irradiated fuel bays).

OPG operating experience, particularly from Darlington Refurbishment and Pickering Units 2 and 3 safe storage, as well as benchmarking of local and international industry experience has been integral to informing preparations for safe storage and will continue to do so as planning efforts progress.

OPG will continue to provide periodic updates to the CNSC with regards to the preparations for the execution of the stabilization of the Pickering station. More information on the planning for stabilization of the station and the SSS can be found in the Stabilization Activity Plan (Reference 6). Information on the safe storage phase can be found in the Preliminary Decommissioning Plan (Reference 7).

To ensure the protection of human health and the environment, OPG undertook a Predictive Effects Assessment (PEA) to evaluate the potential for adverse effects to human health and the environment from the activities associated with transitioning the station from operation to a safe storage state. The PEA encompasses both the stabilization phase and the safe storage phase (that is, it looks beyond the requested licence term). The PEA report was submitted to the CNSC staff (Reference 8) and has been posted on OPG's external website.

Overall, the change from power generation to the stabilization and safe storage phases will result in reductions in emissions from the Pickering NGS. No interactions are predicted to pose an unacceptable risk to humans or the environment during the stabilization and safe storage activities. Therefore, no new mitigation is required, based on the conclusions of the PEA that there are no predicted potential adverse effects from the stabilization and safe storage activities.

During both the stabilization and safe storage phases, OPG's environmental programs will be maintained, and will be updated as needed.

Emission control measures and discharge limits are specified within specific permits. These permits and mitigation measures provided in the station design will remain in place until it can be demonstrated, in discussion with the regulator as applicable, that they are no longer required.

In summary, with the successful safe storage of Units 2 and 3, OPG has demonstrated its ability to carefully plan and carry out stabilization activities at the Pickering NGS. Given this proven experience and detailed planning, OPG is confident that it will effectively and safely perform the necessary stabilization activities to systematically place the remaining Pickering units in a safe storage state as planned in the requested licence term. Furthermore, this will be performed in an environmentally responsible manner with further reductions to the already low emissions and with adequate protection of the public, workers and the environment, and in compliance with all applicable regulatory requirements.

1.4 Format and Organization of this CMD

In presenting evidence in support of the licence renewal request, and as recommended by the CNSC guideline on CMD writing, this CMD has been prepared to address the interests and concerns of a wide range of audiences. Accordingly, it presents the main points of evidence for continued safe and reliable operation through the requested licence period at a relatively high level, and provides more detailed technical information on certain key topics in a set of addenda.

The CMD presents the information supporting the licence renewal request in two parts. The first, in Section 2, summarizes the evidence in terms of six key commitments that underpin the case for relicensing of Pickering NGS:

- Nuclear safety will be assured such that plant personnel, the public and the environment are protected;
- Systems, structures and components at the plant are fit to continue commercial operation to the end of 2024, and inspection programs will ensure fitness for service during the next licence period;
- Staff are qualified and competent to operate the plant, and this will be maintained through the next licence period, including sufficient staffing numbers;
- Impacts of plant operation to the public, workers, and the environment will continue to be of low risk and adequately mitigated, while continuing to provide the various societal and environment benefits of plant operation;
- Transparency and appropriate public and Indigenous engagement will continue;
- OPG will continue to invest in Pickering to support the above objectives, including to improve equipment reliability, assure fitness for service until the end of commercial operations, and to further enhance nuclear safety.

The second part, in Section 3, consists of a brief description of each of the CNSC's Safety and Control Areas (SCAs), highlights strengths and noteworthy achievements in these areas, and updates information contained in the Licence Application to reflect 2017 results.

Section 4 contains discussions on specific issues of interest including the Cobalt-60 Program, financial guarantee, Nuclear Liability insurance and cost recovery.

Finally, Addenda A through C provide more details and technical information on the Periodic Safety Review, Fuel Channel Fitness for Service, and Whole-Site Risk Assessment.

2. The Case for Continued Safe Operation of the Pickering NGS

As noted previously, in submitting its application for a power reactor operating licence renewal for the Pickering NGS to the CNSC in August, 2017, OPG presented a set of six commitments on Pickering NGS performance through the requested new licence term. These commitments encapsulate the main areas of responsibility that OPG bears to the public and to the CNSC; they acknowledge public concerns and expectations; and they reflect the necessary compliance with regulatory requirements related to safety and reliability of the plant.

The requirement that each commitment entails, and the evidence that OPG is meeting it and will continue to meet it through the requested licence term, are explained in the Sections that follow. Each Section includes a description of the ways that OPG meets the commitment, supported by technical background information where this is helpful for an understanding of the concepts and terms used. The information includes some important evidence from the Licence Application that demonstrates that OPG has met, and in many cases gone beyond, regulatory requirements related to each Safety and Control Area (SCA), and that it is qualified and prepared to continue to do so through the next licence period.

2.1 Plant Safety Provisions Assure the Protection of the Public and the Environment

Nuclear safety is the primary and driving consideration for activities carried out by all personnel working at the Pickering NGS. The Nuclear President and Chief Nuclear Officer is accountable to the CEO and the Board of Directors for establishing a management system that fosters the priority of nuclear safety through the entire organization. Guiding principles established by the Nuclear Safety Policy state that:

- Nuclear safety shall be the overriding priority in all activities performed in support of OPG nuclear facilities;
- Nuclear safety shall have clear priority over schedule, cost and production
- Everyone must demonstrate respect for nuclear safety and conduct themselves in a manner that is consistent with the traits of a healthy nuclear safety culture (this is described in Section 2.3, below).

These principles are continually reinforced at Pickering NGS and are internalized by all personnel (employees and contractors) who support the operation of the plant.

The functions and activities described in this Section relate primarily to the Physical Design SCA and Safety Analysis SCA, described in more depth in Sections 2.4 and 2.5 of the Licence Application, respectively; information on emergency preparedness relates to the Emergency Management and Fire protection SCA, which is discussed in Section 2.10 of the Licence Application, and the Security SCA, which is addressed in Section 2.12 of the Licence Application.

2.1.1 Defence in Depth

Nuclear reactors contain a large amount of radioactive material that is contained within the fuel, and that constitutes a unique hazard and a source of heat. For this reason, a deep respect for the reactor core is at the heart of safe reactor operation, not only when the reactors are operating at full power but also when they are shut down (as there is no "off switch" for the heat generation). Accidents can happen - and they have happened, as witnessed by the Three Mile Island, Chernobyl, and Fukushima events, and from which many important lessons have been learned and incorporated in nuclear plants worldwide to improve nuclear safety, including at OPG's nuclear stations. The Pickering NGS maintains a high degree of safety, and the risk of a nuclear accident is very low.

Essentially, the safety of the Pickering NGS is based on the Control, Cool, Contain principle, or "3 C's":

- **C**ontrol the reactor power
- **C**ool the fuel
- **C**ontain the radioactivity

This principle applies at all times under all normal and any abnormal conditions; whether the reactor is at power or shut down; whether the fuel is inside or outside of the reactors (as used fuel is removed from the reactor cores and stored in irradiated fuel bays for a number of years before eventually being transferred to dry storage facilities). The Control, Cool, Contain principle is a universally accepted cornerstone of the nuclear safety philosophy, which is rigorously met at Pickering NGS through the fundamental concept of Defence in Depth.

What is Defence in Depth?

Defence in depth is the provision of multiple and redundant "barriers" to protect the public, workers and the environment from the radiological hazards of nuclear power plant operation. Conceptually, these barriers include engineered structures and equipment (and multiple backups), and they also include people-based barriers such as administrative processes and procedures as well as training; such provisions are all elements of a defence in depth approach to assure nuclear safety.

The defence in depth philosophy involves multiple, overlapping barriers so that no single initiating event or failure at the plant would directly impact on human health and the environment; many barriers are in place to prevent that from occurring. Each barrier is treated as though it is the last or only one, and no barrier is allowed to degrade on the assumption that other barriers are present for protection.

As such, the defence in depth approach requires high quality in the activities of design, procurement, construction, operation and maintenance. The approach also recognizes that barriers may not be perfect and that occasionally, people can make mistakes or equipment may fail.

However, that is part of the underlying basis for the defence in depth philosophy – it compensates for such scenarios, should they occur, by ensuring that redundant barriers are in place to prevent or mitigate accidents. The defence in depth approach is applied extensively at Pickering NGS, and for each of the 3 C's.

There are five physical barriers in place at Pickering NGS to restrict radioactivity from reaching the public. These barriers include:

- The fuel itself (ceramic pellets) within which most of the radioactivity is trapped;
- The fuel sheaths within which the fuel pellets are enclosed;
- The heat transport system, which is composed of the fuel channels, piping, and vessels through which the reactor coolant circulates to cool the fuel and contain any radioactive gases that may escape from the fuel sheaths;
- The containment system, designed to house the reactors and contain any potential releases of radioactivity from the heat transport system; and
- The exclusion zone that surrounds the facility and provides distance to the public from any potential releases.

These barriers are an integral part of five levels of defence in depth for the overall design and operation of the Pickering NGS. This is an international principle of nuclear reactor safety that encompasses reactor design, components and equipment, and operation.

Five Levels of Defence in Depth for Pickering NGS

The first level of defence is to be able to maintain normal operating conditions and prevent any failure in structures, systems or components (SSCs). This is achieved through use of conservative design, adherence to high standards and following best industry practices in the design and analysis of the plant, and by the use of high-quality materials and equipment. Furthermore, to ensure that SSCs are available and reliable to carry out their intended design functions, they are tested, inspected and maintained on a regular basis.

Should the first level fail, the second level of defence in depth is in place to detect any deviations from normal operation. Although the deviations may still be within the "safe operating envelope" (where safety analysis has shown that plant operation is still safe), the control and safety systems are conservatively designed to intervene and return the reactor to the more restrictive, normal operating state so that a deviation does not escalate to an accident condition. These systems continuously monitor operating conditions (such as reactor coolant pressures, temperatures, and flows, and reactor power), and in the event of abnormal conditions, they function to return the reactor to normal operating conditions or safely shut down the reactor if necessary. These detection and control functions are carried out by systems made up of a number of independent, redundant, and diverse instruments and equipment in and around the reactors to ensure the full ranges of normal operating conditions are adequately monitored and controlled.

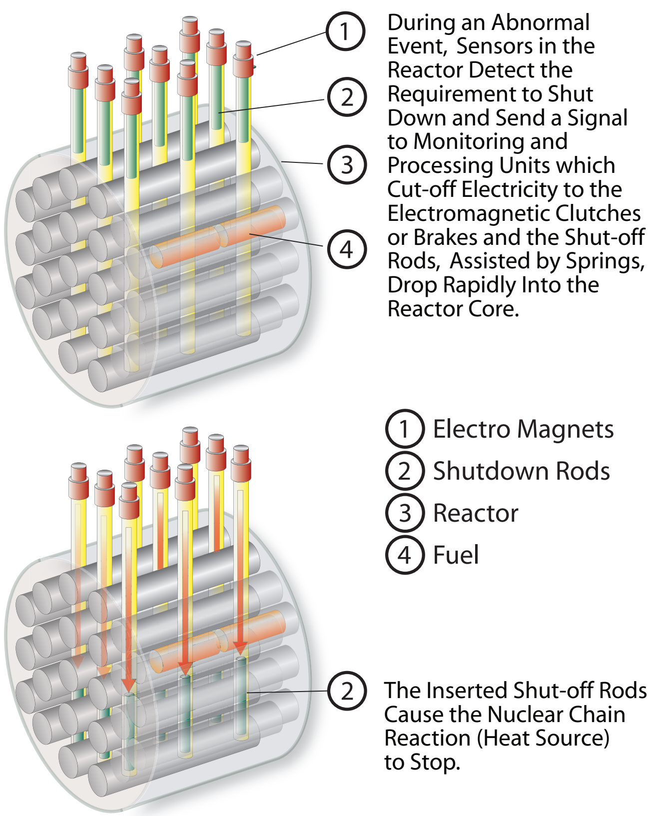


Figure 4 - Example of Pickering defence in depth level 3

Should both the first and second levels fail, and an accident occurs, then the third level is in place to activate systems specifically designed to mitigate a design basis accident (DBA); this is an event that engages special safety systems, and to which the reactor is designed to respond (described in the text box "What are Design Basis Accidents?", page 23). For example, if there were a large rupture in the piping of the heat transport system (HTS) at one of the Pickering reactors that led to a loss of coolant accident (LOCA), one of the two shutdown systems (SDS) would rapidly shut down the reactor and the emergency coolant injection system (ECIS) would automatically start up and inject cooling water into the HTS. These actions would ensure that the fuel inside the reactor core is adequately cooled and that any release of radioactivity outside of the reactor core is limited.

Safety systems, such as the SDS, ECIS, standby power and other water supplies, that are designed to mitigate DBAs, have built-in redundancy for reliability and allow for maintenance of the systems. There is more than one way to carry out any safety function (e.g., supply water or electrical power, or control reactor power) and the associated safety systems are designed to be independent of each other (Group 1 and Group 2 systems), with equipment that is physically separated and spaced in different locations around the plant (so that a single hazard, such as a fire, is unlikely to impact all the equipment needed for a safety function). Furthermore, the plant design typically uses diverse means of carrying out the same safety function so as to avoid a common deficiency; for instance, either shutoff rods or liquid "poison" injection can be used to rapidly shut down the reactors in Pickering B. In addition, there are "fail-safe" features, meaning that if a component in a system fails, it fails in such a way that does not interfere with the safety functions of the rest of the system.

The fourth level of defence is the containment system which is intended to limit any releases of radioactivity to the environment during an accident. The containment system includes the reactor buildings and the vacuum building to which the reactor buildings are connected. If any radioactive gases and steam were released into a reactor building, they would be drawn into the vacuum building where the steam would be condensed (thereby reducing pressure in the reactor building) and the radioactivity would be contained with no large releases to the environment.

It should be noted that the containment system at Pickering NGS is very robust and is not limited to mitigating DBAs. In the very unlikely scenario that the third level of defence in depth fails and the event progresses to a beyond design basis accident (BDBA) (i.e., an extremely unlikely event for which the station has not been specifically designed; see “What are Design Basis Accidents” page 23) – the containment system offers substantial capability to continue to limit off-site releases.

With respect to BDBA management, the Phase 1 emergency mitigating equipment (EME) at Pickering NGS (portable pumps and electrical generators installed as a result of post-Fukushima reviews) serves as an additional set of barriers to further strengthen defence in depth. There are two types of strategies for their use as part of the fourth level of defence:

- (Level 4A) via Emergency Mitigating Equipment Guidelines that focus on fuel cooling, if the design basis equipment is unable to achieve that, and on preventing the event from progressing to a severe accident; and
- (Level 4B) via Severe Accident Management Guidelines, which focus on both the protection of containment and fuel cooling if an event has progressed to a severe accident, and on stopping the progress of the severe accident.

The Phase 2 EME serves to restore power with a focus on further protecting containment and minimizing radioactive releases to the public. Specifically, Phase 2 EME provides emergency back-up power to important containment equipment, namely, boiler room air conditioning units to assist with post-accident pressure suppression; hydrogen ignitors to limit post-accident hydrogen concentrations to safe levels in containment; and the emergency filtered air discharge system (EFADS). These provisions serve to protect containment integrity and allow the use of the existing EFADS for controlled filtered post-accident venting of containment.

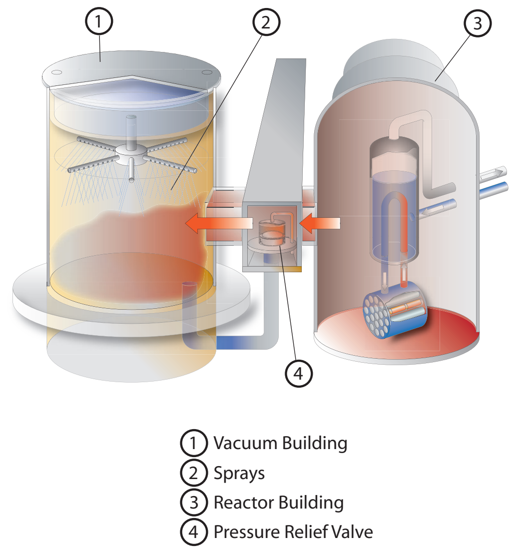


Figure 5 - Pickering containment system defence-in-depth level 4

Finally, in the highly unlikely event that all of the first four levels of defence in depth are breached, the fifth level of defence in depth provides both on-site responses and off-site protective measures that are associated with emergency preparedness (EP) provisions to mitigate the potential radiological effects of releases. This includes the possible sheltering and temporary evacuation of the local population, and the use of potassium iodide pills. The significant OPG efforts in support and strengthening of EP in the vicinity of Pickering NGS are discussed further in Section 2.1.4.

As a summary of the above plant provisions and defence in depth concepts, Figure 6 below depicts the various levels of defence in depth and the general type of equipment and documentation involved in responding to event progression. For Pickering NGS, multiple barriers to event progression, and multiple means to supply cooling water and electrical power, are in place to ensure adequate protection of the public and the environment, including for severe accident events.

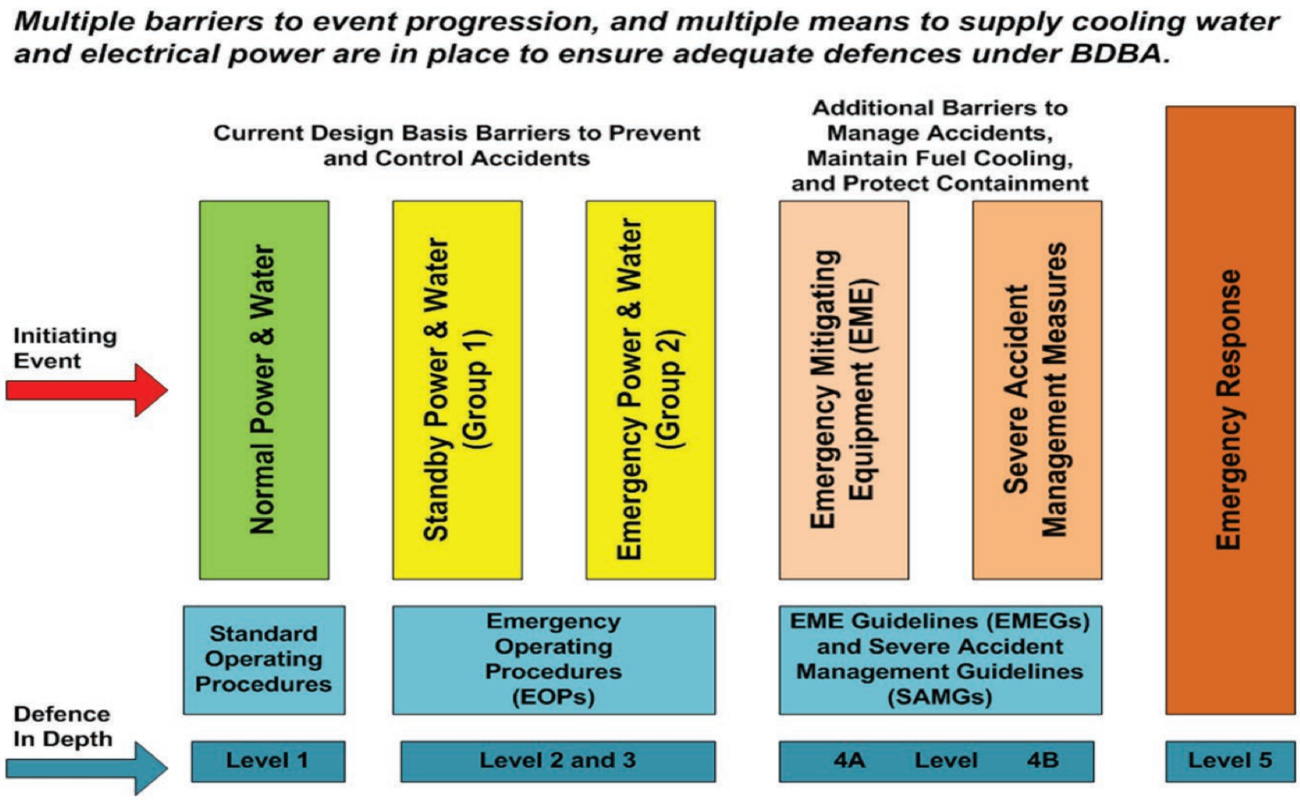


Figure 6 - Five levels of defence in depth with associated plant and administrative barriers.

What are "Design Basis Accidents", "Beyond DBAs", and "Severe Accidents"?

Design Basis Accident (DBA): Accident conditions and/or event sequences against which a nuclear power plant is designed and for which the damage to the fuel and the release of radioactive material are known and kept within authorized limits. DBAs are low frequency events.

Beyond Design Basis Accident (BDBA): Accident conditions and/or event sequences which are very low frequency events (and hence are not part of the design basis) and which are potentially more severe than Design Basis Accidents. A BDBA may or may not involve significant degradation of the reactor core.

Severe Accident (SA): A subset of BDBA where there is potential for a large release of radioactive materials (i.e. in excess of regulatory limits) due to the following:

- Significant fuel and/or reactor core degradation has occurred,
- Radioactive materials have been released into the containment system, and
- Containment failure has occurred or could occur.

As a result of the Fukushima accident, beyond design basis accidents and severe accidents have been assessed for Pickering NGS. While these events remain extremely unlikely to occur, prevention and mitigation measures such as additional equipment and procedures have been implemented as a precautionary measure.

2.1.2 Nuclear Safety Analysis

OPG's safety analysis programs play a key role in supporting the plant safety provisions and the overall safety of the plant, as provided through the functions of controlling reactor power, cooling the fuel, and containing or limiting any releases from the plant. The basic types of safety analysis are deterministic and probabilistic. These serve different purposes but are complementary.

Deterministic Safety Analysis (DSA)

Deterministic safety analysis has been extensively used from the inception of the Pickering NGS design, and is a key tool for supporting the adequacy of the plant safety provisions. It is also integral to supporting the defence in depth approach (through to Level 5). DSA uses validated scientific models and conservative assumptions to analyze the response of the reactor and other plant systems to hypothetical abnormal or accident conditions, and assesses the potential consequences.

The applications of DSA include:

- Helping to demonstrate the effectiveness of the plant safety provisions used to mitigate design basis events;
- Showing that DBA licensing requirements are met (i.e., public dose limits);
- Helping to define the acceptable range and limits of plant operating conditions (safe operating envelope);
- Assisting in the design or modification of DBA equipment; and
- Providing information about accident consequences for use in probabilistic safety assessment (PSA).

The Pickering NGS DSA is governed by OPG's Reactor Safety Program and is periodically updated and submitted to CNSC staff. For Pickering NGS, the DSA demonstrates that adequate safety margins are in place for design basis events.

Of particular note, as the aging of the heat transport system may have an impact on safety margins, additional focus has been given to this aspect in the DSA. Deterministic safety analyses have been completed for several future aged condition accident scenarios for all Pickering units. The effects of aging of the Pickering reactors are managed effectively and OPG will ensure that safety analysis margins are maintained through to the end of commercial operation.

Probabilistic Safety Assessment (PSA)

PSA has long been an important tool for assessing and managing nuclear power plant risk, and it is another key tool used to support the adequacy of the plant safety provisions. It too is integral to supporting the defence in depth approach (up to Level 5).

PSA answers three questions:

- What can go wrong?
- How likely is it?
- What are the consequences?

This is accomplished through detailed modelling of a reactor and the various supporting plant systems, and by conducting a systematic assessment of the possibility and consequences of incidents initiated by system failures or other events. In so doing, PSAs realistically simulate accident scenarios and potential system performance, and enable the identification of vulnerabilities in the plant so that nuclear safety can be enhanced through plant design modifications or changes to operating procedures, thereby further reducing the likelihood of an accident and its potential outcome.

PSAs are conducted separately for internal and external types of hazards, in particular for internal events, internal fires, internal floods, seismic hazards, and high wind hazards. Many other hazards are also examined and addressed as part of the PSA hazard screening process (in the process, some hazards – meteorites, for example – are deemed to be of such low likelihood that they were screened out, and not developed into PSA models).

Furthermore, the PSAs consider both 100% full-power operating conditions as well as outage conditions, in which a reactor is shut down with some equipment taken out of service.

Following are some examples of the valuable and practical uses of PSA:

- To identify safety improvements in the station design and operation;
- To understand the effects of different plant configurations and test the effects of alternate safety measures;
- To support operational decisions, for example, to assess the consequences of taking equipment out of service for maintenance, during normal operation or planned maintenance outages (this assessment determines if modifications to scheduled activities are required to reduce the risk levels of the activities);
- To provide insights into the important contributors to risk, i.e., the main initiating events that contribute to risk, and into the relative risk benefits of the different systems and components that are used to mitigate accidents (both these types of insights serve to help raise awareness and prioritization of safety-significant activities at the station); and
- To provide information about the likelihood of hypothetical events for use in the DSA (as such information is considered in determining the methodology and analysis rules to use for the different events analyzed by DSA).

The Pickering NGS PSAs are governed by OPG's Risk and Reliability Program and are updated periodically and submitted to CNSC staff. In addition, OPG's PSA methodology is subject to CNSC acceptance.

Of particular interest, the PSAs provide quantitative estimates of risk in the form of calculated risk metrics for each hazard type, for comparison to OPG's PSA safety goals. OPG's PSA safety goals are used as targets to help ensure that the overarching objectives around protection of the public and the environment are met.

This is achieved by limiting the likelihood of certain undesired consequences, namely, severe core damage and large off-site releases. As such, the OPG PSA safety goals are expressed in terms of a frequency with which severe core damage or a large release might occur for an individual reactor unit. That is, the safety goals are applied on a per-unit, per-year basis. To help manage risk, the safety goals are set at very low values:

- Severe core damage frequency (SCDF) should be less than 1 in 10,000 per reactor, per year;
- Large release frequency (LRF) should be less than 1 in 100,000 per reactor, per year.

These safety goals are aligned with international norms and CNSC safety goal definitions.

What do SCDF and LRF mean?

The SCDF value represents the probability of a severe core damage accident occurring in the next year – with the goal being less than 1 in 10,000.

It is a "measure" of the plant's severe accident prevention capabilities (i.e., roughly associated with the effectiveness of Level 4A of defence in depth, Figure 6).

Similarly, the LRF value represents the probability of a large-release accident occurring in the next year – with the goal being less than 1 in 100,000. Note: The probability of a radiological health effect on the public from a large-release accident is even lower still.

LRF is a "measure" of the plant's severe accident mitigation capabilities (roughly associated with the effectiveness of Level 4B of defence in depth, per Figure 6).

Whole-Site Risk Assessment

As discussed above, DSA and PSA are complementary analytical tools used to support the adequacy of plant safety provisions and to help demonstrate that plant risk is low.

These methods tend to focus on individual reactor units, while also taking into account possible interactions and effects associated with other reactors on the site. For instance, the current PSAs, and safety goals, are based on individual reactor units.

An action was placed on OPG to characterize and evaluate the overall risk of an entire nuclear power plant site, including the multiple reactor units at a station ("multi-unit" risk), other sources of radioactivity on the site (such as irradiated fuel bays), internal and external hazards, and reactor operating modes other than full power and outage states. This is referred to as "whole-site" risk. It should be noted that there is no international consensus yet on whole-site risk assessment methodology.

Arising from the 2013 relicensing of the Pickering NGS, the Commission requested that a whole-site PSA methodology be developed to estimate the Pickering whole-site risk. OPG has since led the development of a whole-site risk assessment in concert with owners and operators of other CANDU reactors. A comprehensive and first-of-a-kind, pilot study was conducted for the Pickering whole-site risk assessment. The work was submitted to CNSC staff in December 2017, and OPG presented a summary to the Commission on December 14, 2017.

Site risk has always been considered and managed at Pickering; nonetheless the pilot study enabled OPG to revisit the topic from a fundamental and holistic perspective, and to better characterize whole-site risk. The salient points from the work on Pickering whole-site risk assessment are noted below, and more details on this assessment can be found in Addendum C.

- The overall evaluation of whole-site risk involves the consideration of both qualitative and quantitative information that informs the judgement of risk. This includes many factors within a broad perspective that encompasses various programmatic, deterministic, and defense in depth considerations, as well as PSA.
- The traditional OPG PSAs have always been "multi-unit" PSAs in that they explicitly account for multi-unit interactions, even though the PSA results are expressed on a per-unit basis.

- Whole-site PSA is an important tool that supports whole-site risk assessment. The Pickering whole-site PSA has identified some additional risk insights, particularly around the understanding of the relative contributions of purely single vs. multi-unit risks and of the relative risk of different hazards from a site perspective.
- As part of the whole-site PSA approach, the per-unit based PSA results have been carefully combined to more fully quantify PSA risk metrics for each hazard and across all units on site (the "per-site" LRF results are shown in Table 1).
- The risks associated with other on-site sources of radioactivity, such as the irradiated fuel bays, as well other (lower power) modes of reactor operation, have also been systematically assessed.

It is important to note that whole-site risk should not be characterized by a single number, and the simple addition of risk estimates across all hazards is not technically appropriate.

Nonetheless, the calculation is straightforward and has been performed for Pickering NGS: the total per-site LRF is 0.82 x 10^{-5}/yr, as shown in Table 1. This is a very impressive result as it is better than the current LRF safety goal of 1 x 10^{-5}/yr – which is defined on a per-unit basis (i.e., the target for which individual reactor units are assessed against, for each hazard) and was not intended for site- based results that encompass all reactor units and all hazards.

The overall conclusion from the pilot study is that the Pickering whole-site risk is very low.

2.1.3 Safety Enhancements

As discussed in Section 1, OPG has continuously looked for ways to enhance the plant safety provisions at Pickering. These efforts have incorporated (a) enhancements that are identified as part of OPG's ongoing programmatic activities, including (b) lessons learned from incidents and operating experience elsewhere, as well as (c) other initiatives.

For instance, with respect to item (a) above, the Risk and Reliability Program requires that a risk improvement plan be developed and implemented to decrease the per-unit SCDF and/or LRF to the extent practicable if the calculated per-unit SCDF or LRF values are below the per-unit PSA safety goals but above the more stringent per-unit Administrative Safety Goals that are also in place at OPG (these are a factor of 10 lower than the PSA safety goals). As mentioned in Section 1, such a plan exists for Pickering NGS, with a focus on the Pickering Units 1 and 4.

Hazard	Large Release Frequency (x 10^{-5} per year)
	per site
Internal Events	0.18
Internal Floods	0.07
High Wind	0.31
Internal Fires	0.17
Seismic	0.09
Total	0.82

Table 1 – Pickering NGS LRF summary. Numbers show expected frequency per 100,000 years of an accident caused by each hazard

With respect to operational experience (item (b)), the substantial enhancements implemented at Pickering NGS in response to the Fukushima accident are a prime example. These enhancements, such as Phase 1 EME, are also captured as part of the Pickering risk improvement plan.

Other initiatives (item (c)) include the additional plant modifications being pursued via the IIP actions associated with the recent Periodic Safety Review (PSR2).

To further drive improvements, OPG has set more challenging expectations through the per-unit Administrative Safety Goals. With the post-Fukushima improvements, Pickering NGS Units 5-8 already met the Administrative Safety Goals on a per-unit basis for all hazards. While the Pickering NGS Units 1 and 4 large release frequency values are already better than the per-unit PSA safety goal, OPG is endeavoring to further reduce the Pickering NGS Units 1 and 4 risk such that the more challenging Administrative Safety Goal is also met for all hazards on a per-unit basis. Section 1 highlighted a number of the key improvements to enhance the plant safety provisions at Pickering and enable the risk reduction.

Figure 7 illustrates the very significant progress and ambitious efforts to drive down the already low Pickering 1, 4 estimated per-unit risk, from the pre-Fukushima to post-Fukushima plant safety provisions, and to the post-IIP improvements. The pre-Fukushima results are representative of the station prior to the installation of modifications to address lessons learned from the Fukushima event. The post-Fukushima results are representative of the station upgrades and risk modelling improvements associated with OPG's follow-up to the Fukushima event. The post IIP estimate results are representative of the station after the PSR committed fire water supply to the Pickering 1, 4 steam generators, heat transport system and moderator are installed.

The risks associated with the operation of Pickering NGS are lower today than in the past and with the implementation of the PSR2 enhancements will be even lower.

As confirmed by the Pickering PSR2, there are no safety issues that would preclude continued safe operation of Pickering NGS through 2024.

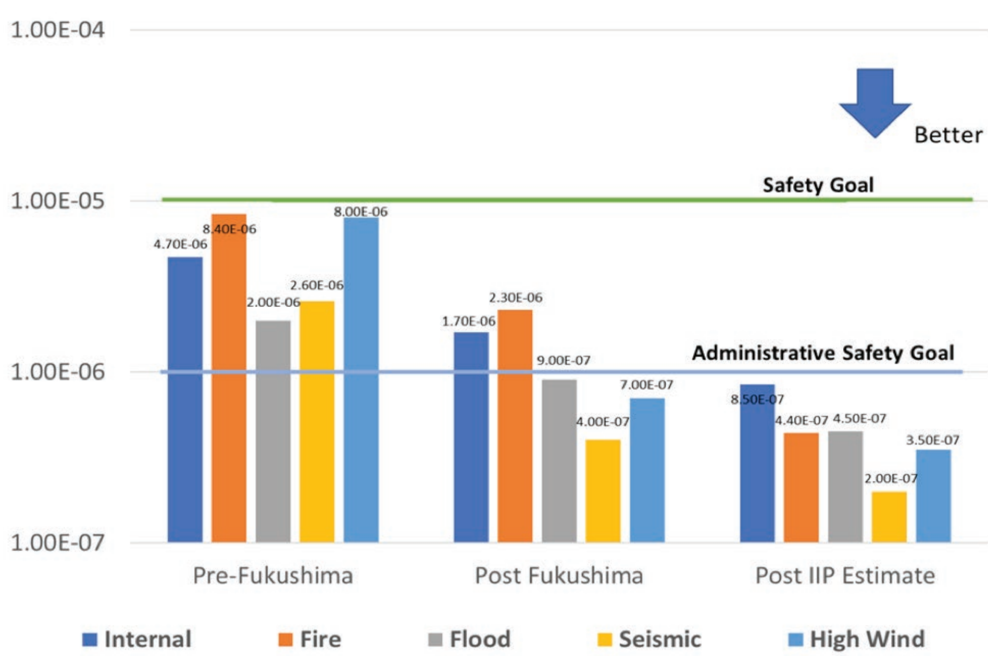


Figure 7 - Pickering NGS Units 1 and 4 reduction in estimated per-unit LRF

Beyond Design Basis Accident (BDBA) Containment Protection

From an integrated public risk perspective, OPG concludes that the most effective means of protecting containment and minimizing large releases resulting from a BDBA is to prevent an accident from progressing to the point of challenging containment.

OPG has in place comprehensive probabilistic safety assessments (PSAs) for Pickering NGS 1, 4 and Pickering NGS 5-8 that demonstrate that the likelihood and public risk from a serious accident remains very low. Nonetheless, OPG continues to invest to further enhance safety at its nuclear facilities, as demonstrated by OPG's post-Fukushima actions that are intended to prevent an accident progressing to a severe accident following a BDBA. Specific safety enhancements include:

- Completion of hydrogen passive autocatalytic recombiners (PARs) installations in all Pickering units;
- Provisions for Phase-1 emergency mitigation equipment (EME) to provide emergency make-up water and power for ensuring continuous fuel cooling and monitoring. (See Figures 8 and 9);
- Completion of Severe Accident Management Guidelines (SAMGs) to provide plant staff with guidance on prevention and mitigation of accident progression to a severe accident;
- Completion of Phase-2 EME provisions that provide emergency back-up power to important containment equipment (boiler room air conditioning units and hydrogen ignitors on all units to protect containment integrity allowing the use of the existing emergency air filtered discharge system (EFADS) for controlled filtered post-accident venting of containment).

The purpose of a containment filtered venting system is to reduce large radiological releases following a BDBA by providing a provision for controlled filtered containment venting. At Pickering NGS this capability is achieved through use of the existing EFADS.

As committed in the PSR2 IIP, modifications are scheduled for implementation that are intended to further enhance safety by providing additional barriers that prevent BDBA progression to a severe accident, specifically;

- Provisions for emergency make-up of water to the calandria vessel, heat transport system and steam generators on Units 1, 4 to provide post-accident fuel cooling, thereby limiting radiological and environmental conditions within containment.

The modifications that are currently being implemented and committed in the IIP will minimize the likelihood of a large release by providing additional barriers to prevent accident progression, thereby protecting containment.

The design of the Pickering containment system minimizes post-accident radiological releases by its thick concrete structure that is maintained at negative pressure through use of the vacuum building and in the longer term, the EFADS.

The Pickering EFADS is comprised of multistage filters, a demister stage to remove most of the radionuclide-bearing water aerosols, high efficiency particle absorption (HEPA) filters to remove micron and submicron aerosols, and a charcoal filter to remove volatile radionuclides like iodine.

Although originally designed for design basis accidents, the Pickering EFADS can be also be used following a BDBA. There are two options for using EFADS post-BDBA. For the first option, operator procedures are currently in place for manually opening inlet valves to EFADS in the absence of electrical power. The second option allows EME-Phase 2 to restore power to the EFADS. Both options will allow controlled filtered venting of containment in the extremely unlikely event of a multi-unit BDBA.

2.1.4 Emergency Preparedness

As the fifth and final level of defence in depth, emergency preparedness provides a highly robust means of contending with any accident scenario and protecting the public. Pickering NGS has effective emergency response and fire protection programs that ensure a rapid and effective response to fire and conventional emergencies, as well as nuclear emergencies.

These programs consist of plans and full preparedness capabilities and activities, including frequent drills and exercises. These plans are integrated with plans and training with local municipalities, the Region and the Province of Ontario.

Fire Protection and Conventional Emergency Preparedness and Response

The OPG Fire Protection Program includes measures and activities to prevent fires, and to detect and suppress any fires that may occur at the Pickering plant. The Pickering Fire Protection Section includes specially trained staff and standardized emergency response procedures, equipment and training. Continued training for Emergency Response Maintainers (ERMs) is required, and team and individual performance is documented and evaluated yearly. Training has been enhanced through the use of field training simulators at the Wesleyville Fire and Rescue Academy, which is owned and operated by OPG.

Fire protection capability at OPG is integrated with City of Pickering fire services through a Memorandum of Understanding that defines the mutual responsibilities of each party and provides additional OPG resources for training of emergency response staff, and for dealing with major incidents. Pickering Fire Services and Pickering Nuclear Fire Protection staff participate in joint Incident Command Training, and in joint live fire training at Wesleyville each year, strengthening the working relationship and capabilities of both sides.

Nuclear Emergency Preparedness Program

The OPG Nuclear Emergency Preparedness Program ensures that OPG has adequate provisions for the nuclear preparedness and response capability to mitigate the effects of releases of radioactive material during postulated accidents. The program describes the structures, roles and processes that would be necessary to implement an effective OPG response to a nuclear emergency. It also provides a framework for interaction with external authorities and describes OPG's commitments under the Ontario Provincial Nuclear Emergency Response Plan (PNERP). OPG has completed many program enhancements, which ensure the program conforms with regulatory requirements including CNSC Regulatory Document 2.10.1.

An effective response to a nuclear emergency requires the use of some specific equipment. To ensure that necessary equipment is available to respond to a nuclear emergency, the Equipment Important to Emergency Response (EITER) program has been implemented. This program involves the identification of equipment that is required in a nuclear emergency response, as well as back-up equipment. EITER requirements are integrated into work management for planned maintenance activities as assurance that the equipment is available.

Substantial upgrades to the station emergency mitigating equipment (EME) have been undertaken including implementation of Phase 2 EME, which improves response to beyond design-basis events, and mitigates the risks of severe accidents.

Licensees are required to have real- time radiological detectors around the perimeter of their nuclear facilities, and communicate the results to the offsite authority and CNSC. OPG has real time fixed radiological detection and monitoring devices operating around the perimeter of the Pickering nuclear facility. These devices are equipped with appropriate backup power and the information is automatically available to off-site authorities in the event of an emergency.

OPG installed and implemented a new emergency personnel accounting system within the Pickering NGS protected area. The system utilizes access card scanners to enable efficient accounting of all staff on site during an emergency. This system is an effective enhancement to the safety of station staff, and the process is exercised annually through drills.

OPG implemented a program at Pickering to ensure that in the event of an extreme external event that requires essential staff to be sequestered at site, there are adequate supplies to sustain them. There are 72-hour emergency supplies that provide food, water, hygiene and sleeping requirements until outside aid can be brought in. Radiation Personal Protective Equipment (RPPE) is also maintained to ensure a 72- hour independent emergency response.

OPG, the Province, and local municipalities have clearly defined roles for responding to emergency events and protecting the public. The OPG planned exercises test and strengthen these partnerships.

Drills and Exercises

Drills and exercises are an important aspect of the OPG emergency preparedness program. The conduct of vigorous drills and exercises at OPG, based on an all-hazards approach, is a critical component of maintaining this robust emergency management capability. The all-hazards approach considers technological and human-caused hazards. Pickering NGS maintains an extensive exercise program that includes the planning and conducting of drills and exercises, and critical evaluation to learn from them and drive improvements.

For example, the "Exercise Unified Response" in 2014 tested and practised the effectiveness of the integrated emergency response of OPG and agencies at the federal, provincial and municipal levels to respond to a simulated nuclear event that included an off-site radiological release at the OPG Darlington station. This exercise involved more than 2000 participants in 54 agencies over a three-day period, and demonstrated the successful integration of nuclear response plans at all levels of government. Most of the participants would fulfil similar roles in an event at the Pickering station.

In 2015, OPG conducted an exercise based on a simulated severe accident event that involved multiple reactor units at the Pickering station. Though this type of event is extremely unlikely, the exercise was designed to test OPG's ability to respond to a large-scale event using the emergency mitigating equipment.

Exercise Unified Control

Most recently, in December 2017 OPG (Pickering) completed Exercise Unified Control (ExUC) to further assess the emergency preparedness of OPG, as well as emergency response agencies at the local, municipal, provincial and federal levels, to respond to a nuclear event at Pickering. This two-day inter-operability exercise involved more than a thousand participants from over 30 agencies. The exercise scenario was a severe accident at the Pickering plant leading to a significant off-site radiological release.

Figure 8 - Deployment of EME

The ExUC was successful in meeting the objective of testing many key elements of the emergency response plans. OPG also gained some valuable lessons, while demonstrating that Pickering NGS staff and the various external agencies are well prepared and ready to work together. Relationships between all agencies were strengthened through the planning and coordinating of the major exercise, which serves to enhance the collective emergency management capability.

The exercise successfully demonstrated a number of new initiatives including:

- OPG, the Province, and the Canadian Nuclear Safety Commission successfully used the new dose assessment software (URI) to predict projected radiological effects and inform protective action decision-making by the Province;

- The CNSC and the Provincial Emergency Operations Centre utilized the new Plant Information Emergency Summary Page to obtain access to emergency information without the need to transmit manually;
- OPG demonstrated enhanced interoperability using the new P25 radio system, which is common between OPG's Emergency Response Team (ERT) and Pickering Fire Services;
- Health Canada demonstrated the capability to calculate doses with a software called ARGOS using real time weather data;
- Corporate communications participants from all organizations exercised their response to simulated public communications and learned valuable lessons on managing social media.

OPG has prepared an Exercise Report with opportunities for improvement and corrective actions identified within its own organization.This OPG After Action Report was submitted to the CNSC on January 30, 2018.

Figure 9 - Deployment of EME

OPG, in partnership with International Safety Research (ISR), is currently facilitating development of a Joint Exercise Planning Team – After Action Report. This report will identify key findings and recommendations from an interoperability of participating organizations perspective. Once complete, the After Action Report will be shared with the CNSC and the learnings will be used to further improve the robust emergency preparedness capability to respond in the unlikely event of a nuclear emergency in Pickering.

Exercise GridEx IV

As another recent example, OPG participated in Exercise GridEx IV on November 15th and 16th 2017, with over 4000 North American participants, and 99 OPG employees engaged.

The GridEx series of exercises are a biennial endeavor led by the North American Electric Reliability Corporation (NERC) meant to simulate a response to a sophisticated and coordinated cyber and physical attack scenario on the North American electrical grid. The exercise provides participants an opportunity to practice and strengthen their capability to prepare for, mitigate, respond to, and recover from simulated severe threats and incidents affecting the reliable operation of North America's Bulk Electric System. The exercises are aimed to further the resilience of the electricity industry.

With the participation of North American Reliability Coordinators, Generators, Transmitters, Distributers and Wholesale Customers, this was a significant Bulk Electric System exercise. Ontario saw collaboration with the Independent Electricity System Operator (IESO), Hydro One, Bruce Power, Toronto Hydro, Alectra Utilities Corporation, and Hydro Ottawa, to name a few.

At OPG, GridEx IV provided the opportunity to exercise three key objectives:

- Incident Management: Exercise OPG internal and inter-agency incident management capabilities for cyber and physical incidents that impact the Bulk Electric System (BES);
- Communications: Exercise internal and inter-agency communication;
- Interoperability: Exercise the interoperability between OPG and external stakeholders in incident management, as well as between OPG departments.

Overall, this was an excellent opportunity for OPG to engage in a highly sophisticated North American exercise. It tested and verified OPG's ability to effectively prepare for, and respond to, both cyber and physical threats and incidents, across a broad range of challenges. The exercise further enabled OPG to demonstrate its ability to work collaboratively with internal work groups, and external stakeholders in the management of the simulated threats and incidents.

Public Emergency Alerting and Protection

OPG is aware that people may be concerned about being informed of an accident at Pickering in time to protect themselves and their families. The Regional Municipality of Durham, the City of Toronto, the Province of Ontario, and OPG are prepared with several different methods to alert members of the public in the unlikely event of an accident requiring protective action such as sheltering or evacuation. These methods include sirens, mounted on poles within three km of the Pickering site, that send out a single tone that can be heard outside. Local media, including radio, television and social media, will be provided with instructions on what to do in the event of a nuclear emergency, which they will broadcast to the public. An automated telephone system will also alert a large population in a short time, by delivering a recorded emergency message to landline home phones.

More recently, OPG has collaborated with Durham Region, the Office of the Fire Marshall and Emergency Management (Province of Ontario), Bell Canada and the Weather Network to pilot a Wireless Public Alerting System (WPAS) in the Durham Region. This system will broadcast messages through wireless (cell phone) technology about emergencies of public concern, and has been used in other jurisdictions outside of Canada. In the Durham Region pilot project, approximately 80 people were provided with WPAS-enabled cell phones and received test messages to validate the system's effectiveness. The Canadian Radio-television and Telecommunications Commission has taken steps to direct wireless service providers to implement wireless public alerting capability on their networks in 2018.

As additional support to emergency preparedness and response measures, OPG has developed an Evacuation Time Estimate study for people affected in an emergency, to provide off-site planners with an understanding of the time that would be required to evacuate affected zones around the plant. The study was formulated using census data as well as projections for future growth, to ensure that it accounts for the size of the population that could be involved. It considers the time to evacuate schools, hospitals and other such institutions, and incorporates factors such as the time of day and day of the week, as well as other possible constraints like roadwork or special events.

OPG consults with the Province, the Region of Durham and the City of Pickering on land use policies and activities that could be relevant to emergency planning zones, to make sure that these are consistent with the implementation of any nuclear emergency plans.

To further support emergency response and public protection, OPG pre-distributed potassium iodide pills to the entire population in the primary zone (10 km radius) around Pickering NGS. Potassium iodide, or KI, protects the thyroid gland of people who may be exposed to radioactive iodine from a radiological release from a nuclear power plant. In support of the provision of KI pills, OPG conducted a communications campaign to inform the population of the distribution program, and placed information on how and when to use the pills on the product packages, which were themselves designed to be recognizable so that people who received them would store them safely.

Extensive supportive information has been provided to assist the community on the use of KI pills. Factsheets were prepared on the use of KI and distributed to local and provincial help lines and to local physicians to help them answer any questions they might get from the public. A website was created and is maintained, to provide information on the use of the pills, including FAQs in the nine most common languages that are spoken within 10 km of the plant, and allowing people within 50 km of the plant to order the pills if they desire. Information packages and KI pills are sent to new residents who move into the primary zone.

Update of the Provincial Nuclear Emergency Response Plan

The Office of the Fire Marshal and Emergency Management (OFMEM) administers the Provincial Nuclear Emergency Response Plan (PNERP) on behalf of the Province and coordinates nuclear emergency preparedness and response in Ontario.

The PNERP is subject to Cabinet approval. The elements of the PNERP Master Plan are applied to each major nuclear site, trans-border emergencies and other types of radiological emergencies, and detailed provincial plans have been developed. All other major organizations that are involved (e.g., municipalities, nuclear power plants) develop their own plans consistent with the requirements of the PNERP, its implementing plans and their mandate.

Following the accident at the Fukushima Daiichi nuclear power plant, OFMEM initiated a project to review the PNERP and the planning basis for nuclear emergency response. An important part of this review process was an opportunity for the public to participate by reviewing and providing feedback on a planning basis discussion paper, which included proposed updates to the PNERP Master Plan. The document was posted publicly for review for 75 days in 2017.

A provincially established advisory group reviewed the comments received from both the public and stakeholders, and made recommendations to the Minister of Community Safety and Correctional Services on how the feedback should be incorporated in the PNERP. The advisory group was made up of independent experts in the fields of emergency management, risk assessment, nuclear and radiation safety and nuclear emergency response.

The advisory group recommendations informed the revision of the PNERP Master Plan, which was approved by Cabinet on December 13, 2017. The Province's goal with this update was to make the plan more transparent and accountable, increase alignment with national and international standards, and enhance emergency planning.

In 2018 revisions and updates to the various PNERP Implementing Plans, including the Pickering and Darlington plans, will be completed to align with the approved PNERP Master Plan. These changes will ensure that Ontario's emergency planning and response to nuclear emergencies incorporates lessons learned from recent international emergencies and best practices from leading experts.

The Pickering PNERP Implementing Plan is expected to be approved by Provincial "Order in Council" in the first half of 2018. Upon approval, OPG will conduct a gap assessment between its existing Consolidated Nuclear Emergency Plan and the updated PNERP Implementing Plans, and will create a transition plan to expeditiously revise OPG plans, as necessary, to align with the provincial plan. One significant change in the PNERP is the introduction of a new 20 km Contingency Planning Zone (CPZ). OPG is currently reviewing the requirements of this new zone, and will be engaging expert transportation engineering consultants to update the existing Evacuation Time Estimate study as required.

2.2 Pickering is Fit For Commercial Operation

Pickering NGS is reliable. The station has had its best forced loss rate performance in its history over the last three years, showing that Pickering NGS is continuing to achieve improved reliable operation.The station received a rating of Fully Satisfactory in annual CNSC industry evaluations, in both operating performance and overall ratings for 2015 and 2016.

The information describing the activities that support and demonstrate that Pickering is fit for service relates to the Fitness for Service SCA (Section 2.6 in the Licence Application). Information pertaining to the transition to safe storage also refers to the Predictive Effects Assessment which relates to the Environmental Protection SCA, and is described in sub-Section 2.9.10 of the Licence Application.

Station Performance Measures

Forced Loss Rate

This is a measure of the lost generation due to unplanned shutdowns or load reductions. It is measured only during plant operating periods and reflects the power plant's reliability performance.

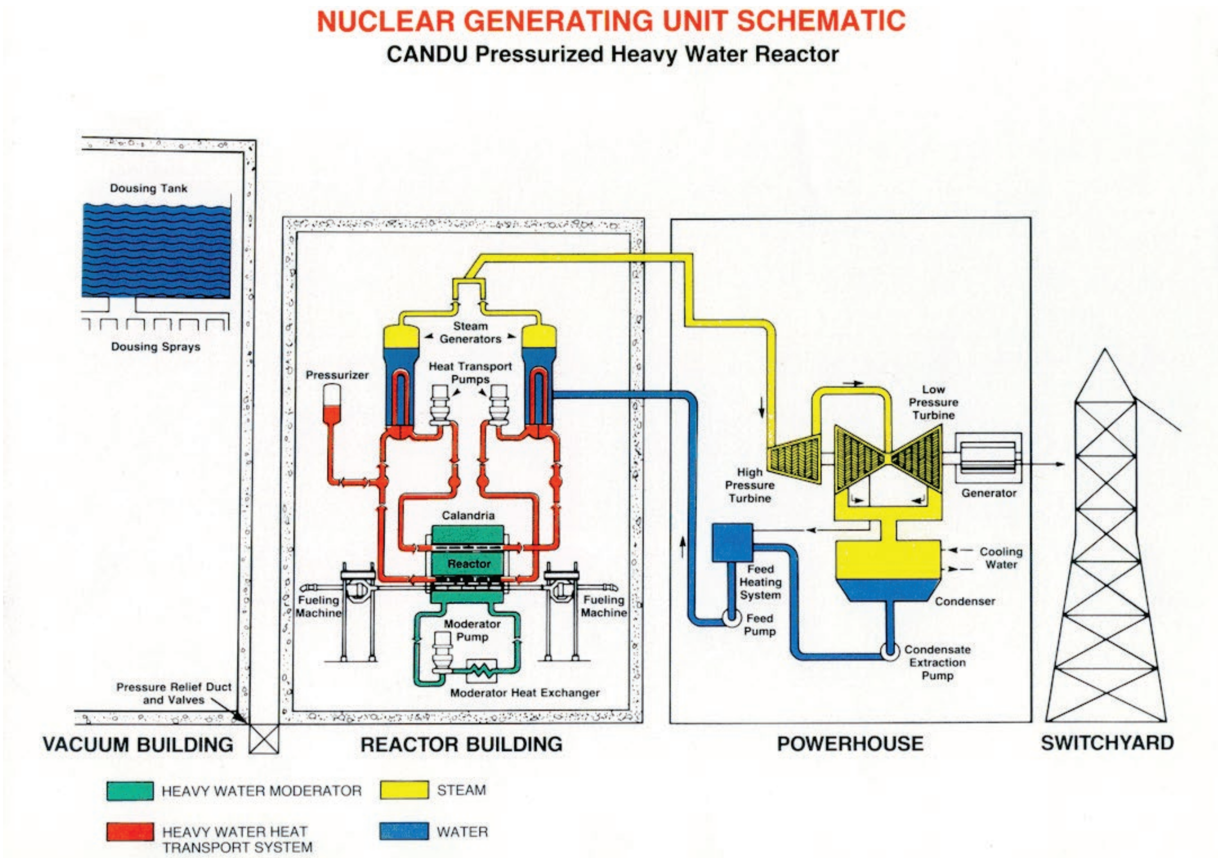


Figure 10 - Schematic showing major components including calandria, fuel channels, steam generators and the feeder piping system

The systems, structures and components at Pickering are maintained so they will remain available, reliable, effective and consistent with design, analysis and quality control measures through the licence period. These conditions are assured through several key programs, including the Integrated Aging Management Program, the Equipment Reliability Program, the Major Components Program, and the Periodic Inspection Program.

2.2.1 Aging Management

Pickering is being maintained in a safe and reliable operating condition through the planned end of commercial operation in 2024, in part through the Integrated Aging Management Program. This program ensures that OPG understands the condition of structures, systems and components (SSCs) which include critical station equipment, and that the necessary activities are in place to assure the health of these SCCs through the licence period.

Integrated aging management is implemented through the coordination of several programs. These include the Equipment Reliability Program, the Major Components Program, and the Component and Equipment Surveillance Program, discussed in more detail in the following Sections.

Equipment Reliability

The Equipment Reliability Program is in place to assure and improve the reliability of station equipment by ensuring that components that are important to nuclear safety and production are reliable and available for service. The program incorporates a number of activities through which plant personnel monitor and evaluate the condition and performance of important equipment; make continuing adjustments to preventive maintenance tasks and their frequencies based on equipment performance experience; and develop and implement long-term equipment health plans.

Plant personnel conduct these activities through surveillance and testing, life cycle management planning, and equipment performance and condition monitoring.

Pickering NGS uses an industry benchmarking metric called the Equipment Reliability Index (ERI) to provide an aggregate assessment of equipment reliability and programs that support it, measuring 17 key indicators of equipment reliability to produce a station score out of a maximum 100 points.Pickering's score has improved through the current licence period: for example, in 2016 the ERI was 72, exceeding the target of 70; the target for 2017 was raised to 72, and by June 2017 Pickering had exceeded that with an ERI of 74.

Major Components

The Major Components Program establishes an integrated set of processes and activities to demonstrate fitness for service of several key major reactor components, and ensure that these components will perform safely and reliably through to the end of the commercial operating period. The program also develops long-term life cycle management strategies for the continued safe and reliable operation of the station. The components that are addressed under this program are the fuel channels, feeders, steam generators, and reactor components and structures.

Fuel channels

OPG recognizes that there is concern with the aging of the fuel channels in the Pickering reactors, and with the condition changes that have been observed with the fuel channels. To address this, OPG has paid close attention to the continued safe operation of the fuel channels at Pickering, through many years of inspections and targeted monitoring of known degradation mechanisms, and measures to mitigate that degradation. A Fuel Channel Life Cycle Management Plan has been implemented to demonstrate that these degradation mechanisms are understood, and to employ inspections and monitoring to ensure and confirm that the fuel channels remain in an acceptable condition for continued safe operation.

On the basis of technical reviews of fuel channels on all reactor units, fuel channel aging management programs including inspections, ongoing research, and the availability of mitigating measures where these are required, OPG is confident that fuel channels are fit for service to the intended end of service in 2024.

In support of the application for a ten-year licence renewal, OPG assessed the operation of the fuel channels on all reactor units. It found that there is additional margin on fuel channel fitness for service limits that applied to the previous target service life of the reactors of December 2020. In other words there is still a lot of life left in these components. These assessments provide assurance that operation with the fuel channels is safe beyond the current limit of 247,000 EFPH. OPG further undertook an assessment of the fitness for service of the Units 5-8 fuel channels to the new target service life of December 31, 2024, based on technical reviews, established controls for managing fuel channel aging, and the availability of required mitigation measures. Observations show that slow degradation is occurring at the rates that were predicted, and no new degradation mechanisms have been identified.

OPG continues to assess fuel channel aging with industry peers and with CNSC staff, and plans for further research and testing have been submitted to the CNSC for review. OPG also continues to conduct research and development activities to enhance and demonstrate the understanding of the key degradation mechanisms, properties of materials and component fitness for service. Findings from these activities are incorporated with inspection results and industry operating experience into the fuel channel program, to ensure that adequate margins on fitness for service are maintained for the full operating life of the Pickering station.

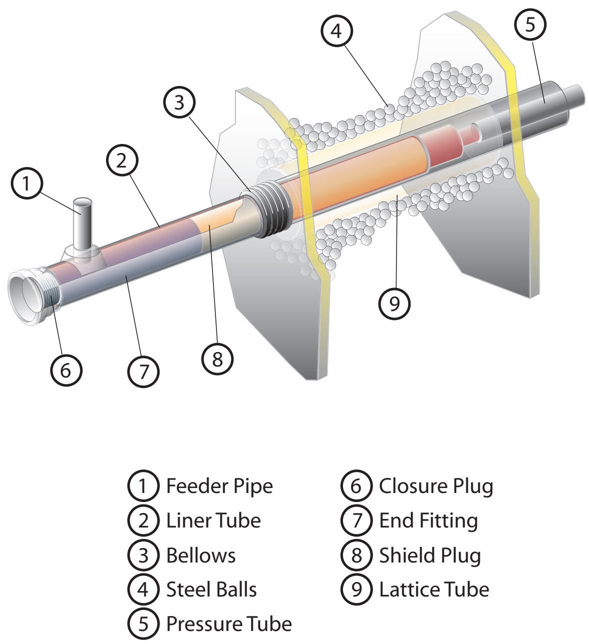


Figure 11 - Fuel channel penetration through reactor core

The inspections, reviews, and research and development completed to date have confirmed that the Units 5-8 fuel channel fitness for service can be demonstrated up to 295,000 EFPH through existing programs, as would be required for station operation through 2024. More information on the management of the fuel channels is available in Addendum B.

Steam Generators

Steam generators (SG) are boilers that heat water into steam, which drives the turbines that generate electricity. The reliable performance of steam generators through to the end of commercial operation is ensured through activities under the Steam Generator Life Cycle Management Program. These activities include an inspection program to detect and manage plausible mechanisms of degradation in these components, and monitor degradation mechanisms that could limit the life of steam generators. Due to effective inspection and maintenance strategies, there were no SG leaks during the current licence period.

This inspection program discovered a new degradation mechanism in the SGs on Pickering Unit 4 that is causing thinning of the SG tubes in some locations; this is being controlled and mitigated through effective chemistry control, inspections, detailed analysis and conservative decision-making strategies.

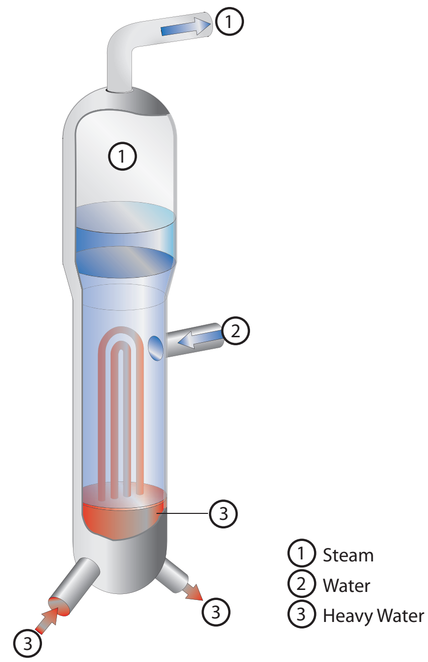


Figure 12 - Steam generator

Feeders

The feeder piping system is part of the fuel cooling system that transports heat from the fuel to the steam generators for the generation of steam that produces electricity. This system is maintained in a reliable and safe operational condition through the feeder piping system life cycle management program, and is fit for service until the end of commercial operation. This reliable condition is maintained and demonstrated through inspection and assessment activities. When inspections and analysis demonstrate a feeder is reaching its end of life it is replaced.

Feeder Replacement Program

Feeder wall thickness decreases over time, resulting from corrosion that is accelerated by flow. In addition, feeders can suffer wear from fretting (contact with other components). Both of these degradation mechanisms are closely monitored and analyzed. Acceptance criteria for feeder degradation assessments are provided by guidelines on feeder thickness for service developed by the CANDU Owners Group (COG) Feeder Joint Integrity Project, which are used in conjunction with other industry standards and codes. The need for feeder replacement is developed from the most recent feeder thinning inspections and assessments of remaining life based on minimum required wall thickness, to demonstrate continued fitness for service. The need for replacements will continue to be assessed through to the end of commercial operation.

Reactor Components and Structures

Finally, the Component and Equipment Surveillance Program sets out the requirements for the surveillance of a set of key components through functions that include inspection, maintenance, certification and testing. Examples of the component programs to which surveillance activities apply include heat exchangers, check valves and power-operated valves. Equipment that is subject to inspection and testing includes pipe wall thickness, pressure relief valves and buried piping.

The Reactor Components and Structures Life Cycle Management Plan establishes the strategy for the management of the effects of aging on reactor components, and identifies actions that are necessary to manage any effects appropriately. The plan is updated annually, and assessments are incorporated into the life cycle management strategies.

Inspections and assessments of reactor components and structures continue to demonstrate that these components are fit for service. Ongoing inspections and monitoring will continue to manage degradation mechanisms effectively to the end of commercial operation.

2.2.2 Periodic Inspection and Testing

The periodic inspection program and the in-service inspection program are in place to ensure pressure boundary integrity, fitness for service, and effective management of aging of the nuclear plant systems and components at Pickering. Standards and criteria for the inspection programs are defined by the Canadian Standards Association (CSA), and ensure that the likelihood of a failure that could pose a danger to health and safety remains low.

Figure 13 - Equipment inspections

There are two main periodic inspection programs: these are the Periodic Inspection of CANDU Nuclear Power Plant Components; and the Periodic Inspection of CANDU Nuclear Power Plant Containment Components. The Periodic Inspection of CANDU Nuclear Power Plant Components applies to inspections of piping and vessel welds, pumps, valves, pipe and component supports, heat exchangers and mechanical couplings, with inspections on a ten-year inspection cycle.

Containment components that are included in the inspection program include containment penetration seal welds, pipe supports, piping and ducting, valves, and containment dampers.

In-service inspections are performed for newly installed equipment, and for newly installed components that will be inspected under one of the periodic inspection programs. The in-service inspections establish the condition of the equipment or component when it was placed into service and provide an initial inspection result for comparison in subsequent inspections at 10-year cycles.

In-service inspections are also conducted on major structures including the vacuum building (VB) and pressure relief duct (PRD) containment structures. The inspections include concrete components, vacuum building joint sealant, vacuum building roof seal and pressure relief duct joint seals. OPG will continue to meet regulatory requirements for VB and PRD inspections.

2.2.3 Maintenance

Maintenance of plant equipment is important to support plant safety and reliability, through minimizing equipment failures as well as ensuring that safety systems remain available and operational. Preventive and corrective maintenance activities are conducted, in addition to routine inspections of system components. Maintenance programs support equipment fitness for service requirements by being aligned organizationally with the Engineering, Work Management, Operations and Supply Chain functions.

Figure 14 - Turbine maintenance

2.3 Qualified and Competent Staff will be Maintained to Ensure Safe Plant Operation Through to Shut-Down

This commitment relates to the Management System SCA and the Human Performance Management SCA, which are described in Sections 2.1 and 2.2, respectively, of the Licence Application.

2.3.1 Staffing Management

Workforce planning looks at current staff and business plans, and makes projections to ensure that sufficient qualified staff are available to operate and maintain the stations. Staff projections for continued operations of Pickering and the end of commercial operations form part of the overall people strategy for OPG.

Key aspects of this program include knowledge management and succession planning.

OPG ensures that staff have the necessary qualifications, knowledge and skills required to perform competently. The knowledge management program complements these foundational programs by providing tools and techniques to maintain and share tacit knowledge. Given OPG's demographics, employee attrition and the lengthy training and development required for specialized roles, OPG has invested in knowledge management for ongoing operations as well as the delivery of projects and initiatives to ensure that the critical knowledge and expertise of employees are sustained. Long-term hiring strategies are also in place, and will continue to be refined, to address corporate and nuclear staffing needs through to and beyond the shut-down of the station.

OPG recognizes the importance of succession planning for the retention and transfer of knowledge to ensure that the necessary knowledge and skills are available when they are needed, and for continuity in critical roles. An additional succession planning process that is complementary to the broader OPG process is in place for the nuclear organization. This involves identifying critical positions and determining the priority of each, in order to assign a degree of management oversight of succession planning that is appropriate to the priority of each role.

As discussed in Section 1.3.4, to address the new challenges due to the transition from an operating station to the end of commercial operation a Sustainable Operations Plan (SOP) will be pro-actively developed five years before the shutdown of the first unit. The SOP will address staffing management issues to ensure safe, reliable operation of Pickering to the end of commercial operation.

2.3.2 Ensuring a Qualified and Competent Workforce

One component of human performance management is to ensure that positions are filled by qualified staff.

Certification and Training

Safe reactor operation is assured in part through the use of certified staff in safety critical positions. Under the Pickering Power Reactor Operating Licence, valid certification is required for personnel who work in the positions of Authorized Nuclear Operator, Control Room Shift Supervisor, Shift Manager, and Responsible Health Physicist.

Certification for these positions is achieved through training and certification examinations, and confirms that successful candidates have the level of knowledge and skills required to work competently in their assigned position. Certified individuals must undergo periodic requalification testing; they are also required to complete refresher training, and to update their training in accordance with changes to the plant and to procedures.

Certified operations staff, for example, undergo more than 200 hours of continuing training each year.

The CNSC specifies a minimum number of certified individuals who must be available for each of these positions; Pickering NGS exceeds the minimum required certified staff for each position, and also has training programs to prepare trainees to become certified and move into these positions.

In recent years there have been improvements in the initial certification and continuing certification training programs, with increased attention to operator fundamentals, reactivity management and emergency response, including response to beyond design basis events. Training has also been improved and made more realistic with the use of full scope main control room simulators for emergency preparedness drills and exercises.

In addition to skilled operator certification, OPG makes significant investments in training, and all employees (regular and temporary staff) are required to participate every year in training that is relevant to their work. OPG uses a Systematic Approach to Training to provide the structure, processes and tools for defining, developing, implementing, documenting, assessing and improving the training required to ensure staff have appropriate knowledge, skill, and behaviors for safe and efficient plant operation. This involves systematically evaluating the tasks involved in carrying out a role and evaluating the necessary training for each task, and applying another systematic evaluation to determine the most appropriate kind of training.

Training programs consist of initial training, re-qualification training to maintain an employee's qualifications, and refresher training. Training programs are maintained through a regular cycle of revision and updating of program content.

As an example, OPG has improved and expanded training in emergency response. In 2016, the Emergency Response Organization (ERO) Betterment Project was implemented and successfully completed. Achievements include consistent application of the systematic approach to training to all ERO role-related documentation as well as creation or revision of over 200 training documents. More information related to emergency preparedness and response training was provided in Section 2.1.4, above.

OPG Nuclear Employee Training Programs

Engineering training includes an initial training program and a continuing training program. The initial training program has been improved, and enhanced with an additional classroom course on the design basis. The continuing training program includes a Conduct of Engineering workshop that focusses on a new topic each year, as determined by senior engineers and industry experience, and delivered to approximately 1000 engineers. Initial training for maintenance staff consists of Control and Mechanical programs, both of which provide approximately 120 days of training over a three-year period. Continuing training, which is done for 10 days each year, remains flexible in order to address key performance issues, and can be tailored to the needs of specific groups. For example, in 2015 and 2016 workshops were developed on leak management and valve assembly and were delivered to 300 maintenance staff at Pickering NGS.

Training Facility

Operations training also includes initial and continuing training programs, in which all qualified operators participate. Operator training focusses on advancing operator proficiency, to achieve an objective of error-free operation. This consists of knowledge and skills refreshers as well as re-qualification training.

The scope of operator training has expanded, as a result of lessons learned from the Fukushima accident, to include response to beyond design-basis events and the operation of emergency mitigating equipment that has been installed to mitigate the risks of severe accidents.

Leadership training is required for all leadership and supervisory roles, including those within the engineering, operations and maintenance departments. This training is wide-ranging in content and can consist of short one-day courses or others that take several months. OPG company-wide leadership training for first line managers, first line manager assistants and middle level managers was redesigned in 2015 according to international benchmarking and industry best practices. OPG also has leadership training that is specific to nuclear plant management. It developed the International Senior Nuclear Plant Manager program, and since 1996 has offered it to senior managers within the OPG nuclear organization, as well as to senior managers from major contract suppliers. This program has become internationally recognized, and OPG is now providing it in England in collaboration with EDF Energy in the United Kingdom.

2.3.3 Operational Staffing Policies

To ensure the safe operation of the Pickering station, OPG enforces a Minimum Shift Complement (MSC), which is the minimum number of qualified workers who must be present at all times to operate the plant safely. This also considers the staffing requirements for a response to any station emergency that may arise and ensure adequate emergency response capability for even the most resource- intensive conditions. The qualifications and staff requirements for each role to which the requirement applies are set out in procedures and comply with CNSC regulatory requirements.

Assessments of various station roles are undertaken to verify the adequacy of shift complement requirements and make any necessary adjustments. For example, an assessment of the capabilities of the Emergency Response Team, which was undertaken as a response to the lessons learned from the Fukushima accident, determined the appropriate Emergency Response Team complement for completing the necessary emergency response actions, such as deploying emergency mitigating equipment.

A set of staffing policies are implemented to ensure that all staff are fit for duty at the facility. One such procedure, Limits of Hours of Work, describes the expectations and process for monitoring and controlling the number of hours and shifts that employees work, to control the effects of fatigue per regulatory limits.

Supervisors are responsible for monitoring their employees' hours of work and for ensuring that employees are aware of their limits, while employees are responsible for being aware of their time limitations, for tracking their work hours and notifying their manager in advance of a potential violation.

An additional fitness for duty consideration pertains to staff behaviors that may indicate a risk to the security, safety, or health of employees, facilities or the public. Training under the Continuous Behavior Observation Program describes the process to be followed if a worker who reports for work is suspected of being unfit for duty; all OPG supervisors must complete this training during initial training and undergo refresher training every 36 months.

As an additional safety measure OPG Security monitors all personnel who enter the station protected area for indications of being unfit for duty or under the influence of intoxicants, and deny access to any employee who is suspected of being unfit. Periodic monitoring for drug use is carried out using canine drug monitoring, as an additional screen to ensure that all staff in the protected area are fit for duty.

CNSC has updated its requirements for hours of work and fatigue management, and for alcohol and drug testing. OPG is updating its procedures on fatigue management, and is developing plans for implementing alcohol and drug testing, in alignment with these new requirements.

2.3.4 Safety Culture

More than 30 years ago, nuclear power plant operators recognized that in addition to the other safety and defence in depth provisions they had in place, it was also important to emphasize that an organization must hold nuclear safety to be its top priority overriding all others.

OPG has defined the elements that make up a healthy nuclear safety culture, and the operational and organizational components by which it is implemented. These are formally defined, with performance criteria for each, as the ten Traits of a Healthy Nuclear Safety Culture. The nuclear safety culture is described in the box on page 42.

OPG’s Nuclear Safety Culture

OPG’s Nuclear Safety Culture consists of three main principles, which are put into practice through the observation by all employees of a set of ten nuclear safety culture traits.

Principles of the Nuclear Safety Culture

- Nuclear Safety shall be the overriding priority in all activities performed and shall have clear priority over schedule, cost and production;
- Nuclear safety is based on Reactor Safety, Industrial Safety, Radiological Safety and Environmental Safety;
- The Nuclear Safety Culture program provides an objective and transparent safety-focused process while continuously strengthening safety culture.

Ten Traits of a Healthy Safety Culture

1. **Personal accountability**
   All individuals take personal responsibility for safety.
2. **Questioning Attitude**
   Individuals avoid complacency and continuously challenge existing conditions and activities in order to identify discrepancies that might result in error or inappropriate action.
3. **Effective Safety Communication**
   Communications maintain a focus on safety.
4. **Leadership Safety Values and Actions**
   Leaders demonstrate a commitment to safety in their decisions and behaviours.
5. **Decision-Making**
   Decisions that support or affect nuclear safety are systematic, rigorous and thorough.
6. **Respectful Work Environment**
   Trust and respect permeate the organization.
7. **Continuous Learning**
   Opportunities to learn about ways to ensure safety are sought out and implemented.
8. **Problem Identification and Resolution**
   Issues potentially impacting safety are promptly identified, fully evaluated, and promptly addressed and corrected commensurate with their significance.
9. **Environment for Raising Concerns**
   A safety-conscious work environment is maintained where personnel feel free to raise safety concerns without fear of retaliation, intimidation, harassment or discrimination.
10. **Work Processes**
    The process of planning and controlling work activities is implemented so that safety is maintained.

The Nuclear Safety Culture Program is overseen through a set of processes and activities, including the Nuclear Safety Culture Monitoring Panel, Nuclear Safety Review Board, self-assessments, and the Corrective Action Program. The Nuclear Safety Culture Monitoring Panel tracks indications of the health of Pickering's nuclear safety culture. The panel consists of the senior plant leadership team and meets each quarter to discuss the status of the nuclear safety culture at Pickering NGS.

OPG has used different methods to review, evaluate and critique the safety culture at Pickering NGS. For example, in 2015 Pickering NGS conducted a station-wide assessment of the perceptions, attitudes and behaviors associated with Pickering's safety culture through reviews, interviews and observations. It found that Pickering NGS has a healthy safety culture, that employees respect nuclear safety, and that nuclear safety is not compromised by production priorities. Station personnel feel they can challenge a decision without fear of retaliation; for example, Pickering has a healthy Station Condition Record (SCR) reporting culture, with employees comfortable reporting any abnormalities or deficiencies that they observe in the plant. All new SCR reports are read and dispositioned by management several times each week; while most of the SCRs are not significant or related to plant safety, some will require a corrective action plan or a root cause investigation.

The safety culture assessment also noted some areas for improvement, and actions taken to address them have been tracked. Further station-wide safety culture assessments will be conducted periodically, with the next scheduled for 2018.

2.4 Impacts of Pickering NGS Operation on the Public, Workers and the Environment Will Remain Low

OPG understands the fundamental importance of preventing impacts to the public, workers, and the environment as a result of normal Pickering NGS operations. The activities focused on minimizing impacts associated with normal plant operation, described below, are in addition to OPG's extensive plant safety provisions and well practised capabilities to respond to any type of emergency, which are discussed in Section 2.1, above, in this document. The programs and activities discussed in this Section relate to several SCAs: these are Radiation Protection (Section 2.7 of the Licence Application); Conventional Health and Safety (2.8 in the Licence Application); Environmental Protection (2.9 in the Licence Application); and Waste Management (2.11 in the Licence Application).

The Environmental Management Program at Pickering Nuclear is consistent with the International Organization for Standardization (ISO) 14001 Environmental Management System.

The program ensures, first and foremost, that no members of the public are exposed to any unsafe level of radiation. Pickering keeps emissions to a minimum, far below regulatory limits. Second, Pickering maintains extensive monitoring programs that measure levels of radiation in air, water, groundwater and soil, to verify that levels are low and to ensure prompt detection of any elevated levels so these can be addressed.

In addition to regular monitoring programs, risks to humans and the environment were recently assessed in an updated Environmental Risk Assessment that focused on operations of Pickering site facilities from the year of 2011 to 2015. The assessment consisted of a Human Health Risk Assessment (HHRA) and an Ecological Risk Assessment (EcoRA) for the risks of radiological and non-radiological contaminants and physical stressors associated with Pickering and its activities.

The HHRA assessed the risks of non-radiological contaminants and radionuclides, to off-site members of the public (i.e. critical groups that are used for dose calculations).

The EcoRA focused on Valued Ecosystem Components that exist on and in the vicinity of the Pickering site and near shore of Lake Ontario and includes consideration of threatened or endangered species. Findings and conclusions from these assessments are included in the discussion of the risks to human health and the environment, from radiological and conventional hazards.

Other activities that protect the public and workers from exposure to radiation are the careful packaging and transport of radioactive materials, and the safe management of radioactive waste. OPG is transparent about these activities, providing information to local communities and the public on station performance so that interested or concerned individuals can verify for themselves that levels remain low.

It is also important that the workers and the public be protected from impacts from conventional, or non-radiological, activities resulting from industrial activities on the site. Pickering's Conventional Health and Safety program is very effective. OPG received the Canadian Electricity Association President's Gold Award of Excellence for Employee Safety, in recognition of its employee safety performance for 2013-2015. In an effort to further improve employee safety beyond compliance with health and safety program rules, OPG has implemented an “iCare” safety culture to encourage all employees to protect themselves and others in their work. OPG's goal is zero workplace injuries.

As discussed in Section 1.3.4, OPG also undertook a Predictive Effects Assessment (PEA) to evaluate the potential for adverse effects to human health and the environment from the activities associated with transitioning the station from operation to a safe storage state. The PEA encompasses both the Stabilization Phase and the Safe Storage Phase. The PEA concluded that there are no predicted potential adverse effects from the stabilization and safe storage activities.

2.4.1 Environmental Safeguards

The goal of OPG's comprehensive environmental protection program is to continually minimize impacts from station operation to the environment and human health. This is achieved by ensuring that there are multiple barriers in place to control and minimize radioactive emissions to the environment and to ensure all emissions are monitored.

The framework to control emissions is based on the guiding principle of keeping radiation impacts to the public and the environment As Low As Reasonably Achievable (ALARA). This is achieved by establishing operational emission limits to ensure that the dose to the public does not exceed the legal limit of 1000 µSv and in fact is kept far below that limit.

The official public dose to the public from Pickering NGS has been consistently much lower than the legal limit. The annual dose to the critical group (the urban resident adult) from 2011-2016 ranged from 0.9 to 1.5 µSv, or approximately 0.15% of the regulatory dose limit for the public of 1000µSv. The protection of these most exposed critical groups ensures that other populations near Pickering NGS are protected.

How is Public Dose Calculated?

Radiation doses to humans are measured in Sieverts, (Sv) which combine a measure of the type of radiation with the impact it has on the body. The annual legal limit for a member of the public from a man- made source of radiation is 1000µSv – a millisievert, or 1/1000 of a Sievert. These limits are consistent with recommendations by international radiation protection authorities.

The radiation dose from a nuclear plant is calculated to a set of representative people called "potential critical groups" (such as "Urban Resident (Adult))" who are defined as living in the vicinity of the plant and engaging in various activities.

The highest dose to any of these critical groups is used as the official public dose.

The Figures, 15 and 16 below, illustrate the dose from the Pickering station to a member of the public in relation to regulatory limits. Note that in figure 16, the vertical axis uses a logarithmic scale.

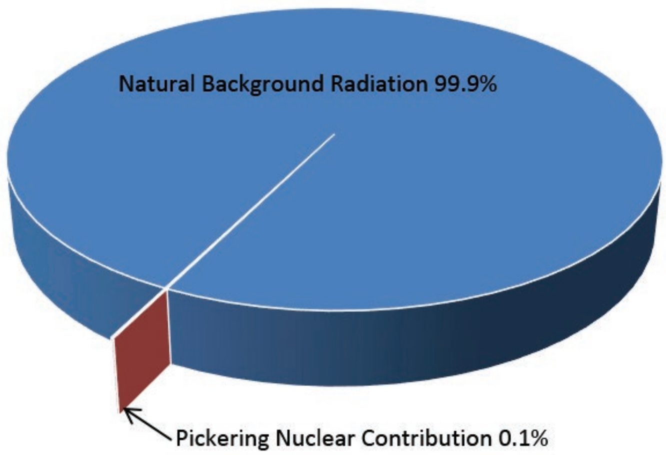


Figure 15 - Radioactive Dose to the Public (2017 results will be available by May 2018)

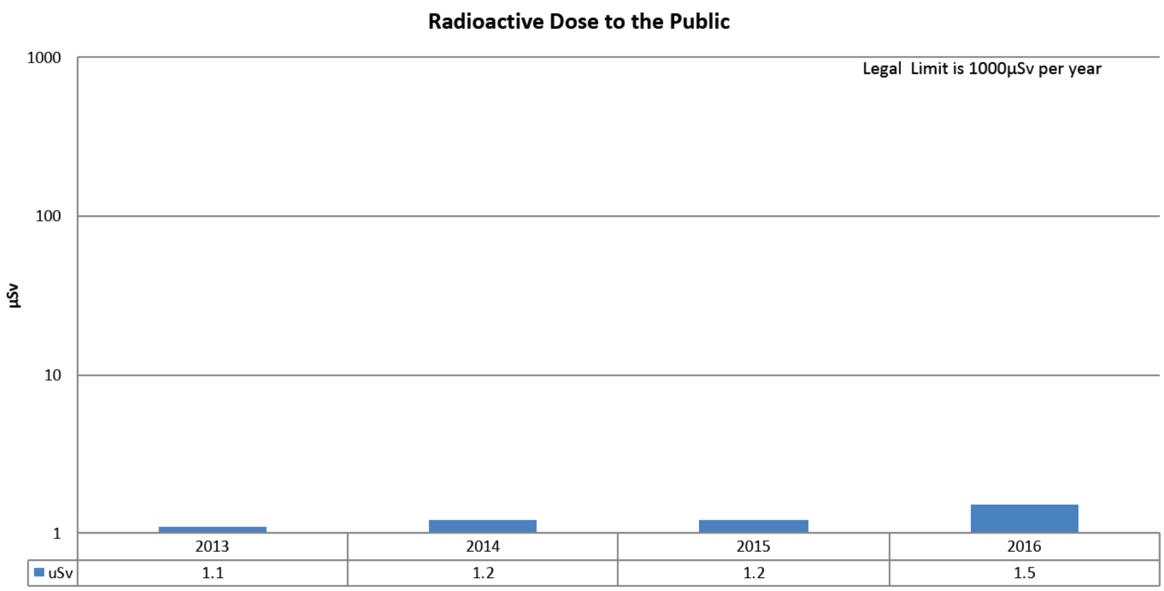


Figure 16 - Radioactive Dose to the Public (2017 results will be available by May 2018).

The routine environmental monitoring of radiological emissions and their potential impacts on the public includes measurements of radionuclides in air, water and food products, taken near Pickering NGS as well as at other background locations in the province for comparison purposes. The measurement data are used with data on station emissions to determine the dose of radiation received by members of the public. The CNSC also conducts independent sampling and has posted results that demonstrate Pickering's safety record.

Discharges to water from the radioactive liquid waste management system are also monitored and controlled, and are reported each quarter to the Ontario Ministry of the Environment and Climate Change (MOECC).

Groundwater is also monitored for emissions of radioactive materials – primarily tritium - into and through groundwater at and near the Pickering site. Tritium in groundwater is localized within the station's Protected Area.

OPG maintains an annual groundwater monitoring program at Pickering designed to provide early detection of potential impacts to groundwater. Approximately 140 locations were sampled in 2016. The concentrations of tritium that have been observed have no adverse off-site environmental impacts. OPG continues to take actions to reduce and minimize any tritium emissions to groundwater that occur.

2.4.2 Conventional Hazards: Environmental Monitoring

Monitoring for non-radiological, or conventional, hazards is also carried out at Pickering NGS, in support of programs to minimize these events and their possible impacts on people and the environment.

Groundwater is monitored for petroleum hydrocarbons, benzene, toluene, ethylbenzene, xylenes and volatile organic compounds (VOCs). Some ozone-depleting substances are used at Pickering NGS in water coolers, air conditioners and refrigerators; emissions of these substances have been decreasing due to the installation of new equipment, including the replacement of older chiller equipment in Units 5-8. Emissions of these substances vary but remain low.

Pickering NGS reports the release of certain industrial substances, including hydrazine, nitrogen oxides, particulate matter and sulphuric acid, to the National Pollutant Release Inventory managed by Environment Canada. In addition, these and some other industrial chemicals are regulated by the MOECC. Discharges to water from the water treatment plant are regulated by the MOECC; all discharges during the current licence period were via approved pathways, and complied with regulations.

Pickering NGS also has extensive programs to minimize spills to the environment and to manage those that occur effectively. Spills that may cause an adverse effect are categorized as Category A (major); Category B (moderate and Category C (minor) and are reported to the Ontario MOECC. From 2013 to 2017, there were no Category A or Category B spills at Pickering. There were 12 Category C spills through that period, involving substances like ethylene glycol, different types of oils, and sewage. The number of these spills has been decreasing since 2004 due to improved environmental awareness and stricter spill control practices.

2.4.3 Environmental Protection: HHRA, EcoRAand Physical Stressors

The effects of Pickering NGS activities and operations on the environment are examined through an Environmental Risk Assessment (ERA) The ERA is prepared to meet the requirements of CSA N288.6-12.

The ERA is a systematic process used to identify, quantify and characterize the potential for biological effects arising from contaminants and physical stressors in the environment. It addresses potential effects on both humans and the natural environment (i.e. plants and animals) that may be exposed to contaminants and physical stressors. The contaminants of interest may be radionuclides or other chemical substances released to the environment. Physical stressors may include emissions of noise, heat, or the intake of cooling water at a nuclear power station. The ERA includes a Human Health Risk Assessment (HHRA) and an Ecological Risk Assessment (EcoRA) for biota. The outcomes of the ERA are risk-based recommendations, which may result in changes to the environmental or effluent monitoring programs.

The ERA is reviewed every five years or more frequently as major facility changes are proposed. This ongoing, iterative process ensures that the ERA accounts for changes such as new activities or processes, environmental monitoring data, scientific advances and regulatory requirements, and thereby confirms that the environment and health and safety of persons are protected through the entire life cycle of the facility.

The ERA for the Pickering site used routine environmental and effluent monitoring data for the period of 2011 to 2015. A comprehensive sampling campaign in 2015 to collect samples in a number of environmental media was also considered in this assessment.

HHRA Results

Human receptors evaluated included off-site members of the public, specifically those critical groups used for dose calculations in the annual OPG Environmental Monitoring Program reports. Measured and modeled concentration of contaminants and noise levels were evaluated against screening benchmarks that are protective of human health.

For exposure of human receptors to radiological contaminants of potential concern, the relevant exposure pathways were those presented in OPG's annual public dose assessments. The annual dose to the critical group (the urban resident adult) between 2011 and 2016 ranged from 0.9 to 1.5 uSv/a, approximately 0.15% of the regulatory public dose limit of 1000 μSv and approximately 0.1% of the dose due to Canadian background radiation. Since the critical group receives the highest dose from Pickering NGS, the fact that this group is protected ensures that other receptor groups near Pickering NGS are also protected.

The HHRA results indicated that likely exposure levels for non-radiological contaminants are below benchmark values, and therefore no adverse effects on human receptors are expected.

The review of noise monitoring data indicated that sound levels were occasionally slightly above benchmark values, which is typical in populated urban areas. The occasional elevated noise levels were not attributable to Pickering NGS activities.

EcoRA Results

The EcoRA identified a number of plant and animal receptors known as Valued Ecosystem Components (VECs) to be assessed at their most exposed locations near or within the Pickering NGS site. The assessment of these receptors for the EcoRA focused on the nearshore in Lake Ontario, the Pickering NGS site, and Frenchman's Bay.

In addition to evaluating the effects of Pickering NGS emissions, the EcoRA also considered the thermal effects of the cooling water discharge, and impingement and entrainment of aquatic organisms at the cooling water intake.

Impingement - A certain number of fish are taken up in the water and caught in the screens that keep external objects and substances out of the cooling water - which results in the loss of those fish.

Entrainment - Occurs when very small fish eggs and small young are able to pass through the screens and are carried through the turbine condenser system.

In general, the EcoRA showed that the exposure levels for non-radiological contaminants are below benchmark values. Where benchmark values were exceeded, the effects are highly localized and therefore the receptor populations are not expected to experience any adverse effects due to non-radiological releases from Pickering NGS operations.

Radiation doses were calculated for fish, aquatic plants or invertebrates, and riparian birds and mammals at the Pickering NGS outfall and Frenchman's Bay; and for terrestrial plants or invertebrates, and terrestrial birds and mammals on the Pickering NGS site. Calculated doses were compared to accepted dose benchmarks for aquatic and terrestrial biota. The radiation doses calculated for all VECs at all locations were well below these benchmark values.

Overall, the Environmental Risk Assessment confirms that Pickering NGS continues to operate in a manner that is protective of human and ecological receptors residing in the surrounding area.

Fish Protection Programs

Pickering NGS takes cooling water (used to condense steam from the turbine) from Lake Ontario, via surface level water intakes in the lake.

Pickering monitors the fish that are impinged each week, identifying the fish species and reporting the estimated biomass of impinged fish to the CNSC each year.

To reduce the number of fish that are impinged, a fish diversion system, consisting of a net placed around the water intake, is installed in the ice- free seasons of the year. This system, shown in Figure 17, has reduced fish losses by more than 80%. The CNSC has set a target for the reduction of fish impingement, and this target has been achieved, with ongoing monitoring continuing to verify reductions in impingement.

Figure 17 - Fish Diversion System

To offset any losses, OPG has proposed three measures: two are habitat creation projects, one that has been completed in the Big Island Wetland in the Bay of Quinte, and the second to be created in the Simcoe Point Wetland near the outlet of Duffins Creek. The third project is OPG's contribution to the stocking of the Lake Ontario Atlantic Salmon Program, to which OPG is the lead sponsor from 2016 to 2020.

OPG applied to the federal Department of Fisheries and Oceans (DFO) for authorization for its continued operations and stabilization phases of the Pickering Nuclear facility. The application for this authorization included assessments of the impacts on aquatic species after the mitigations are in place, offsets such as habitat improvement, and engagement with concerned Indigenous communities. In January 2018, the DFO granted the authorization for Pickering NGS.

Finally, the thermal plume, or the area of warmer water that is created in Lake Ontario by the return of cooling water from its cycle through the turbine condenser, is assessed for a possible impact on the survival of Round Whitefish embryos.

It was determined that the thermal plume from the Pickering NGS is not having an adverse impact on Round Whitefish embryo survival. This is on account of the water temperature for all plume stations staying below the threshold effect level of 6 °C during the spawning and egg incubation period, and the reduction in survival at the plume stations was below 10%, which is the threshold for a no-effect level for those fish.

2.4.4 Biodiversity and Wildlife Habitat Protection

The Biodiversity and Natural Areas Management Program has been established to protect, maintain and enhance the natural environment around the Pickering site, including species and wildlife habitat. Initiatives under this program include the enhancement of wildlife corridors across the site, protection of species such as the peregrine falcon, and enhancement of the ecological value of natural areas on and adjacent to the Pickering site.

Pickering Nuclear's biodiversity program continues to provide planting, butterfly gardens, and numerous other initiatives. More than 15,000 native trees and shrubs have been planted in the vicinity of Pickering Nuclear since 2000 by OPG staff and community volunteers. In January 2017, OPG's Nuclear Operations received "Conservation Certification" for 2017-2019 from the international Wildlife Habitat Council, and Pickering Nuclear has twice been recognized as Wildlife Habitat of the Year.

OPG also contributes to habitat enhancement off the Pickering site in partnership with Environmental Stewardship Pickering. Projects under this initiative include the creation of a wildflower garden at a local school, tree planting events and the creation of habitat for birds and pollinators (such as bees). Other community activities, such as community workshops on gardening, habitat creation and environmental stewardship are also carried out.

Figure 18 - Tree planting activities

2.4.5 Waste Management

Pickering NGS has an effective waste management program that covers the management of conventional solid waste, hazardous and chemical wastes, as well as low-level radioactive waste and irradiated fuel. Solid waste materials are separated into conventional, hazardous and radioactive waste streams so that each type can be handled appropriately and impacts on humans and the environment minimized.

Irradiated Fuel Interim Dry Storage

When fuel is no longer useful for generating electricity, it is removed from the reactor and placed in a strong concrete, water filled "bay" for at least ten years until it is cool enough that it can be moved to dry storage. Dry storage is a safe method of passive storage that does not require active management for safety. The storage containers are made of concrete and steel; these containers are designed to last for 50 years, though studies show they can be used safely for much longer. Once they are filled the containers are sealed shut so they comply with international non-proliferation requirements. Pickering NGS has been storing used fuel in the Pickering Waste Management Facility (PWMF) since 1996, and to date has processed more than 330,000 bundles of spent fuel in 855 dry storage containers within three storage buildings on the Pickering site.

The PWMF is subject to CNSC regulation and licensing under separate regulations, and is not part of the operating Licence Application.

However, it is managed with consideration of the future needs of the Pickering station through to the end of the requested licence extension period. It is anticipated that shutdown activities following the end of commercial operation will increase the volume and types of waste that are generated, for a short period. An aspect of the Stabilization Activities Phase Planning is therefore concerned with ensuring that all hazardous wastes are removed from the station, packaged and disposed of appropriately in order to protect workers and the environment during this transition phase.

Figure 19 - Monitoring of waste for radioactivity

Low Level Radioactive Waste

Low level radioactive waste (LLRW) is made up of material such as cleaning items like mop heads, rags, paper towels, and protective clothing that is worn for routine operations in the nuclear station.

These items have low levels of radioactivity and do not require shielding for safe handling; they are packed in plastic bags and shipped to the Western Waste Management Facilitybeside the Bruce Nuclear Power Plant in steel containers for processing and storage.

If possible LLRW is compacted or incinerated to reduce the volume that needs to be stored.

To reduce the amount of LLRW that must be handled and stored, OPG removes plastic, wood, cardboard and other packaging from equipment before bringing it into the station, thus ensuring that these materials can be handled as conventional waste or recycled. Groups that produce waste are held responsible for their waste reduction strategies, and these are under continual evaluation and improvement.

Conventional, Hazardous and Chemical Wastes

OPG makes efforts to reduce the amount of solid conventional (non-radioactive) waste that it generates, through activities like recycling. It participates in organic waste segregation and blue box recycling. Non-hazardous, non-radioactive waste that cannot be recycled is sent to a public landfill.

Some hazardous wastes are generated at Pickering in operational and maintenance activities. These include cleaning agents, grease, oil, waste fuels and acids, as well as batteries and PCBs. Pickering's PCB Waste Management Program was inspected by Environment Canada in 2015, and the operation was found to be in full compliance with requirements.

2.4.6 Packaging and Transport of Radioactive Materials

Pickering has shipped many hundreds of shipments of radioactive material without any incidents resulting in a radioactive release, or in any serious personal injury due to a conventional accident. Radioactive material that is transported includes low and intermediate level waste, tritiated heavy water, and occasionally used fuel (for testing). Other materials that are transported include cobalt-60, associated with OPG's medical cobalt-60 production program, and radioactive devices such as radiography cameras.

OPG has a set of packages for radioactive materials, and maintains them to ensure that they comply with regulations. All packages, except those that are meant for a single use only, are maintained annually.

Maintenance procedures may require disassembly, visual inspection and replacement of worn parts, and each package is tested after maintenance to ensure that its containment is effective. Some older nuclear waste transportation packages are being replaced, and newer packages incorporate industry best practice and operating experience.

Some radioactive materials packages must be certified for specific uses, and OPG must receive CNSC confirmation that its intended use of a certified radioactive materials package has been registered. At present OPG is a registered user for 12 different package designs, including packages for intermediate level waste and tritiated heavy water transportation packages, and shipping packages from external agencies for used fuel, cobalt-60 and radiation devices such as radiography cameras.

Nuclear Transport Packages

Radioactive materials are transported in shipping containers referred to as packages. These are strong engineered containers that are built according to specifications in the CNSC's Packaging and Transport of Nuclear Substances Regulations. There are several different types of packages, which are meant to safely contain different types of radioactive substances as they are transported. For example, Type B packages for intermediate and high-level waste must be able to withstand a nine-metre drop onto an unyielding surface; a one-metre drop onto a steel pin; 30 minutes in an 800 degree celsius fire; and eight hours immersed in 15 metres of water. An example of a shipping container is shown below.

The transportation of nuclear materials must meet requirements of the Transport of Dangerous Goods (TDG) Regulations and the Packaging and Transport of Nuclear Substances Regulations. This activity at OPG is governed by the Radioactive Material Transportation (RMT) Program, operated by the Nuclear Waste Management division. As required by the TDG Regulations, employees who handle radioactive material for transport must hold a valid training certificate; and Type A and B radioactive shipments are reviewed and approved by an RMT Transportation Officer before they leave the site.

2.5 Pickering NGS Will Continue to be Transparent and Engage with the Public and Indigenous Communities

The activities and programs described in this Section are not related to an SCA, but to the CNSC's Licensee Public Information Program requirements, which are discussed in Section 3 of the Licence Application.

2.5.1 Public Information Program

OPG recognizes that members of the public, stakeholder groups, and local communities have a legitimate interest in the operations of the Pickering NGS; the way in which it is operated and managed; and the means by which OPG keeps the risks to human health and safety, and to the environment, at a low level. OPG therefore shares information on facility operations and performance with members of the public, to enable interested individuals to monitor the safety of the plant and OPG's management record. OPG also works to develop positive relationships with local communities, including those in the vicinity of the Pickering facility and Indigenous communities, as well as with stakeholder groups that have a longstanding interest in the safety of nuclear power.

These activities are of several types. First, OPG publishes facility operational and performance data from monitoring and other processes, for anyone to access. Second, it provides a large amount of background and other information on nuclear power and on the Pickering NGS operation, both online and at its facilities in Pickering, Ontario.

Third, it establishes and maintains positive relationships with the people in the nearby communities and works to improve and maintain the local environment. Finally, it has developed a program to consult with Indigenous communities that have an interest in the Pickering facility and with the land on which it lies.

Station Reporting and Performance Data

OPG uses its public website to provide up-to-date information on the performance of the Pickering station, on environmental assessments, projects, probabilistic safety assessment summaries, and regulatory information such as licensing hearings.

Data and other information on the Pickering NGS from environmental monitoring programs is also made available to the public through OPG's public website. Monthly environmental emissions data have been published on the OPG website since 2014. The information reported includes radiological emissions to air and water, waste management facility monitoring results, and spills to the environment. In addition, OPG's annual reports to the CNSC on the Environmental Monitoring Program are available to the public on the OPG website.

OPG Nuclear and Pickering Nuclear Performance reports are produced quarterly. OPG posts performance reports on station operations on a quarterly basis on its website, at **www.opg.com**. Information is also shared electronically with key stakeholders, and ads on station performance are placed in local newspapers. Additionally, starting in 2014 OPG developed and began issuing a quarterly Environment report in an easy to read format.

OPG regularly and proactively provides information to the public on its facility activities. For operational status changes or unscheduled operations that may cause public concern or media interest, OPG follows a protocol to provide prompt notification of key community stakeholders. OPG maintains a duty on-call position 24 hours a day, seven days a week.

In conjunction with the Durham Emergency Management Organization, OPG notifies key community stakeholders of activities or events that may be of interest to the public or media. This is to ensure that the emergency agencies (fire, police, and emergency management) and political offices are aware of events so they can respond accurately if they receive questions from constituents.

Background and Educational Information

OPG provides background and educational information on many aspects of nuclear power in forms that are accessible to the public, including brochures and factsheets. The website also serves as a means of interaction with members of the public and stakeholder groups, through contact links. OPG provides a quick response to issues and questions raised by stakeholders and the public, and tracks these to become aware of interests, concerns and other emerging issues on which it may want to engage.

Pickering NGS maintains an Information Centre where members of the public and school visitors can receive information on current operations and issues, and have questions addressed by an OPG staff member. Students are offered curriculum-based educational presentations and are free to review the material in the centre.

OPG hosts annual information sessions for the local and regional communities, which are widely advertised in the community and in nearby Toronto. Staff from OPG, the Canadian Nuclear Safety Commission (CNSC), the Region of Durham, the City of Toronto Emergency Management Office, and the Office of the Fire Marshal and Emergency Management have been present to answer questions and provide information about safety and station operations. As well, Pickering Nuclear provides presentations and tours to community groups, key stakeholders, industry partners and the general public.

Ads on station activities and community events are also run in newspapers and aired on local television stations. 120,000 copies of Pickering Neighbours newsletter are distributed quarterly to all residents and businesses in the City of Pickering, Town of Ajax and Toronto East.

Community Consultation and Environmental Activities

Pickering Nuclear works with the local communities on matters of interest and concern related to the nuclear station, as well as on the local environment.

The Pickering Community Advisory Council (CAC) meets monthly to exchange information and provide advice to senior plant management on issues of environmental, economic and public concern. Media attends and reports on the meetings.

Pickering Nuclear has a representative on the Durham Nuclear Health Committee (DNHC) and OPG Nuclear staff makes regular presentations to the DNHC on a variety of environmental, community outreach and operational issues.

They also discuss matters of interest with committee members and observers.

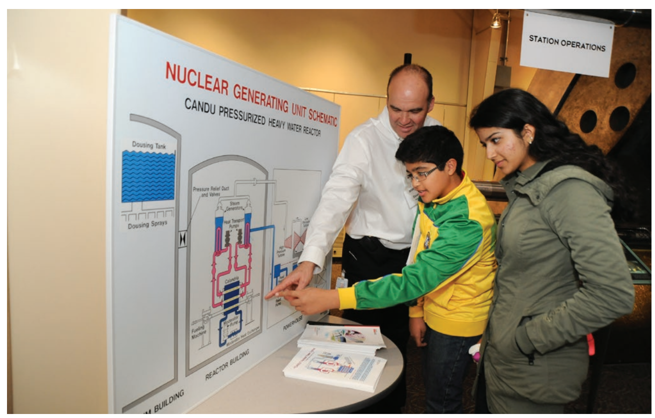


Figure 20 - Open house and public awareness

In order to learn concerns and interests of members of the community and broader public, Pickering conducts focus groups; for example, focus groups were held in support of direct mail campaigns for emergency preparedness, and in relation to emergency exercises. The Public Information Centre is open every weekday and members of the public are welcome to drop in and talk to staff about nuclear energy and the safe operation of the Pickering station.

Pickering Nuclear also engages in more general community outreach activities as a way of becoming involved in the community in which it operates, and in which many of its staff live. OPG encourages community groups to use the Information Centre for events unrelated to the industry. Its meeting room and event space were built to help build greater ties to the community.

Since 2006, Pickering Nuclear's Corporate Relations and Communications division has provided a community-based program known as "Tuesdays on the Trail", reaching over 16,000 community members on Tuesdays throughout the summer months of July and August at Alex Robertson Park, which is adjacent to the Pickering Nuclear site. Information about station operations and public waterfront trails is distributed to new residents in the Pickering and Ajax community via the Welcome Wagon.

Figure 21 - Tree Planting near the Pickering site

Finally, OPG recently held external stakeholder engagement sessions with over 30 external groups including municipalities, community groups, and environmental groups. These included full-day and half-day sessions to increase awareness of Pickering relicensing efforts and to provide a forum to discuss key topics of public interest (for example, Periodic Safety Review, Emergency Preparedness, and Environment).

2.5.2 Engagement with Indigenous Communities

OPG acknowledges the Aboriginal and Treaty Rights of Indigenous communities as recognized in the Constitution Act, 1982. Under its Indigenous Relations Policy, OPG regularly undertakes engagement with Indigenous communities with asserted or established Aboriginal and Treaty Rights and/or interests in the vicinity of Pickering NGS. These communities include:

- Members of the Williams Treaties First Nations, including
    - Scugog First Nation
    - Hiawatha First Nation
    - Curve Lake First Nation
    - Alderville First Nation
- Mississaugas of the New Credit First Nation
- Mohawks of the Bay of Quinte
- Métis Nation of Ontario, Region 8

OPG holds regular meetings with these Indigenous communities to provide them with details of nuclear operations and reports, and to discuss interests and identify concerns over current and future operations. OPG also maintains a listing on a designated external website of all relevant documents and notices of events such as the Pickering NGS licence renewal, and notifies the communities of updates on the site when they occur.

Beginning in 2015, OPG began a renewed series of conversations on the ways in which Indigenous communities near Pickering NGS wish to be engaged. Topics of interest included the information that should be provided and discussed; the frequency of meetings; and the support needed to enable communities to understand potential impacts of station operations or concerns. The scope of the engagement was discussed and agreed upon, consultation protocols were reviewed, representatives were identified, and work objectives were outlined.

Figure 22 - OPG staff on tour with First Nations community

As a part of OPG's overall engagement with the Indigenous community as a whole, tours have been undertaken by Indigenous communities that have rights or interests in current and planned OPG Nuclear and related operations. There were two tours for Indigenous communities in 2016 of the Pickering Waste Management Facility, with twenty-two participants. There was also a tour for Williams Treaties First Nations representatives on January 19, 2017.

At their request, OPG held community information sessions with the Williams Treaties Curve Lake and Hiawatha First Nations in August 2016. The sessions covered a number of issues, including the Pickering Waste Management Facility (PWMF) and Pickering site licensing processes.

OPG also met with representatives of the Williams Treaties First Nations, Mississaugas of New Credit, Mohawks of the Bay of Quinte and the Métis Nation of Ontario Region 8 between January and March 2017 regarding OPG's mitigation and off-set measures for fish impingement and entrainment. Further engagement on this topic and others, with an emphasis on Pickering re-licensing, was undertaken between September 2017 and February 2018.

Additionally, OPG participated in the second annual Aboriginal Apprenticeship Board of Ontario (AABO) Day in the Trades event, hosted by LiUNA Local 183 at their facility in Cobourg. Representatives from various building trades, suppliers and contractors interacted with Indigenous high school students from the communities as diverse as the Mohawks of the Bay Quinte, Curve Lake First Nation, Pikwakanagan First Nation and Durham Region Métis.

The OPG Native Circle, made up of Indigenous employees, organizes and hosts the annual National Aboriginal Day celebrations every June and oversees the John Wesley Beaver Memorial Awards for Indigenous post-secondary students. The Native Circle serves, in part, as a connection to the wider Indigenous community and participates in various Indigenous events such as the annual Indspire career fair, of which OPG is a sponsor.

Indigenous community representatives have expressed a number of concerns about operations and activities at the Pickering plant. These are described below, along with planned discussions with OPG on the issue.

- Transportation and storage of nuclear waste: OPG continues to provide information to communities, and additional information sessions are being planned on OPG's Transportation Emergency Response Plan.
- Emergency preparedness and the ability for community members to be notified: OPG has provided information on notification protocols by OPG and appropriate authorities.
- Environment and fish impact as a result of operations: OPG has made many presentations on work it has completed to reduce fish impingement and entrainment at the Pickering station.
- Potential outcomes of an event that could impact traditional First Nation and Métis territories: recognizing the close relationship these communities have with the land, OPG continues to provide information on the risks of station operations, on the lessons learned from the Fukushima event in Japan and the actions that have been applied as a result.
- A desire to remain involved in future environmental monitoring opportunities: OPG commits to ongoing, participatory engagement with communities, and to their involvement in actions that result from them. OPG will also appropriately confirm the environmental impacts of operations at Pickering.

- An expressed interest in economic opportunities through procurement and employment through OPG's nuclear operations: as part of its Silver designation from the Canadian Council for Aboriginal Business' Progressive Aboriginal Relations (PAR) program, OPG is working to improve its business procurement and employee recruitment with local Indigenous communities.

2.6 Continued Investments will Further Improve Pickering Safety, Reliability and Fitness for Service until 2024

Continued investment at Pickering addresses many different systems and programs including the Safety and Control Areas of the Management System (Licence Application Section 2.1), Human Performance Management (Licence Application Section 2.2), Environmental Protection (Licence Application Section 2.9), and the Security and Safeguards and Non-Proliferation SCAs (Licence Application Sections 2.12 and 2.13).

As noted above in Sections 1 and 2.1, OPG has implemented a number of safety improvements to which it committed as a follow-up to the previous Pickering licence renewal in 2013.

During that licence renewal process, OPG indicated that it would continue to invest in the Pickering plant to improve safety and reliability through to the end of commercial operation. At that time, in addition to the regulatory work to ensure safe operation of the fuel channels, OPG committed to including $200M in the business plan, for reliability improvements (Reference 9). Over the course of four years from 2011 - 2014, OPG completed reliability improvements to equipment, material condition improvements to the plant, and additional inspection and maintenance activities to confirm fitness for service of major components in the life extension period. Additionally, 2000 reliability and material condition improvements were completed, including 129 pumps, 106 motors, and 688 valves. Completion of this maintenance helps to ensure that the station will operate reliably to deliver important, low-cost virtually carbon free power until the end of commercial operation.

As part of the current Licence Application process, OPG continues to commit to ongoing investments in the Pickering plant as required and reasonable to further mitigate the already low plant risk and to add reliability enhancements. For example, investments of $307 M are planned from 2017 to 2020 for additional equipment inspections, the implementation of the PSR2 modifications (eg., Pickering 1,4 fire water supply to the steam generators, heat transport system, and the interconnection of Pickering 1,4 and 5-8 fire water systems) and equipment reliability upgrades.

Investments to improve environmental protection include the completion of a dyke associated with the emergency coolant injection system to reduce the risk of oil spills, and the installation of improved sewage sump pumps with an additional switch to prevent overflows. Mitigation measures to minimize fish impingement through the use of the fish diversion system will continue, as will verification of its effectiveness. OPG has committed to fisheries productivity offsetting measures, with the construction of a habitat creation project in the Simcoe Point Wetland and the ongoing salmon stocking program.

Nuclear security will also be maintained, with initiatives to enhance the Security Monitoring Room by 2019 in order to improve response capability.

There will also be continued investments in nuclear safety emergency preparedness drills and exercises.

In accordance with the emphasis on the safety and reliability of the Pickering plant through the licence period, OPG will continue to commit resources and invest in plant operations and improvements. Innovation will continue to be encouraged and supported through the operating period. Employees in the X-Lab have recently developed innovative technologies for application in equipment maintenance and repair, battery monitoring and maintenance, and training programs. These innovations will improve safety, effectiveness and efficiency in many areas of station operations.

Sufficient qualified staff required to operate the station and to maintain safety at the plant will be retained through to the end of commercial operation. This includes the maintenance of certification training and examination resources, and training programs that are provided regularly to all workers.

3. Safety and Control Areas

The 14 Safety and Control Areas (SCAs) are a set of technical areas that the CNSC uses to assess, evaluate, review, verify and report on regulatory requirements and performance. The performance of Pickering NGS in meeting the requirements of each SCA is discussed in detail in the Licence Application (Reference 1). A summary is provided in this document.

OPG also provided supplementary information in support of the Licence Application in response to CNSC staff requests for additional information (Reference 2). It was noted in that submission that the Licence Application, together with the supplementary document, contains the information to demonstrate that Pickering NGS meets all of the legal requirements of the NSCA and the associated regulations, and demonstrates that OPG is qualified to carry on the licensed activities and makes adequate provisions to protect the health, safety and security of persons, and the environment and maintain international obligations.

The following provides a brief description of the SCAs, highlights strengths and noteworthy achievements in these areas, and updates information contained in the Licence Application to reflect 2017 results. The updated information is provided under Licence Application heading titles and numbers. These SCA Sections should be read in conjunction with the full information provided in the Licence Application.

3.1 Management System

The OPG Nuclear Management System provides a framework that establishes the processes and programs required to ensure OPG achieves its safety objectives, continuously monitors its performance against these objectives, and fosters a healthy safety culture. Monitoring of OPG's performance takes place at several levels, including at the industry level where experts from various utilities worldwide perform a peer review of their nuclear stations. Internally, OPG has a well-established corrective action program, incorporating self-assessments, benchmarking, and independent audits through its Nuclear Oversight Division.

These elements of the management system, including the organizational structure which supports it, are discussed in further detail in Section 2.1 of the Licence Application.

Pickering's management system meets or exceeds all regulatory requirements and related objectives: it is mature and effective, enabling OPG to monitor and manage performance against performance and other safety objectives, and to maintain a healthy safety culture.

Highlights

OPG's Management System ensures high performance...

- ✓ Strong safety culture is fostered and periodically evaluated
- ✓ Effective internal and external oversight
- ✓ Centre-led organization for efficiency and accountability

The following updates information contained in the Licence Application to reflect 2017 results. The Licence Application Section number and heading are reproduced below, followed by the updated information.

Licence Application Section 2.1.11 – Business Planning

Major Projects

OPG document, OPG-PROG-0039, Project Management replaces document N-PROG-AS-0007, Project Management.

3.2 Human Performance Management

Human performance management includes the activities that enable effective performance of staff, through the development and implementation of processes that ensure a sufficient number of licensed personnel in all relevant job areas with the necessary knowledge, skills, procedures and tools to carry out their duties. Additional information on Human Performance Management can be found in Section 2.2 of the Licence Application.

The Human Performance Management Program is intended to ensure safe and reliable station operation, and minimize and reduce the frequency and severity of events of consequence. The strategy involves the use of systematic approaches to reducing human error, and methods to achieve zero events of consequence.

Highlights

OPG's human performance programs ensure...

- ✓ Consequential events resulting from human error are prevented
- ✓ Training provides staff with required knowledge and skills
- ✓ Industry demographic challenges are addressed through knowledge management and retention strategies

The following updates information contained in the Licence Application to reflect 2017 results. The Licence Application Section number and heading are reproduced below followed by the updated information.

Licence Application Section 2.2.1 - Human Performance Management Program

As seen in the Figure 23, in 2016, Pickering had 1 Site Event Free Day Reset (SEFDR) event against a target of 2. The 2017 SEFDR target remained at 2, but after a strong first half of the year 5 SEFDRs occurred in a three-month span (Aug - Oct 2017). Notwithstanding the recent spike in these events, the overall reduction in SEFDR over the past licensing period speaks to the improvements implemented under the human performance strategic plan and the ability of the Station Leadership Team to recognize weaknesses and address them.

Site Event Free Day Resets (SEFDR)

The SEFDR value is the number of human performance errors that result in events with significant consequences within a given period; it is an industry-wide measure of the effectiveness of organizational safety and other human performance programs.

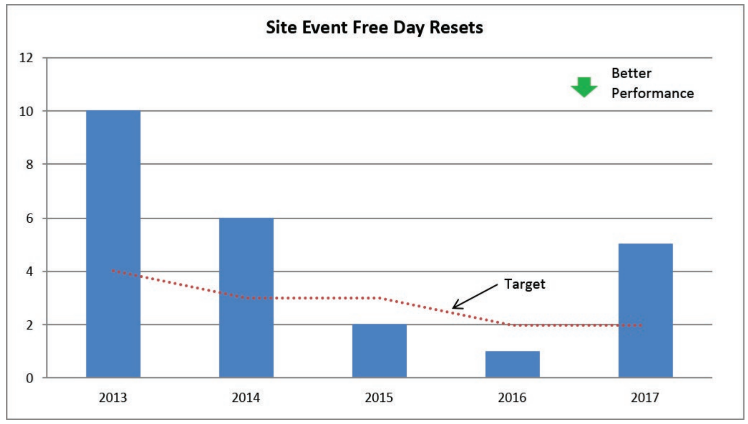


Figure 23 - Pickering Site Event Free Day Resets

Planned Improvements

As a result of the 2017 performance trend Pickering initiated a station wide stand down to highlight the significance of these events to staff, and increased Human Performance communications involving a "back to basics" campaign.

In addition, focus groups are used to identify opportunities for improvement and lessons are shared within the broader station team.

Licence Application Section - 2.2.2 Personnel Training

Operations Training

At the end of 2017, there were 384 qualified operators at Pickering including 64 supervising nuclear operators and 20 field shift operating supervisors. There are 72 operators in the initial training program, and all qualified operators participate in the continuing training program

Licence Application Section - 2.2.7 Applicable OPG Documents

Effective August 2017, procedure N-PROC-OP-0047, Limits of Hours of Work replaced the previous procedure, N-PROC-HR-0002, Limits of Hours of Work.

3.3 Operating Performance

The Operating Performance SCA includes an overall review of the conduct of the licensed activities and the activities that enable effective operating performance. Pickering's Operations Program ensures that plant operation is safe and secure, and gives appropriate and adequate attention to health, safety, security, radiation protection and environmental protection. More information on the Operating Performance SCA is available in Section 2.3 of the Licence Application.

Operations leadership establishes safe, uniform and efficient operating practices and processes at Pickering NGS to enable nuclear professionals to operate the facility in accordance with the Licence, Operating Policies and Principles, and applicable regulations and requirements. It does this through a series of standards and procedures for safe reactor operation.

Plant Operational Focus, defined as organizational behaviours that are necessary for highly safe and reliable operation, is used at Pickering to ensure that Operations leaders are providing appropriate oversight of work management processes. This ensures the risks to plant operation due to equipment deficiencies are appropriately addressed.

Highlights

Pickering has improved operating performance...

- ✓ Committed to continuous improvement
- ✓ Supervisors and managers reinforce high standards
- ✓ Reliable operation resulting in low forced loss rate

The following updates information contained in the Licence Application to reflect 2017 results. The Licence Application Section number and heading are reproduced below followed by the updated information.

Licence Application Section - 2.3.2 Plant Status Control

One measure of plant status control is a misposition, which refers to a component being off its baseline position without documented approval; a component is operated incorrectly; or the incorrect component is operated. Mispositions are reviewed to learn the organizational or individual reasons behind the event and to identify actions to prevent similar events in the future.

Misposition events are categorized as Level 1, Level 2 or Level 3 events, with Level 1 being the most significant. Pickering has experienced a significant reduction in Level 1 and Level 2 mispositions over the last five years.

Figure 5 in Section 2.3.2 of the Licence Application shows Pickering performance regarding misposition events for 2013 to 2016. For 2017 Pickering has achieved the following performance: 0 Level 1 events; 2 Level 2 events; and 32 Level 3 events.

3.4 Safety Analysis

OPG maintains and routinely updates the safety analysis that supports the overall safety case for Pickering NGS. This safety analysis consists of a systematic evaluation of the potential hazards associated with the operation of Pickering NGS, and considers the effectiveness of preventative measures and strategies in reducing the effects of these hazards. Deterministic safety analysis demonstrates compliance with CNSC public dose limits for internal and external design basis events, such as piping failures and seismic events. Probabilistic safety assessment is a comprehensive set of models of plant systems and operator actions in response to postulated abnormal events. This analysis demonstrates that the public risk from Pickering NGS remains low. More information on the Safety Analysis SCA is available in Section 2.4 of the Licence Application.

Highlights

OPG has demonstrated that Pickering is a safe plant...

- ✓ Comprehensive safety analysis demonstrates likelihood of a serious accident remains very low
- ✓ PSA concludes low and continued reduction in public risk
- ✓ Emergency Mitigating Equipment significantly reduces risk

The following updates information contained in the Licence Application to reflect 2017 results. The Licence Application Section number and heading are reproduced below followed by the updated information.

Licence Application Section - 2.4.2 Deterministic Safety Analysis

The deterministic safety analysis is being updated in compliance with a new REGDOC-2.4.1, Deterministic Safety Analysis approved during the last licence period, by including an appendix for common cause events (CCE) analysis in the Pickering Safety Reports. The two new Safety Report appendices for CCE analysis were completed and submitted to the CNSC in December 2017 (Reference 10) to address the single largest enhancement required for REGDOC-2.4.1. OPG's REGDOC-2.4.1 Implementation Plan was also updated to cover the period of 2018 - 2021 to focus on aspects for which safety margins can be improved. OPG has considered the Darlington experience during implementation of REGDOC-2.4.1 when determining the potential analysis upgrades for Pickering, as reflected in the revised REGDOC-2.4.1 Implementation Plan submitted to the CNSC in November 2017 (Reference 11).

Licence Application Section - 2.4.5 Probabilistic Safety Assessment (PSA)

Probabilistic Safety Assessment

In the PSA framework, risk is characterized in terms of the frequency of two event categories: "severe core damage" and "large release."

Severe core damage refers to a category of events whereby failure of both fuel and fuel channels can occur. Large release refers to a category of events that can lead to a significant radiological release to the environment. Large release requires severe core damage with coincident failure of containment.

"Safety Goals" refer to a set of numerical values, expressed in terms of the frequency of severe core damage or large release events, against which the safety of nuclear reactors can be judged. These goals represent the high standards of safety and reliability for nuclear power plant operations and are summarized below in Table 2.

OPG Safety Goals		
	Administrative Safety Goal	Safety Goal
Severe Core Damage Frequency (per hazard, per unit)	10^{-5}	10^{-4}
Large Release Frequency (per hazard, per unit)	10^{-6}	10^{-5}

Table 2 - OPG Safety Goals Expressed as a Frequency

Both the Pickering A (Units 1 and 4) Risk Assessment (PARA) and Pickering B (Units 5 to 8) Risk Assessment (PBRA) are performed in accordance with CNSC Standard S-294, Probabilistic Safety Assessment (PSA) for Nuclear Power Plants. The S-294 compliant PBRA was first completed in 2012 and the S-294 compliant PARA was first completed in early 2014.

The Pickering B PSA was updated and submitted in 2017. The updated 2017 PBRA addresses Level 1 and Level 2 PSA aspects for various internal and external events, for both at-power and outage operating conditions, including internal events, internal fire, internal flood, seismic, high winds, as well as an external and internal hazard screening assessment.

The PBRA reports submitted to CNSC staff in 2017 demonstrate that Pickering B satisfies safety goals for all internal and external hazards, and hence represents very low public risk.

The 2018 PARA update is currently in progress. The previously submitted PSA results satisfied OPG's safety goals and it is expected that the 2018 PARA will also satisfy OPG's safety goals for all internal and external hazards considered.

OPG continues to meet industry best practices through periodic updates to account for operating experience and changes at the station.

Summary of 2017 PBRA Update

The baseline 2017 PBRA update incorporates enhancements under the OPG Fukushima Action Plan, in particular Phase 1 emergency mitigating equipment (EME). The impact of Phase 2 EME has also been considered as a sensitivity case as Phase 2 modifications have been recently implemented.

The severe core damage frequency (SCDF) and large release frequency (LRF) values shown below are within the safety goals for each of the internal and external hazards considered in the 2017 PBRA update. The benefits of EME are incorporated into the baseline 2017 PBRA results for SCDF and LRF as shown in Tables 3 and 4, respectively.

Summary of 2018 PARA Update

The baseline 2018 PARA update will incorporate enhancements under the OPG Fukushima Action Plan, in particular Phase 1 emergency mitigating equipment (EME). The impact of Phase 2 EME will also be considered in a sensitivity cases as Phase 2 modifications are implemented.

The SCDF and LRF values shown below are within OPG's safety goal for each of the internal and external hazards. Since the 2018 PARA is in the process of being updated, the values summarized in the tables below are the most current baseline results available for PARA.

Severe Core Damage Frequency (x 10^{-5} per reactor-yr)		
PSA Hazards	**2017 PBRA Baseline (with EME)**	**Current PARA Baseline (with EME)[1]**
Internal Events at Power	0.10	0.88
Internal Events during Outage	0.06	0.66
Fire at Power	0.06	1.5
Flood at Power	0.02	0.56
Seismic Event at Power	0.10	0.18
High Winds at Power	0.12	0.30
Safety Goal	10	10

Table 3 - Severe Core Damage

Large Release Frequency (x 10^{-5} per reactor-yr)		
PSA Hazards	**2017 PBRA Baseline (with EME)**	**Current PARA Baseline (with EME)[1]**
Internal Events at Power	0.08	0.17
Internal Events during Outage	Approx. 0	0.01
Fire at Power	0.04	0.23
Flood at Power	0.01	0.09
Seismic Event at Power	0.10	0.04
High Winds at Power	0.10	0.07
Safety Goal	1	1

Table 4 - Large Release Frequency

Footnote [1] The current PARA baseline results are taken from the later of 2013 S-294 PSAs or the 2014 Fukushima Action Plan updated PSAs. The exception is Level 1 Internal Events At-Power, which has been updated for 2018, and the Internal Fire for At-Power results, which are from the Pickering risk improvement action plan assessments.

Whole-Site Risk

Standard current PSAs, and safety goals, are based on a single reactor unit. However, at Pickering's 2013 licence hearing, views were expressed that the risks should be assessed and reported for incidents involving more than one unit at a station, (i.e., providing one risk number for all units on the site). Such a risk estimate is referred to as "whole-site" risk estimate.

OPG has recently completed a whole-site risk assessment for Pickering, fulfilling a commitment to the CNSC to conduct such an assessment by the end of 2017. The conclusions of this assessment provide further support to the assurance that the risk of the whole Pickering site is low. Further details are provided in Section 2.1.2 of this document and in Addendum C.

Licence Application Section - Appendix F – CANDU Safety Issues

A safety issue is defined as an issue related to the design or analysis of a nuclear power plant that has the potential to challenge safety functions, safety barriers or both.

An initial list of issues was developed by the CNSC using the IAEA TECDOC-1554 "Generic Safety Issues for Nuclear Power Plants with Pressurized Heavy Water Reactors and Measures for their Resolution", and each issue was classified by the CNSC in 2007 into one of three categories:

- Category 1: Not an issue in Canada.
- Category 2: The issue is a concern in Canada. However, the licensees have appropriate control measures in place to address the issue and to maintain safety margins.
- Category 3: The issue is a concern in Canada. Measures are in place to maintain safety margins, but further experiments and/or analysis are required to improve knowledge and understanding of the issue, and to confirm the adequacy of the measures.

The CNSC confirmed that the safety case for CANDU reactors was not in question but identified control measures for these categories to address any residual concerns on nuclear safety.

At present, Pickering has four Category 3 issues pending CNSC re-categorization. One issue is on Non-Large Break Loss of Coolant Accident (LBLOCA) and three issues are related to LBLOCA.

OPG continues to work with the CNSC to address the outstanding CANDU safety issues to improve knowledge and understanding of the issue and confirm the adequacy of the measures in place to maintain safety margins.

3.5 Physical Design

The Physical Design SCA includes activities that impact the ability of structures, systems and components to meet and maintain their design basis, given new information arising over time, and taking changes in the external environment into account. OPG has a program to maintain the design basis that assures that the structures, systems and components at Pickering remain available, reliable, effective and consistent with design, analysis and quality control measures. Additional information on this SCA is available in Section 2.5 of the Licence Application.

There are no significant recent changes in plant design to update since the Licence Application, however Addendum A on the PSR outlines changes to be made in plant design during the upcoming licence period.

Highlights

Pickering's design proven to be solid...

- ✓ Defence in depth approach
- ✓ Rigorous process for plant modifications

3.6 Fitness for Service

OPG has several programs in place to ensure systems, structures, and components credited in licensing documents are fit for service and continue to satisfy their design intent over time in accordance with applicable CNSC regulatory documents and CSA standards. These programs ensure all equipment is available to perform its intended design function when called upon to do so.

Routine on-power maintenance activities are performed on a daily basis, while other more complex tasks or inaccessible equipment require a unit shutdown, or 'outage' to perform required repairs or inspections. Various programs address long-term equipment reliability, including component surveillance, work management, and aging management programs. Major components such as fuel channels, feeders, and steam generators have specific life cycle management plans to address aging issues and code requirements, which are communicated to CNSC staff on a routine basis. The various elements of the overall OPG fitness for service program are discussed in further detail in Section 2.6 of the Licence Application.

Highlights

Fitness for service of major components is confirmed...

- ✓ Equipment is well maintained to ensure performance requirements are met throughout life of plant
- ✓ Fuel channels are fit for service to end of station life
- ✓ Periodic inspections confirm major components remain fit for service

The following updates information contained in the Licence Application to reflect 2017 results. The Licence Application Section and heading are reproduced below followed by the updated information.

Licence Application Section - 2.6.1 Equipment Reliability

The Equipment Reliability Index (ERI) is an industry standard indicator used to reflect overall station equipment reliability, and assess the health of a plant reliability program.

Pickering's ERI score for the fourth quarter of 2017 was 78 against a target of 81. This represents a 4-point increase from the 2017 third quarter performance. Efforts to reduce the corrective maintenance backlog on key components to zero, and improvements to the preventive maintenance program through station initiatives like value based maintenance, have helped Pickering improve ERI performance over the licence period as shown in Figure 24 below.

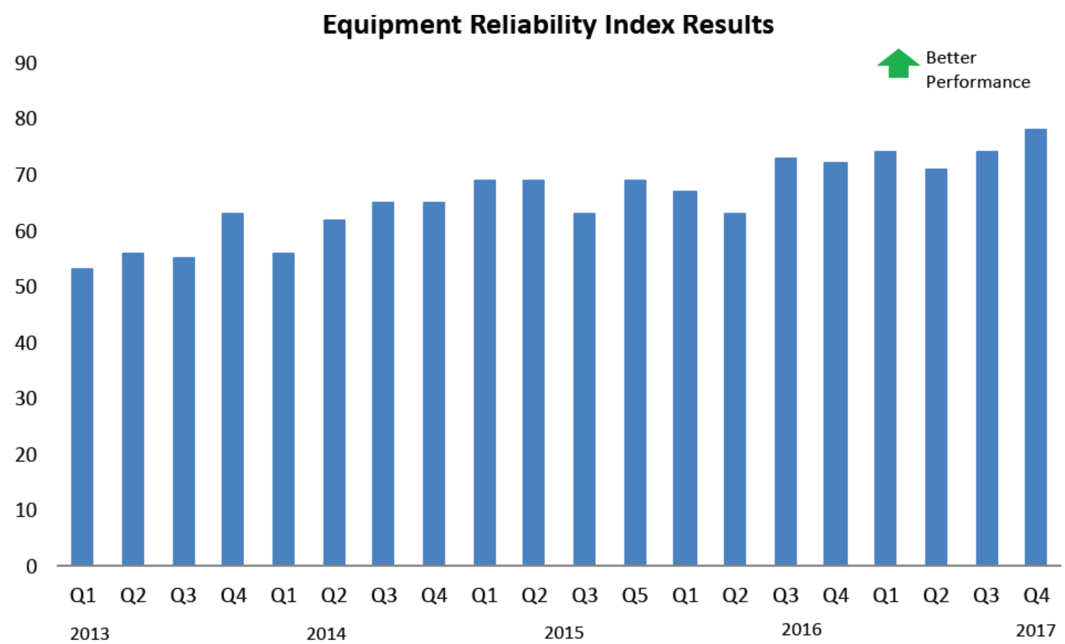


Figure 24 – Pickering Equipment Reliability Index 2013 - 2017

An improved ERI score is also reflected in an improvement (reduction) in forced loss rate (FLR), a measure of the amount of unplanned production losses in a period of time. Three straight years of strong performance (2015 to 2017) for Pickering NGS (with 2015 the best in the history of the plant) demonstrates how much the investments made can and will enable strong performance to the end of life.

Licence Application Section - 2.6.6 Chemistry Control

The Chemistry Performance Index (CPI) compares the concentration of selected impurities and corrosion products to corresponding limiting values, with focus on the steam generator demineralized water system chemistry.

As shown in the Figure 25 below, the trend shows improving performance. This is a reflection of combined efforts to improve the demineralized water treatment plant performance, as well as to improve start-up chemistry and outage practices, and to eliminate lake water getting into the steam generator demineralized water system via the steam condensers.

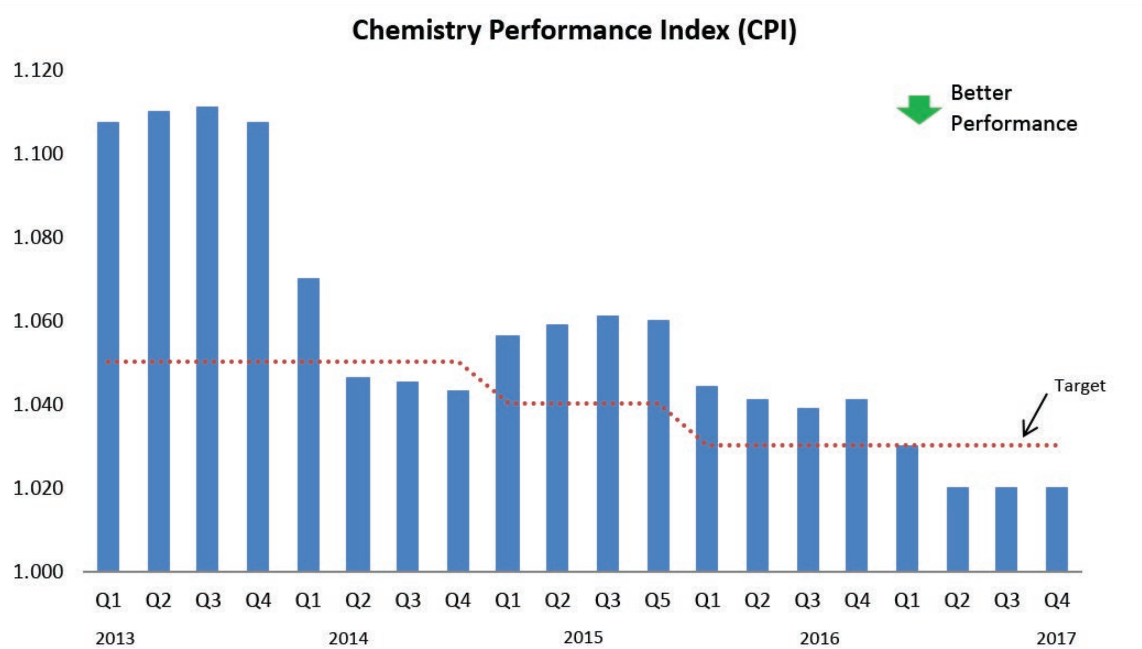


Figure 25

Licence Application Section - 2.6.8 Fuel Handling Reliability

Pickering NGS Fuel Handling developed a reliability plan in 2012/2013 focused on specific equipment areas. From 2014 onwards, annual self-assessments have been performed to analyze the overall effectiveness of the plan. This plan has been modified over the years to best reflect the station's needs.

The unplanned loss of production due to fuel handling equipment being unavailable is a primary indicator of fuel handling equipment reliability. The forced loss rate related to fuel handling equipment in 2016 was 1.54%, and 2.32% in 2017. This is historically good performance for OPG's fuel handling equipment that shows OPG can improve plant reliability to the end of planned operation.

Licence Application Section - 2.6.9 Maintenance Backlog

It is a priority to ensure that the backlog for Corrective Critical (CC) and Corrective Non-Critical (CN) maintenance tasks remains low, so that important preventive maintenance programs can be conducted and system redundancy maintained.

Figure 8 in Section 2.6.9 of the Licence Application shows Pickering performance regarding backlogs for 2013 to 2016. The Corrective Critical and Corrective Non-Critical work orders per unit at the end of 2017 is 24.5 against a target of 28 (i.e., better than target).

3.7 Radiation Protection

The over-riding objective of the Radiation Protection Program at Pickering is the control of occupational and public exposure to radiation. For the purposes of controlling doses to workers, this program has four implementing objectives:

- Keeping individual doses below regulatory limits
- Preventing unplanned exposures
- Keeping individual risk from lifetime radiation exposure to an acceptable level
- Keeping collective doses As Low As Reasonably Achievable (ALARA), social and economic factors taken into account

The various elements of the Radiation Protection Program are discussed in detail in Section 2.7 of the Licence Application.

OPG's Radiation Protection Program ensures...

✓ Pickering's radiation safety performance among industry best

✓ Employee radiation dose always kept well below regulatory limits

The following updates information contained in the Licence Application to reflect 2017 results. The Licence Application Section and heading are reproduced below followed by the updated information.

Licence Application Section - 2.7.2 Application of ALARA

ALARA – keeping risks As Low As Reasonably Achievable, taking social and economic factors into account – is a risk control strategy that is applied in the nuclear industry and other industrial settings. It focuses on reducing risks as low as practicably possible, even when regulatory limits have already been achieved.

The Pickering ALARA strategy includes the setting of annual targets for collective doses – the aggregated doses received by all workers and staff, as well as contractors and visitors - from all work at Pickering, and the identification of actions and programs for the achievement of these targets. Annual targets take into account planned maintenance outage scope, past performance, and anticipated dose savings from planned initiatives and application of ALARA techniques. As work is planned in more detail, collective dose projections are reviewed and actions taken to ensure dose is ALARA. Actual performance against targets is reviewed and corrective actions taken where expectations are not met. Figure 26 below shows a summary of results over the current licence term.

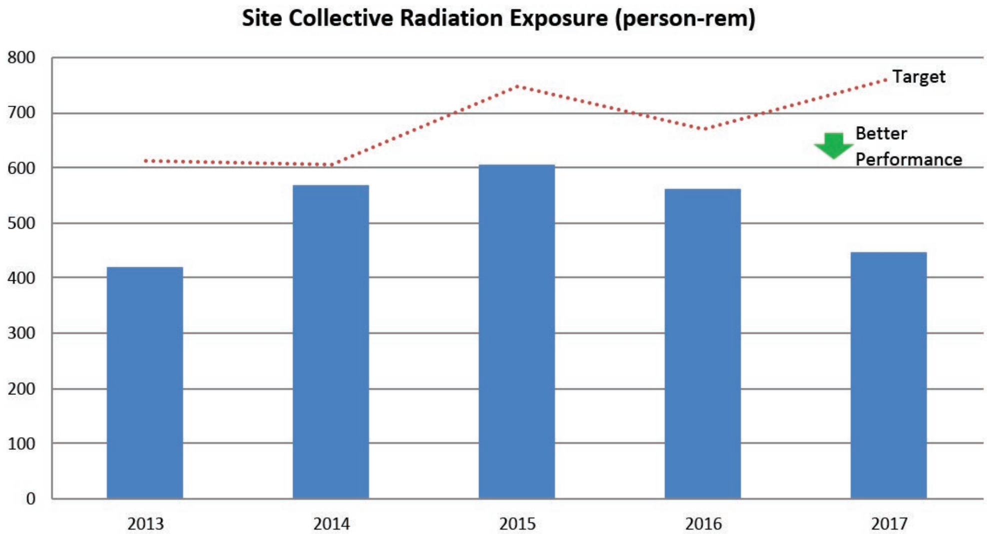


Figure 26 – site collective radiation exposure Note that 100 rem is equivalent to 1 Sv.

Licence Application Section - 2.7.3 Worker Dose Control

Since 2013, there has been continued strong performance in the performance indicators related to worker dose control such as the number of Electronic Personal Dosimeter (EPD) dose alarms (alerting a worker to a higher than expected radiation exposure in a task) and unplanned tritium uptakes (so-called "precursor events) (see Figure 27 and Figure 28 below). These indicators are a measure of how effectively low- level events are used to identify and correct behaviours, or improve radiation work plans, thus preventing more significant events from occurring.

This excellent performance is attributed to improved personal and organizational accountability, careful planning of tritium exposure, and focus on consistently knowing the radiation level a worker is working in and taking all appropriate precautions.

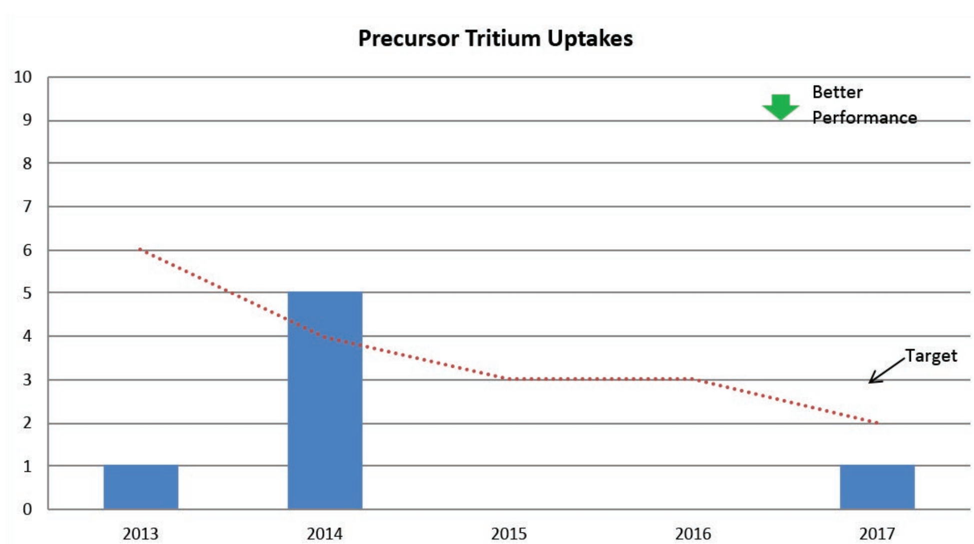


Figure 27 – Precursor Tritium Uptakes

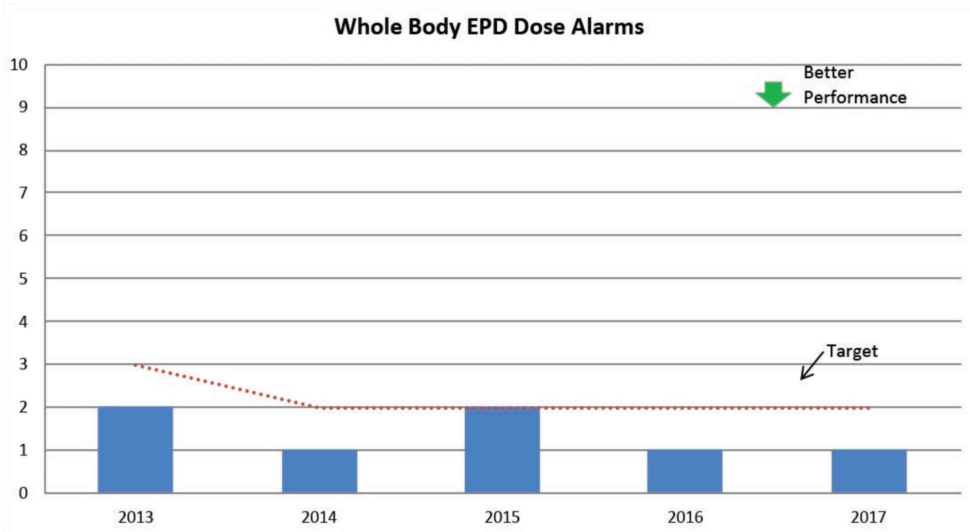


Figure 28 – Number of Whole Body EPD Dose Alarms 2013- 2017

3.8 Conventional Health and Safety

The Conventional Health and Safety SCA involves the implementation of a program to protect personnel and manage work- place non-radiation hazards. Detailed information is provided on this subject in Section 2.8 of the Licence Application.

Pickering had very strong safety performance through the current licence period. In 2014 Pickering reached 11 million person-hours without a lost time accident, with an All Injury Rate of 0.22, the best performance achieved by the station to that point. OPG received the Canadian Electricity Association's President's Gold Award of Excellence for Employee Safety in 2016, in recognition of the company-wide All Injury Rate and Accident Severity Rate performance for the years 2013 to 2015.

Highlights

OPG recognized as a leader in promoting worker health and safety...

- ✓ All Injury Rate of 0.06 in 2017 best ever in Pickering's history
- ✓ Total Health program promotes health and well-being for all employees
- ✓ Numerous awards and recognition from external associations

The following updates information contained in the Licence Application to reflect 2017 results. The Licence Application Section and heading are reproduced below followed by the updated information.

Licence Application Section - 2.8.1 Conventional Health and Safety program

As shown in Figure 29, all injury rate , the 2017 All Injury Rate for Pickering was 0.06 which is better than the 0.22 target. This is the best ever safety performance in this metric at Pickering.

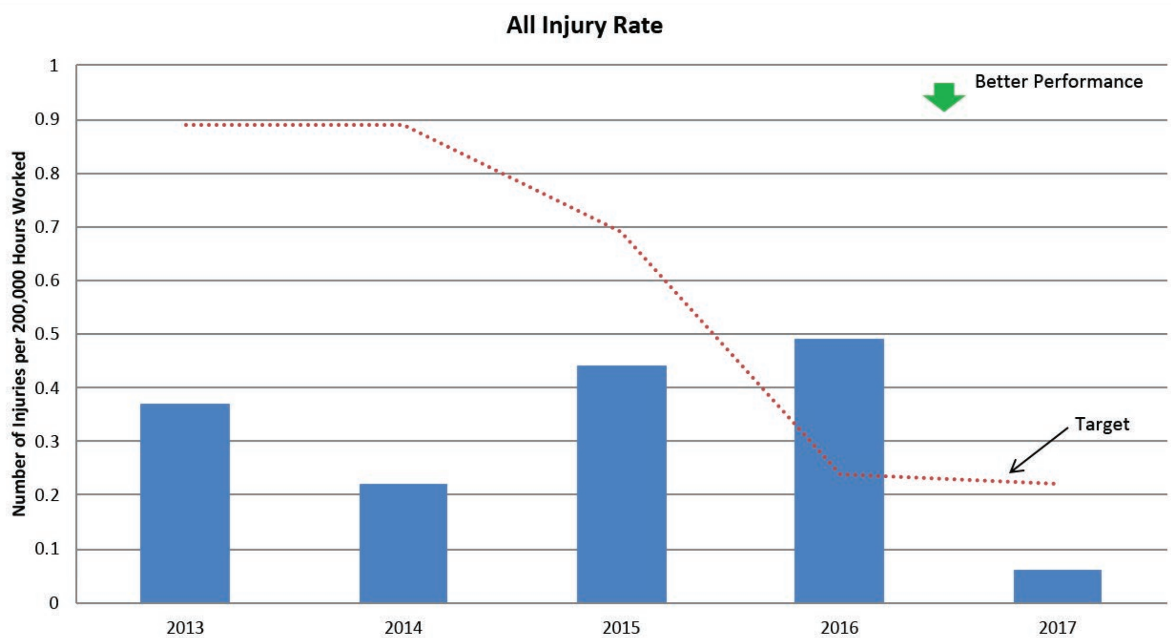


Figure 29 - Pickering NGS All Injury Rate 2013-2017

3.9 Environmental Protection

The Environmental Protection SCA includes the programs that identify, control and monitor all releases of radioactive and conventional hazardous substances and effects on the environment as the result of licensed activities. Pickering NGS has an effective environmental protection program that meets or exceeds all applicable regulatory requirements and related objectives. All reasonable precautions are taken to ensure that adequate provisions for the protection of the environment are maintained. OPG ensures that impacts of plant operation on the public, workers, and the environment will continue to be of low risk and adequately mitigated. Additional and more detailed information on the activities conducted to protect human health and the environment can be found in Section 2.9 of the Licence Application.

Highlights

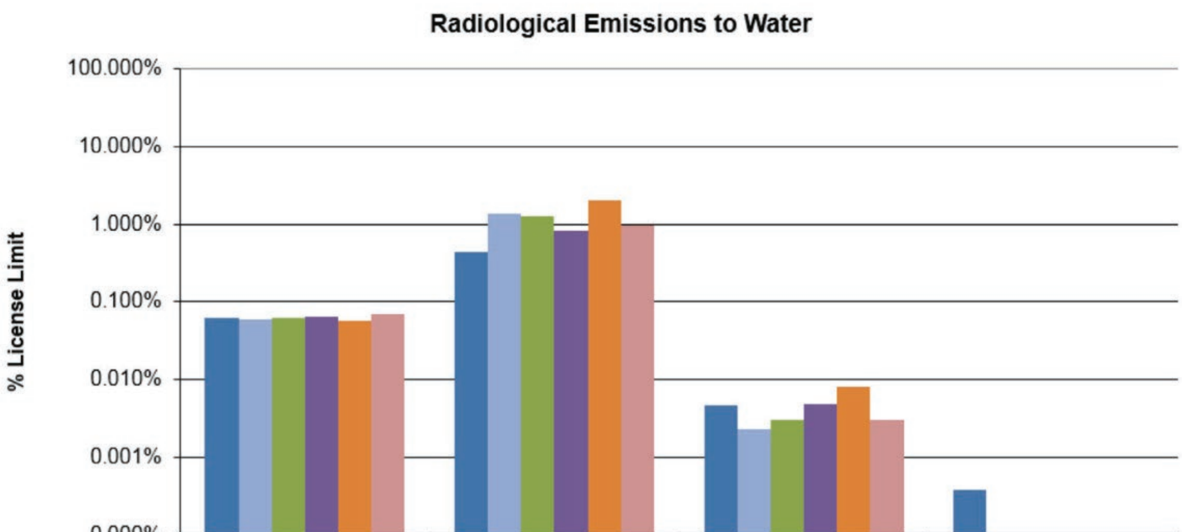
- ✓ OPG understands the importance of environmental stewardship...
- ✓ Internal performance targets are more stringent than regulatory requirements
- ✓ Public dose remains a tiny fraction of the regulatory limit
- ✓ Environmental releases are monitored, and results made available to the public
- ✓ Programs to support wildlife diversity and habitat

The following updates information contained in the Licence Application to reflect 2017 results. The Licence Application Section and heading are reproduced below followed by the updated information.

Licence Application Section - 2.9.3 Protecting the Public Radiological Emissions to Water

During the current licence period, there were no derived release limit (DRL) or action level exceedances for tritium, beta/gamma, carbon-14 or alpha emissions to water on an annual basis. See Figure 30 for a historical summary. The DRL's were updated in 2013 which changed the historical values; therefore data are included as a percentage of the DRL before and after the revision.

The DRL is the amount of radiation which if released for an entire year could result in the most exposed member of the public receiving a dose at the legal limit.



	Tritium	Gross βγ	Carbon-14	Alpha
Pre-April 2013	0.06%	0.43%	0.0047%	0.00037%
Post-April 2013	0.06%	1.38%	0.0023%	0.00005%
2014	0.06%	1.27%	0.003%	0.00001%
2015	0.06%	0.82%	0.005%	0.00002%
2016	0.06%	2.04%	0.008%	0.00001%
Q1-Q3 2017	0.07%	0.97%	0.003%	0.00001%

Radionuclide

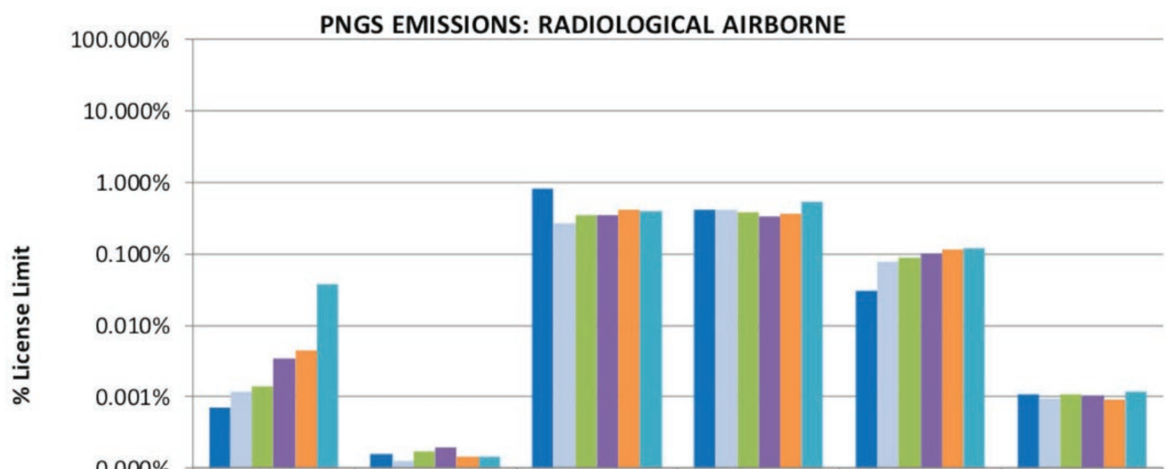
Figure 30 - Radiological Emissions to Water

Radiological Emissions to Air

During the current licensing period, Pickering Nuclear has not exceeded the derived release limit (DRL) or the action level for any radiological emission to air on an annual basis. Details of the emissions can be found in Figure 31 Radiological Airborne Emissions; as shown, all emissions have been well below the licence limit.

Tritium emission values can be attributed primarily to leaks and spills inside the reactor building as well as reactor building ventilation dryer performance issues. A tritium airborne reduction team is currently in place to progress airborne tritium reduction strategies throughout 2018. Prioritizing leak repairs and improvements to dryer reliability are key focus items of the airborne high impact team.

An increase in airborne particulate emissions in 2017 was due primarily to two isolated events where maintenance was performed on the Chemistry lab ventilation ductwork. Dust and particulate were dislodged during maintenance of fan/ducting system, which caused spikes in the levels of particulate releases. Emissions returned to normal levels following the maintenance events.



	Particulate	Iodine	Tritium	Noble Gases	Carbon-14	Gross Alpha
Pre-April 2013	0.0007%	0.00016%	0.82%	0.42%	0.03%	0.0011%
Post-April 2013	0.0012%	0.00013%	0.27%	0.41%	0.08%	0.0010%
2014	0.0014%	0.00017%	0.35%	0.39%	0.09%	0.0011%
2015	0.0034%	0.00019%	0.35%	0.34%	0.10%	0.0010%
2016	0.0045%	0.00015%	0.43%	0.37%	0.11%	0.0009%
Q1-Q3 2017	0.0379%	0.00015%	0.40%	0.54%	0.12%	0.0012%

***Note:** License Limit adjusted in April 2013. Data may appear positiviely skewed prior to License Limit adjustment.

Figure 31 - Radiological Airborne Emissions

Groundwater Monitoring Program

The Pickering Nuclear groundwater monitoring program was established to confirm the predominant on-site groundwater flow characteristics of the site. Monitoring is designed to detect changes to on-site groundwater quality to ensure timely detection of releases. The overall objective of the program is to ensure no adverse off-site impacts from groundwater.

In the last year, the cleaning and/or replacement of the RB foundation drainage sumps non-return valves and pumps have been completed. This will improve the groundwater quality in the vicinity of the Unit 5 to 8 reactor buildings.

In this licence period low levels of tritium in groundwater were observed at the Pickering Units 5-8 irradiated fuel bay area. OPG initiated a project to repair the Pickering Units 5-8 irradiated fuel bay liner and its collection sumps, to reduce the potential for the bay water to negatively impact site groundwater quality. The collection sumps have now been repaired. The liner repair tooling has been fabricated, tested and Phase I of the repair is complete. Phase II (additional scope) is planned to start in April 2018. Surveillance will continue to track the movement of tritium in groundwater in this area.

The release of contaminated groundwater from the site is through monitored release paths. This monitoring confirms that the level of tritium in the discharge is well below regulatory limits and thus has no adverse environmental impact.

Licence Application Section - 2.9.4 Spill Management Program

The following spill mitigation initiatives have been completed driven by OPG's adherence to continuous improvement:

- The Units 1, 2 sewage sump pumps have been replaced with more robust grinder style pumps for improved availability. An additional level switch was also installed to prevent sump overflows. (Completed December 2017).
- Replaced all 4 sodium bisulphite solution storage tanks with one double walled stainless steel tank on Pickering 058. (Completed November 2016)
- All of the Pickering 058 seal oil drain lines to the local water tundish have been cut and capped in order to remove any flow path from the seal oil heat exchangers to the environment. (Completed December 2014)
- Installation of underflow weir system to the existing spill containment surrounding the main output transformers located on all 4 units of Pickering Units 058. (Completed December 2016).
- Upgraded spill containment in the new water treatment plant chemical addition area. (Completed April 2014)

Planned Improvements

A project has been established to design and construct a new overflow tank with inclusive secondary containment associated with the emergency coolant injection system, to reduce the risk of spills to the environment. This project is in the planning stages with design option development targeted for December 2018.

Licence Application Section - 2.9.6 Regulatory Compliance

Pickering operates under numerous environmental regulations governing plant operations. The primary regulators from an environmental perspective are the CNSC and the Ontario Ministry of Environment and Climate Change (MOECC).

During the period 2013 to 2017 there were no major infractions of environmental regulations that resulted in Significant Environmental Events.

Pickering Nuclear had a total of 25 other infractions over the period of 2013 – 2017 (approximately 5 year period), decreasing to 1 infraction in 2016 and 2 infractions in 2017.

Licence Application Section - 2.9.12 Fisheries Act Authorization

Pickering submitted an application for authorization from the Department of Fisheries and Oceans under Section 35 (2)(b) of the Fisheries Act.

OPG has obtained the authorization from the Department of Fisheries and Oceans.

3.10 Emergency Management and Fire Protection

The Emergency Management and Fire Protection SCA covers emergency plans and emergency preparedness programs for emergencies and for non-routine conditions. Emergency preparedness measures and fire protection response capabilities are in place at Pickering NGS to prevent and mitigate the effects of nuclear and hazardous substances releases, both onsite and offsite, and fire hazards in order to protect workers, the public and the environment. Detailed information on this SCA can be found in Section 2.10 of the Licence Application.

Highlights

Expect the unexpected, and be prepared for it...

- ✓ OPG has robust emergency preparedness plans integrated with the Province / Municipality/ international partners
- ✓ "Exercise Unified Control" demonstrated readiness on a large scale
- ✓ Distribution of KI pills completed
- ✓ State of the art fire training facility

The following updates information contained in the Licence Application to reflect 2017 results. The Licence Application Section and heading are reproduced below followed by the updated information.

Licence Application Section - 2.10.1 Fire Protection and Conventional Emergency Preparedness and Response

OPG is partnering in the Durham Regional NextGen public safety radio system and is installing new radio system infrastructure at the site. This will allow seamless integration and interoperable communications with City of Pickering Fire Service responders using their own radios in the plant. Phase I of the installation is complete, providing coverage throughout the Pickering powerhouse structure. Phase II will provide enhanced site wide coverage and link the site to the regional system. Installation of Phase II is partially complete with remaining installation and commissioning scheduled to be completed by the spring of 2018.

Licence Application Section - 2.10.2 Nuclear Emergency Preparedness Program

An update regarding the multi-agency interoperability exercise 'Exercise Unified Control' that was held on December 6-7, 2017 and the Provincial Emergency Response Plan (PNERP) is provided in Section 2.

As discussed in Section 2.1.4 of this document, OPG completed Exercise Unified Control in December, 2017. This was a two-day exercise involving more than 1000 participants in over 30 municipal, provincial and federal agencies, in a severe accident scenario at Pickering which simulated a significant off- site release.

It also included participation of international partners in the nuclear community (eg. The World Association of Nuclear Operators). A number of new initiatives were used successfully, including new dose assessment software to project radiological effects to inform the Province's protective action decision-making, and the calculation of public doses by Health Canada with computer codes using real time weather data. Operational and public communications improvements were also demonstrated, including enhanced interoperability for OPG Emergency Response Team and Pickering Fire Services, with the new P25 radio system, and the use of social media in public communications.

3.11 Waste Management

The Waste Management SCA covers internal waste-related programs that form part of the facility's operations, up to the point where the waste is removed from the facility to a separate waste management facility. This area also covers the planning for decommissioning. Pickering's waste management program includes processes and procedures for the specific handling of different waste streams.

It is audited in order to control and minimize the volume of nuclear waste that is generated by the facility. More detail on the waste management program and processes can be found in Section 2.11 of the Licence Application.

Pickering continually strives to improve on safely managing and reducing the amount of Low- and Intermediate-Level Waste (L&ILW) produced, to reduce both the amount and the types of materials that enter the radiation waste stream, and to ultimately reduce the station's environmental footprint now and in the future. Focus is placed on:

- Minimizing the amount of waste generated by making a plan on how to minimize and manage the waste for each job during pre-job briefs.
- Proper segregation of waste at the point of generation into the three waste categories: incinerable, compactable, and non-processible, prior to shipping to the Western Waste Management Facility (WWMF) beside the Bruce Nuclear Power Plant for processing:
    - Incinerable waste is further reduced by as much as 95% through the incineration process.
    - Compactable waste is also volume reduced by as much as 75%.
    - Non-processible waste cannot be incinerated or compacted and needs to be stored. Pickering sets business planning targets to drive down the generation of non-processible waste.

Emphasis in these activities is placed on performing them safely and at the lowest possible dose to workers and the public.

Highlights

OPG has a well established Nuclear Waste program...

- ✓ Committed to safely managing nuclear waste in a responsible manner
- ✓ Committed to ensuring future generations are not unduly burdened with managing today's waste
- ✓ Investing to ensure costs of future decommissioning are fully covered

3.12 Security

The Security SCA covers the programs that are required to implement and support the security requirements stipulated in the Regulations, and the Licence.

The Nuclear Security Program ensures the safe and secure operation of the station, maximizing protection against threats to security through the use of equipment, personnel and procedures.

The Pickering NGS Security Program is intended to prevent the loss, theft or sabotage of nuclear material and the sabotage of the nuclear facility. More detailed information on the Nuclear Security Program can be found in Section 2.12 of the Licence Application.

Highlights

OPG ensures the Pickering site is safe and secure by...

- ✓ A highly trained security staff that includes both armed and unarmed nuclear security officers
- ✓ Extensive and integrated security drills and training
- ✓ State-of-the-art security equipment deployed throughout the site
- ✓ Cyber security program that protects computer systems and software programs

The following updates information contained in the Licence Application to reflect 2017 results. The Licence Application Section and heading are reproduced below followed by the updated information.

Licence Application Section - 2.12.1 Nuclear Security Program

OPG documents the specific regulatory security requirements for the security program in OPG report, 8690-REP-61400-10003, Pickering Site Security Report. This security protected report has been updated in 2017.

Licence Application Section - 2.12.2 Drills and Exercises

As noted above, under Section 3.10, OPG is partnering in the Durham Regional NextGen public safety radio system and is installing new radio system infrastructure at the site. This will allow seamless integration and interoperable communications with Pickering Fire Service responders using their own radios in the plant. Phase I of the installation is complete providing coverage throughout the Pickering powerhouse structure. Phase II will provide enhanced site wide coverage and link the site to the regional system. Installation of Phase II is partially complete with remaining installation and commissioning scheduled to be completed by spring, 2018.

3.13 Safeguards and Non-Proliferation

The Safeguards and Non-Proliferation SCA includes the programs and activities that are required for the successful implementation of the obligations arising from the Canada / International Atomic Energy Agency (IAEA) safeguards agreements, as well as all other measures arising from the Treaty on the Non-Proliferation of Nuclear Weapons. OPG's safeguards and non-proliferation program enables Pickering to meet Canada's international obligations under the IAEA agreements, and other measures that arise from the Treaty. Additional detail on these measures can be found in Section 2.13 of the Licence Application.

Pickering has met all safeguards conditions in its operating Licence, and staff have cooperated with the IAEA and facilitated the achievement of IAEA safeguards goals.

Highlights

OPG meets its international safeguards obligations...

- ✓ Maintain accounting of fuel at all times
- ✓ Timely support of IAEA inspections
- ✓ Facilitate upgrades to IAEA equipment on site

3.14 Packaging and Transport

The Packaging and Transport SCA is concerned with programs that cover the safe packaging and transport of nuclear substances to and from the licensed facility. The packaging and transport of radioactive substances are controlled through regulations, specifically the Packaging and Transport of Nuclear Substances and the Transport of Dangerous Goods Regulations. The Radioactive Material Transportation Program is owned by OPG's Nuclear Waste Management Division.

The objective of the Radioactive Material Transportation Program is to ensure that shipments of radioactive material are performed safely and in accordance with the regulations.

Details on the packaging and transport of radioactive substances can be found in Section 2.14 of the Licence Application.

Highlights

OPG's radioactive material transportation program ensures...

- ✓ Safe transport of nuclear materials for over 40 years
- ✓ CNSC and Transport Canada requirements are met
- ✓ Drills conducted routinely to validate transportation emergency response plans

4. Other Matters of Regulatory Interest

4.1 Program for Cobalt-60

In addition to electric power, Pickering NGS also produces cobalt-60, a radioisotope that has a range of beneficial industrial, medical and food processing applications.

The cobalt-60 that is harvested from the reactor units is shipped to off-site users in accordance with Transport of Dangerous Goods Regulations, and the Packaging and Transport of Nuclear Substances Regulations. Pickering does not receive cobalt-60 from off-site commercial facilities.

4.2 Financial Guarantee

Canadian Nuclear Power Plant operators are required to establish and maintain a financial guarantee to assure that sufficient funds are collected and administered for the management of all liabilities associated with the operating and decommissioning of all their nuclear facilities, both owned and leased. OPG's financial guarantee makes specific provisions for the decommissioning of the Pickering NGS. It also covers financial provisions for the long-term management of all operational and decommissioning waste, including both storage and eventual disposal of used fuel wastes and low-level and intermediate-level radioactive wastes.

OPG prepares its financial guarantee on a five-year cycle, as required by CNSC regulations, and also provides an annual guarantee report to the CNSC that details the status of the guarantee and compares the amount of the liabilities and financial resources available to discharge the obligations. The financial guarantee provisions for Pickering demonstrate that the current level of funding is sufficient for decommissioning the station and returning the site to an end state that has been agreed with the regulators.

The 2018-2022 financial guarantee is based on OPG's 2016 cost estimates for decommissioning and operational waste management; it was submitted to the Ontario Finance Authority, and approved in December 2016, and to the CNSC in the spring of 2017 and approved in December 2017.

OPG will continue to provide annual financial guarantee reports to the CNSC, detailing the status of the guarantee including the amounts accumulated in segregated funds.

4.3 Nuclear Liability

Under the Nuclear Liability and Compensation Act, OPG is required to maintain $650 million in nuclear liability insurance for the Pickering NGS in 2017. The liability limit increases to $750M, $850M, and $1B in 2018, 2019 and 2020, respectively; OPG will purchase insurance in accordance with legal requirements. Nuclear property insurers conduct inspections at Pickering every 18 months, with conventional insurers who inspect the non-nuclear side of the station.

The current Certificate of Insurance for Nuclear Liability Insurance can be found in Appendix B of the Licence Application.

4.4 Cost Recovery

OPG pays the CNSC fees every quarter, as specified in the Canadian Nuclear Safety Commission Cost Recovery Fees Regulation.

5. References

[1] Letter, R. Lockwood to M. Leblanc, "Application for Renewal of Pickering Nuclear Generating Station Power Reactor Operating Licence", August 28, 2017, P-CORR-00531-05055.

[2] Letter, R. Lockwood to M. Leblanc, "Supplementary Information to the Application for Renewal of the Pickering Nuclear Generating Station Power Reactor Operating Licence", December 11, 2017, P-CORR-00531-05223.

[3] Fisheries and Oceans Canada, Paragraph 35(2)(b) Fisheries Act Authorization for Pickering Nuclear Generating Facility, January 17, 2018, PATH No.: 16-HCAA-00256.

[4] Letter, P. Pasquet to T.E. Schaubel, "Pickering B: Submission of the Pickering B Continued Operations Plan – CNSC Action Item 2010-8-05", September 29, 2010, NK30-CORR-00531-05693.

[5] Letter, R. Lockwood to A. Viktorov, "Pickering NGS – Risk Improvement Plan Update", February 26, 2018, P-CORR-00531-05278.

[6] Letter, B. McGee to A. Viktorov, "Pickering NGS Stabilization Activity Plan (SAP) – 2016 Annual Update", December 2, 2016, P-CORR-00531-04880.

[7] Letter, S. Granville to K. Glenn, A. Viktorov and M. Santini, "Submission of Preliminary Decommissioning Plans", January 30, 2017, N-CORR-00531-18384.

[8] Letter, R. Lockwood to A. Viktorov, "Environmental Risk Assessment Report for Pickering Nuclear and Predictive Effects Assessment for Pickering Nuclear Safe Storage", April 28, 2017, P-CORR-00531-04982.

[9] Letter, G. Jager to M. Leblanc, "Notice of Participation Pursuant to Rule 18 of CNSC Rules of Procedure – Pickering NGS Licence renewal Application Hearing – February 20, 2013", January 21, 2013, P-CORR-00531-03860.

[10] Letter, R. Lockwood to A. Viktorov, "Pickering A and B NGS Safety Report – Common-Cause Events Appendices", December 18, 2017, P-CORR-00531-05204.

[11] Letter, W.S. Woods to N. Riendeau and A. Viktorov, "Status Update on REGDOC-2.4.1 Implementation", November 29, 2017, N-CORR-00531-18903.

[12] OPG Letter, R. Lockwood to A. Viktorov, "Pickering NGS Periodic Safety Review 2 - Submission of Global Assessment Report Revision 1", February 12, 2018, CD# P-CORR-00531-05292.

[13] Letter, R. Lockwood to A. Viktorov, "Pickering NGS Periodic Safety Review 2 - Submission of Integrated Implementation Plan", November 30, 2017, P-CORR-00531-05085.

[14] OPG Letter, R. Lockwood to A. Viktorov, "Pickering NGS Periodic Safety Review 2 - Submission of Integrated Implementation Plan Revision 1", March 1, 2018, CD# P-CORR-00531-05311.

[15] CNSC letter, A. Viktorov to R. Lockwood, "Pickering NGS: CNSC Staff Acceptance of Pickering NGS Periodic Safety Review 2 (PSR2) Integrated Implementation Plan (IIP) Revision 1", March 2, 2018, CD# P-CORR-00531-05333.

Addendum A
Pickering Periodic Safety Review (PSR2)

Pickering PSR2

- ✓ Completed in accordance with CNSC REGDOC 2.3.3, and IAEA SSG-25
- ✓ Comprehensive assessments completed by external companies over several years
- ✓ Purpose was to determine reasonable, practicable safety enhancements that could further enhance safety
- ✓ Supports continued safe operation of Pickering NGS to the end of 2024

OPG has completed a Periodic Safety Review for the Pickering station in accordance with CNSC Regulatory Document 2.3.3, *Periodic Safety Reviews,* and International Atomic Energy Agency's (IAEA) Safety Standards Series, Specific Safety Guide No. SSG-25, *Periodic Safety Review for Nuclear Power Plants*.

The purpose of a PSR is to determine reasonable and practicable safety enhancements that could further enhance safety at the associated nuclear facility.

The safety of Pickering NGS is regularly and thoroughly assessed, verified and assured through several processes that are part of the current licensing framework. OPG also applies routine comprehensive safety assessment and improvement programs that deal with specific safety issues, significant events and changes in standards and operating practices as they arise. These programs allow assessment of safety and plant operation to be improved on a continuous basis that can be correlated to all of the PSR Safety Factor review areas. They include programs that ensure safe operations, effective configuration management, equipment reliability, life cycle management, aging management, periodic inspection and maintenance. Programs are also in place in the area of organizational management and safety culture that focus on safety-related behaviours and accountability.

Pickering's PSR, referred to as PSR2 as it builds on earlier safety assessments, confirms that the design, operation and safety-significant structures, systems and components support continued safe operation of the Pickering units to the end of 2024. The earlier assessments collectively referred to as Pickering PSR1 were:

1. **The Pickering B Integrated Safety Review (ISR)**, completed in 2009 and performed in support of the proposed refurbishment and continued operation (at that time planned for an additional 30 years) of Pickering NGS Units 5-8.
2. **Pickering NGS 1,4 integrated safety assessments** performed during the Pickering A Return to Service (PARTS) work (circa 2000), in support of approval to restart Units 1 and 4. Outstanding actions from the ISR were subsequently documented in a Continued Operations Plan (COP) for which annual updates have been submitted to the CNSC.
3. **Darlington ISR:** The relevant programmatic aspects of the Darlington ISR completed in 2013 in support of refurbishment and continued operation of the Darlington units (programmatic parts are applicable to Pickering where programs and practices are common for the OPG fleet).

CNSC REGDOC-2.3.3 and IAEA SSG-25 identify that subsequent PSRs should focus on changes in requirements, facility conditions, operating experience and new information, rather than repeating activities conducted in previous safety reviews. As such it is forward looking, focusing on: changes to requirements since the last applicable assessment, confirmation that the condition of Pickering NGS supports the additional years of commercial operation, and new operating experience since the last assessments.

Pickering PSR2 Overview

The PSR2 review period was to the end of 2028 to correspond to the requested licence period and to cover those systems and components that would be required to remain in service after the end of commercial operation.

The process that was followed for completing the PSR2 is shown in Figure A.1 and comprised of the following four key elements which are explained in the Sections that follow:

1. PSR2 Basis Document
2. Safety Factor and Complementary Reviews
3. Global Assessment
4. Integrated Implementation Plan

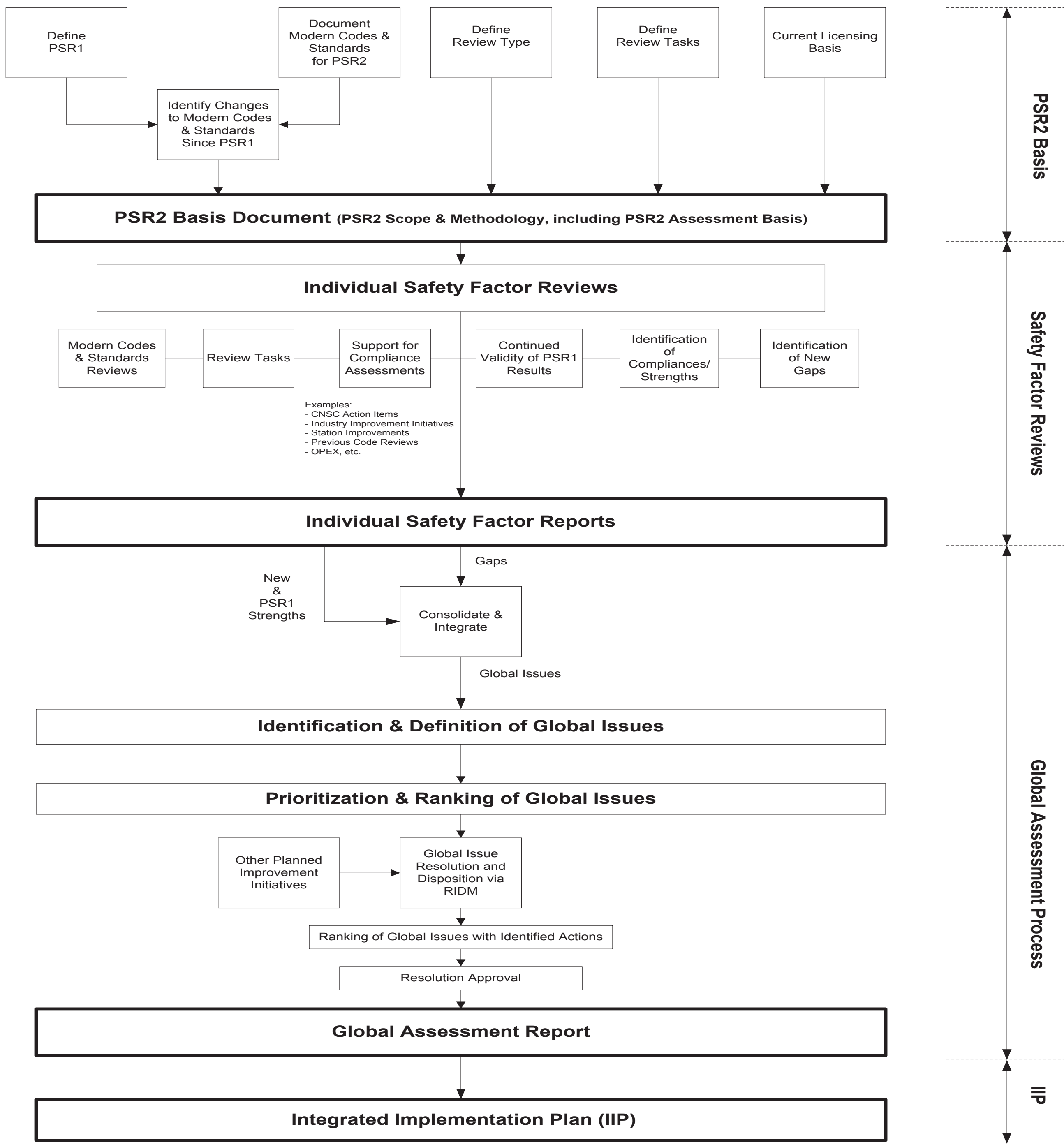


Figure A.1 - Pickering PSR2 Process Flowchart

PSR2 Basis Document

Basis Document
✓ Prepared by OPG
✓ Documents how the PSR2 was to be conducted
✓ Defined the applicable versions of Laws, Regulations Codes & Standards
✓ CNSC staff acceptance received July 2016

The Pickering PSR2 Basis Document, prepared by OPG and accepted by the CNSC in References A.1 and A.2, defined the approach for completing the PSR2:

The PSR2 Basis Document contained the following

- The proposed operating strategy of the facility;
- Scope and methodology, including the conduct of Safety Factor reviews and identification of compliances and gaps;
- The process for categorizing, prioritizing, tracking and resolving gaps arising from the Safety Factor reviews;
- Conduct of the Global Assessment;
- The methodology for preparing the Integrated Implementation Plan;
- Applicable current versions of Laws, Regulations, Codes and Standards;
- The major milestones, including the freeze date for document revisions; and
- The project management and quality management processes.

Current Laws, Regulations, Codes and Standards Applicable to PSR2

The PSR evaluates the extent to which the plant meets current laws, regulations, codes and standards. The process to identify those documents that are applicable to the PSR2 assessment basis involved first creating a broad list from multiple sources (potential candidate laws, regulations, codes and standards) and then filtering them to identify those that are most significant, and that are applicable to the PSR2 scope.

Structures, Systems and Components within the Scope of the PSR2 Review

The structures, systems and components (SSC) within the scope of the PSR2 review encompass the systems important to safety (SIS) and the safe operating envelope (SOE) systems (i.e., systems credited with a safety function following postulated accidents).

Safety Factor and Complementary Reviews

Safety Factor Reviews

- ✓ 15 Safety Factor, 2 Complementary Reviews completed by AMEC-Foster-Wheeler and Tetra-Tech
- ✓ Associated reports submitted by OPG for CNSC staff review
- ✓ No fundamental safety issues were identified
- ✓ Concludes that OPG has in place effective programs and processes for continued safe operation of the Pickering NGS until 2024.
- ✓ Identified findings used as input to the Global Assessment

In accordance with REGDOC-2.3.3, fifteen Safety Factors Reviews covering the full range of important nuclear safety topics were completed and associated reports submitted for CNSC staff review.

Safety Factor Reviews

Safety Factor Review: Plant Design

Objective:
The objective of the Plant Design review was to determine the adequacy of the design of the plant and its documentation by assessment against the current licensing basis and national and international standards, requirements and practices.

Conclusion:
This review confirmed, by assessment against the current licensing basis and applicable standards, requirements and practices that the physical design and documentation supports continued safe operation of Pickering NGS.

Safety Factor: Actual Condition of Structures, Systems and Components Important to Safety

Objective:
The objective of the Actual Condition of Structures, Systems and Components Important to Safety review was to determine the actual condition of SSCs important to safety and to consider whether they are capable and adequate to meet design requirements, throughout the period of PSR2. In addition, the review should verify that the condition of SSCs important to safety is properly documented, as well as reviewing the ongoing maintenance, surveillance and in-service inspection programs, as applicable.

Conclusion:
This review concluded that the plant's SSCs are in good condition and support safe extended station operation to 2024, no major concerns have been identified and the SSCs Important to Safety continue to operate as per the design basis requirements.

Safety Factor Review: Equipment Qualifications (Environmental and Seismic)

Objective:
The objective of the Equipment Qualification review was to confirm that the plant equipment important to safety has been properly qualified (including for environmental conditions) and that this qualification is being maintained through an adequate program of maintenance, inspection and testing that provides confidence in the delivery of safety functions throughout the period of the PSR.

Conclusions:
This review confirmed that the Pickering NGS equipment important to safety has been properly environmentally and seismically qualified and that these qualifications are being maintained through maintenance, inspection and testing programs.

Safety Factor Review: Plant Aging

Objective:
The objective of the Aging Safety review was to determine whether aging aspects affecting systems, structures and components important to safety are being effectively managed and whether an effective aging management program is in place so that all required safety functions will be delivered for the design lifetime of the plant.

Conclusions:
This review confirmed that aging aspects affecting systems, structures and components important to safety are being effectively managed and that an effective aging management program is in place.

Safety Factor Review: Deterministic Safety Analysis

Objective:
The objective of the deterministic safety analysis review was to determine to what extent the existing deterministic safety analysis is complete and remains valid when the following aspects have been taken into account:

- The actual plant design, including all modifications of SSCs since the last update of the safety analysis report or the last PSR;
- Current operating modes and fuel management;
- The actual condition of SSCs important to safety and their predicted state at the end of the period covered by the PSR;
- The use of modern validated computer codes;
- Current deterministic methods;
- Current safety standards and knowledge (including research and development outcomes); and
- The existence and adequacy of safety margins.

Conclusions:
This review confirmed that the deterministic safety analysis programs and procedures at OPG are comprehensive, resulting in a systematic and disciplined approach to identifying, prioritizing and addressing any safety analysis related issues.

Safety Factor Review: Probabilistic Safety Assessment

Objective:
The objective of the Probabilistic Safety Assessment (PSA) review was to determine:

- The extent to which the existing PSA study remains valid as a representative model of the plant;
- Whether the results of the PSA show that the risks are sufficiently low and well balanced for all postulated initiating events and operational states;
- Whether the scope (which should include all operational states and identified internal and external hazards), methodologies and extent (i.e. Level 1, 2 or 3) of the PSA are in accordance with current national and international standards and good practices;
- Whether the existing scope and application of PSA are sufficient.

Conclusions:
This review confirmed that the PSA programs and procedures at OPG are comprehensive, resulting in a systematic and disciplined approach to identifying, prioritizing and addressing safety analysis related issues. Pickering has in place a PSA for Pickering Units 1,4 and Units 5-8 that is compliant with CNSC regulatory document S294.

Safety Factor Review: Hazard Analysis

Objective:
The objective of the Hazard Analysis review was to determine the adequacy of protection of the plant against internal and external hazards, with account taken of the plant design, site characteristics and the actual condition of the systems, structures and components important to safety and their predicted state at the end of the period covered by PSR2, and current analytical methods, safety standards and knowledge.

Conclusions:
This review confirmed that Pickering NGS has robust protection against internal and external hazards, taking into account the plant design, site characteristics, and the actual condition of the SSCs important to safety.

Safety Factor Review: Safety Performance

Objective:
The objective of the Safety Performance review was to determine whether the plant's safety performance indicators and records of operating experience, including the evaluation of root causes of plant events, indicate any need for safety improvements.

Conclusions:
This review confirmed that the safety performance indicators and records of operating experience, including the evaluation of root causes of plant events, exist and are utilized.

Safety Factor Review: Use of Experience from Other Nuclear Power Plants and Research Findings

Objective:
The objective of the Use of Experience from other Nuclear Power Plants and Research Findings review was to determine whether there is adequate feedback of relevant experience from other nuclear power plants and whether research findings are used to introduce reasonable and practicable safety improvements at the plant.

Conclusions:
This review confirmed that for Pickering NGS there is adequate feedback of relevant experience from other nuclear power plants and from findings of research, and that this is used to introduce reasonable and practicable safety improvements at the plant or in the operating organization.

Safety Factor Review: Organization, Management Systems and Safety Culture

Objective:
The objective of the Organization, Management System and Safety Culture review was to determine whether the organization, management system and safety culture are adequate and effective for ensuring the safe operation of the plant.

Conclusions:
This review confirmed that the Pickering NGS organization, management system and safety culture are effective.

Safety Factor Review: Procedures

Objective:
The objective of the Procedures Safety review was to determine whether the operating organization's processes for managing, implementing and adhering to operating and working procedures and for maintaining compliance with operational limits and conditions and regulatory requirements are adequate and effective and ensure plant safety.

Conclusions:
This review confirmed that the Pickering NGS processes for managing, implementing and adhering to operating and working procedures and for maintaining compliance with operational limits and conditions and regulatory requirements are adequate and effective and ensure plant safety.

Safety Factor Review: Human Factors

Objective:
The objective of the Human Factors review was to evaluate the various human factors that may affect the safe operation of the nuclear power plant and to seek to identify improvements that are reasonable and practicable.

Conclusions:
This review confirmed that the various human factors that may affect the safe operation of Pickering NGS have been appropriately addressed, and are effective.

Safety Factor Review: Emergency Planning

Objective:
The objective of the Emergency Planning review was to determine:

a. whether the operating organization has in place adequate plans, staff, facilities and equipment for dealing with emergencies; and

b. whether the operating organization's arrangements have been adequately coordinated with the arrangements of local and national authorities and are regularly exercised.

Conclusions:
This review has confirmed that OPG Nuclear has in place adequate plans, staff, facilities and equipment for dealing with emergencies. In addition, arrangements are in place for regular emergency training and exercises, and interaction and coordination with local and national authorities.

Safety Factor Review: Radiological Impact on the Environment

Objective:
The objective of the Radiological Impact on the Environment review was to determine whether the operating organization has an adequate and effective program for monitoring the radiological impact of the plant on the environment, which ensures that emissions are properly controlled and are As Low As Reasonably Achievable.

Conclusions:
This review confirmed that Pickering NGS has in place an effective program for monitoring the radiological impact of the plant on the environment, which ensures that emissions are properly controlled and are As Low As Reasonably Achievable.

Safety Factor Review: Radiation Protection

Objective:
The objective of the Radiation Protection review was to confirm that Radiation Protection has been adequately accounted for in the design and operation of the reactor facility, that radiation protection provisions (including design and equipment) provide adequate protection of persons from the harmful effects of radiation, and ensure that contamination and radiation exposures and doses to persons are monitored and controlled, and maintained As Low As Reasonably Achievable.

Conclusions:
This review has confirmed that radiation protection has been accounted for in the design and operation of Pickering NGS, and that radiation protection provisions (including design and equipment) protect workers from radiation and ensure that contamination and radiation exposures and doses to persons are monitored and controlled and maintained As Low As Reasonably Achievable.

As a subsequent PSR, the PSR2 Safety Factor reviews focused on changes in requirements (Laws, Regulations, Codes and Standards), updated plant conditions, operating experience and information from research, rather than repeating the activities of previous reviews. The methodology for performing the Safety Factor reviews takes full account of the safety assessments and Law, Regulation, Code and Standard compliance work previously completed by OPG.

Complementary Reviews

In accordance with the PSR2 Basis Document, the following Complementary Reviews were also completed and associated reports submitted for CNSC staff review:

Complementary Review: Continued Operations Plan (COP) Re-Assessment

The COP Re-Assessment reviewed the COP actions pertaining to the 2009 Pickering Units 5-8 Integrated Safety Review for implications given the intent to operate through to the end of 2024. In addition, implications for Pickering Units 1, 4 were also reviewed. Twenty-six items were identified for inclusion into the PSR2.

Complementary Review: Fukushima Action Plan Re-assessment

Following the event at Fukushima Daiichi nuclear plant, the CNSC issued Fukushima Action Items (FAI) to the Canadian Nuclear Utilities to ensure that the lessons learned from this event were appropriately incorporated into Canadian nuclear operations.

OPG was recognized for its achievements in operational and management excellence in its response to the Fukushima Daiichi event and confirmed that its stations remain safe with systems and procedures in place to deal with Beyond Design Basis Events.

The key lessons learned from the Fukushima event have been incorporated and plant modifications were implemented to further enhance the safety of OPG's nuclear facilities.

As part of PSR2, the FAIs pertaining to Pickering were reassessed to determine if the basis for their closure in 2015 remained valid in the context of extension for commercial operations of the station beyond 2020. The FAI Re-assessment did not identify any findings for PSR2.

All fifteen Safety Factor and two Complementary reviews concluded that there are no fundamental safety issues and that OPG has in place effective programs and processes for continued safe operation of the Pickering NGS through to the end of 2024.

Findings, referred to as "gaps", from these Safety Factor Reviews were input to the Global Assessment process described below.

Global Assessment

Global Assessment and Report

- ✓ Conducted by Candesco (a Division of Kinectrics), submitted by OPG for CNSC staff review
- ✓ Results from Safety Factor and Complementary reviews consolidated into Global Issues, prioritized and proposed resolutions developed which were ranked
- ✓ Concludes that the current plant design, operation, processes and management system will ensure continued safe operation of the station both in the short term, and for extended operation.
- ✓ Resulted in 23 Global Issues with 35 Proposed Resolutions.
- ✓ CNSC staff review concluded that the Global Assessment satisfied regulatory requirements of REGDOC-2.3.3 (Reference A. 4).

The objective of the Global Assessment was to provide an overall assessment of the safety of the Pickering station and to arrive at a judgement of the plant's suitability for continued operation.

The Global Assessment took its input from the Safety Factors and Complementary Review findings that covered the plant's design, operation, management, safety analysis, radiological impact on the environment and radiation protection.

The Global Assessment was conducted by an interdisciplinary team with appropriate expertise in operations, design and plant safety, including appropriate participants from the Safety Factor reviews, and members who are independent from the safety factor review teams.

The Global Assessment Process consists of the following elements:

1. Identification and consolidation of Strengths and Safety Factor Review findings.
2. Identification of Global Issues and proposed resolutions.
3. Assessment of interfaces between the various Safety Factors, aggregate impact of Global Issues.
4. Prioritization of Global Issues.
5. Development of Resolutions / Dispositions of Global Issues (and gaps).
6. Consideration of defence-in-depth and aggregate impact of residual Global Issue resolutions.
7. Ranking of Global Issues with proposed resolutions.
8. Senior Management Scope Review Board approval of proposed modifications for the purposes of PSR2.
9. Assessment of overall acceptability of operation of the plant over the period considered in PSR2.
10. Preparation of the Global Assessment Report to summarize the assessments, and document the Global Assessment.

Prioritization of Global Issues

PSR2 global issues were prioritized with respect to their importance to nuclear safety in support of resolution evaluation method and the outcome of the resolution process. This methodology was consistent with OPG prioritization processes used in previous Integrated Safety Reviews and industry practice.

The safety significance level considered deterministic and probabilistic safety analysis impact, as appropriate. The assignment of safety significance values for prioritization was derived based on OPG experience and takes into account the priority values from the OPG guidelines for evaluating and prioritizing Safety Report Issues and the OPG station condition record categorization process. Probability levels selected for delineation between categories are based on significance and engineering judgement, and are as used in previous Integrated Safety Reviews. These values account for overall safety impact and align, where appropriate, with requirements and limits in relevant safety standards. The relationship between safety significance level and impact on nuclear safety is shown in the table A.1.

Safety Significance Level	Impact on Nuclear Safety
1	High
2	Medium
3	Low
4	Very Low

Table A.1 - Relationship between Safety Significance Level and Impact on Nuclear Safety

Development of Resolutions/Dispositions of Global Issues

Proposed Resolution options to address the Global Issues were developed and assessed using risk-informed decision making techniques utilizing the following considerations:

- Evaluation of the Global Issue to understand the safety basis, and intent of the requirement.
- Defence in depth elements and the overall safety significance.
- Consideration of the possible options for resolution/mitigation, safety significance and defence in depth elements.
- Evaluate options with respect to effectiveness, cost, schedule, and practicality. For potential plant modifications, this may require an evaluation of the safety impact, via both deterministic and probabilistic methods. If it is not practicable to fully resolve a Global Issue, other mitigation options will be considered for enhancements.
- Practicality of a proposed resolution was evaluated in terms of cost, resources, schedule in relation to the overall safety impact.
- Items of High or Medium impact on nuclear safety (safety significance levels 1 and 2) required more in-depth analysis to fully understand the issue and potential impact, and to develop the proposed resolution/mitigation. In some cases this required deterministic and/or probabilistic assessments to determine the nuclear safety impact of modifications and more detailed evaluation of the cost/practicality of proposed resolutions.
- Items of Very Low Impact on nuclear safety (safety significance level 4) were generally deemed as “Acceptable Deviations” within the context of PSR2.

- While these very low impact items will not be tracked beyond the Global Assessment, they will be shared with the accountable organizations for consideration as potential enhancement initiatives for their future work program planning purposes. A similar treatment was applied for items of low impact on nuclear safety (safety significance level 3) for which a practicable solution was not readily evident.
- In some cases, the development of resolutions/dispositions to the global issues was part of an OPG or industry initiative already underway or planned. In others, the resolution and development of options may require more detailed analysis and assessment, extending beyond the timelines for submission of PSR2. In these instances, the status of the initiative and plans was included in the disposition. The work was included in the Global Assessment to facilitate continued tracking.

Consideration of Defence in Depth and Aggregate Impact of Acceptable Deviations

An important element of the development of proposed recommendations was to assess the overall defence in depth and aggregate impact of the low safety significance issues and acceptable deviations. After evaluating a range of resolutions for global issues, and determining a recommended resolution to be selected, the impact on defence in depth, considering both deterministic and probabilistic elements, was evaluated to assess the aggregate impact on overall safety.

Ranking of Global Issues with Identified Actions

All global issues whose resolution involves identified actions were ranked from 1 through N, where N represented the total number, in accordance with overall safety significance. This was based on expert judgement applied by the assigned Global Assessment team. The ranking process considered factors such as the priority previously determined (safety significance level), the contribution to defence in depth, the significance of the source (e.g., the type of document that generated the gap(s) leading to the global issue). The ranking process also accounted for the extent of impact on multiple safety factors or areas.

Senior Management Scope Review Board Approval of the Proposed Modifications for the Purposes of the PSR2

OPG Senior Management reviewed the PSR2 Acceptable Deviations and No Further Action statements, confirmed the best available options were recommended, or proposed changes to enhance safety where such improvements are identified.

This review ensured alignment with the Resolution Plans proposed, their basis and context, and provided concurrence that the proposed enhancements are practicable and effective. This process also allows the senior management team to consider potential realignment of priorities based on the insights from PSR2.

Assessment of Overall Acceptability of Operation of the Plant over the Period Considered in PSR2

As a final step in the assessment process, the team confirmed the overall acceptability of operation of the plant over the period considered in the PSR2. This entailed a review of the results of the Safety Factor and Complementary Reviews, a consideration of enhancements planned (both newly identified in PSR2 and from existing station initiatives) and a consideration of plant performance.

Global Assessment Report

The Global Assessment results, including a conclusion about overall acceptability of continued commercial operation of Pickering NGS, were documented in a Global Assessment Report P-REP-03680-00032-R001 that was submitted for CNSC staff review in February 2018 (Reference A.3). The CNSC staff review concluded that the GAR satisfied the regulatory requirements of CNSC REGDOC-2.3.3 and reflected the work performed under PSR2 (Reference A.4).

Integrated Implementation Plan

Integrated Implementation Plan

- ✓ IIP Rev. 0 prepared by RCM Technologies, submitted by OPG for CNSC staff acceptance
- ✓ Transformed 35 Proposed Resolutions from the GAR into 63 IIP Actions with corresponding implementation schedule.
- ✓ Represents OPG's commitment for addressing the results of the PSR2
- ✓ Completion of the IIP Actions will further enhance safety
- ✓ CNSC staff review concluded that the Integrated Implementation Plan (IIP) fulfils the regulatory requirements of REGDOC-2.3.3 and is acceptable (Reference A.6).

The Integrated Implementation Plan (IIP) represents the final step in the comprehensive PSR2 process.

The IIP, P-REP-03680-00031-Rev 1, prepared by RCM Technologies, defines Resolution Actions derived from the Resolutions Statements to address the Global Issues identified in the Assessment. The IIP was submitted by OPG for CNSC staff acceptance in November 2017. CNSC review comments have been addressed in a revised IIP that was submitted to the CNSC (Reference A.5) and subsequently accepted (Reference A.6) in March 2018.

IIP Structure

The IIP has been structured to provide an understanding of the implementation and basis for the plan. Appendices A, B and C of the IIP define the Resolution Actions and supporting IIP Actions with their target completion dates. The IIP Actions include new initiatives derived from the Global Assessment and existing initiatives that were integral to the overall assessment of safety.

IIP Resolution Actions

Appendix B of the IIP documents the 23 Global Issues (from the Global Assessment) having 35 corresponding Resolution Actions (some Global Issues have more than one Resolution Action). These 35 Resolution Actions, in turn have 63 specific IIP actions to address the Resolution Action. Unique to the Pickering PSR2 IIP is that each of the 35 Resolution Actions has a corresponding specific and measurable Completion and Success Criteria to assist with managing the IIP going forward.

Completion Criteria

The Completion Criteria define precisely the measurable activities that OPG is required to perform for the Resolution Action to be considered complete. Once completed, OPG will notify the CNSC and request closure of the Resolution Action.

Completion Criteria may include completed and documented analysis, system inspections, or installed modifications.

Resolution Action completion criteria define the measure that the Resolution Action, supported by IIP Actions, has been successfully completed.

Success Criteria

The Success Criteria define precisely measurable objectives of the IIP Resolution Action that will be used for closure of the IIP Resolution.

IIP Schedule

The 63 documented IIP Actions have been developed to address the Proposed Resolution Statements for 23 Global Issues identified in the Global Assessment. The 63 IIP Actions, based on current planning assumptions, have completion dates distributed over the next three years as shown in Figure A.2.

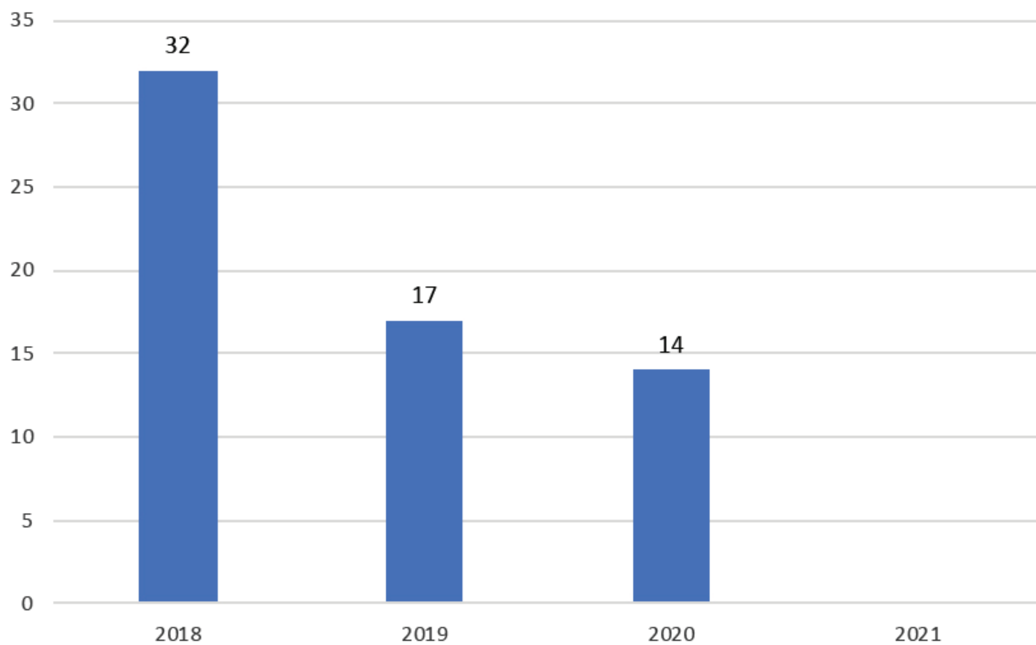


Figure A.2 - Distribution of IIP Actions and Timeline for Completing Actions

IIP Administration

In accordance with CNSC REGDOC 2.3.3, an IIP change management instruction was developed which is documented in an IIP Administration Instruction. Although changes to the Resolution Actions and schedule are not planned, the change management instructions will ensure that the Resolution Actions are effectively managed per the schedule.

The IIP Administration Instruction also specifies quarterly and annual reporting requirements, and interactions between OPG departments and the CNSC.

A structured oversight organization has been established to assign accountability for the IIP and IIP Action ownership, and to ensure that the IIP is resourced to mitigate risks, and enable program success.

Pickering Safety Enhancements

In addition to implementing programmatic improvements, the IIP contains actions for Plant Modifications, Fitness for Service, and Safety Analyses. The IIP listing of enhancements include those resulting from the Global Assessment, including both new modifications and existing planned station modifications that were integral to the overall assessment of safety. The following key IIP Actions are highlighted due to their safety significance for continued operation to the end of 2024.

Firewater System Enhancement (GI-48)

Canadian Standards Association (CSA) standard CSA N293-12, Fire Protection for Nuclear Power Plants, requires independent electrically and diesel driven firewater supply pumps. This is a new requirement that did not previously exist. On Pickering NGS Units 1,4 this requirement is already satisfied. However, a PSR2 gap was identified for Pickering NGS Units 5-8, as firewater is supplied only from electrically driven pumps with redundant power supplies. To address this gap, changes to the existing firewater system are included in the IIP scope to allow the firewater from Pickering NGS 1,4 diesel driven firewater pumps to supply Pickering NGS Units 5-8 through station interconnection. This interconnection will allow the Pickering site fire protection system to meet the most modern standards (CSA N293-12) for the redundancy and diversity of firewater supply.

Pickering NGS Units 1, 4 Probabilistic Safety Assessment (GI-27)

Even though Pickering PSA Safety Goals are met, OPG has set more challenging expectations through Administrative Safety Goals. To meet the more challenging goals, OPG has implemented Fukushima lessons learned that have enhanced plant safety. Following Fukushima lessons learned action implementation, Pickering NGS Units 5-8 meet the Administrative Safety Goals in all areas.

Pickering NGS Units 1,4 PSA large release frequency (LRF) is already better than the Safety Goal. To ensure Pickering NGS Units 1, 4 also meet the more challenging Administrative Safety Goal, IIP Actions have been established to install piping modifications on Pickering NGS Units 1, 4 to provide emergency make-up water to Unit 1 and Unit 4 calandria, heat transport system and steam generators to ensure continuous post-BDBA fuel cooling and protection of containment.

Following the completion of these enhancements as per the IIP Actions, Pickering NGS Units 1, 4 PSA estimated LRF will be better than the Administrative Safety Goal, further improving on already implemented Fukushima lessons learned actions, as shown in Figure A.3.

Beyond Design Basis Accident (BDBA) Accident Management (GI-40)

OPG's response to the Fukushima accident included completion of:

1. Phase-1 emergency mitigation equipment (EME) to provide additional barriers for the prevention of severe accident progression following a sustained station loss of power.
2. Phase-2 EME to restore critical containment functions by providing an emergency back-up source of power to:
    a. The boiler room air conditioning units inside each reactor building to assist with BDBA pressure suppression;
    b. hydrogen igniters to prevent post-BDBA hydrogen concentrations reaching explosive levels;
    c. Independent back-up power to the filtered air discharge system (FADS) to allow use of FADS for containment venting.

Safety analysis and assessments demonstrate that public risk from accidents at Pickering NGS was already very low. The leadership team at OPG continues to invest in Pickering NGS and has committed in the Pickering PSR2 IIP further safety enhancements that will arrest accident progression that could challenge containment integrity following a BDBA, further reducing the risk.

The specific IIP design enhancements provide emergency back-up water from the Pickering Firewater System to the Pickering Units 1 and 4 steam generators, heat transport system and calandria vessel.

These modifications will not only reduce the probabilistic safety assessment (PSA) calculated large release frequency (LRF) for Pickering Units 1, 4 by approximately 50% achieving OPG's Administrative Safety Goal, they will also assure the accident terminates at the in-vessel retention state allowing the use of the existing FADS. The public safety benefit of these modifications is similar to what a Containment Filtered Venting System would have provided.

A sensitivity study was completed which concluded that these modifications combined with modelling refinements will reduce the probabilistic safety assessment (PSA) calculated large release frequency (LRF) for Pickering Units 1, 4 by approximately 50% achieving OPG's Administrative Safety Goal and will result in a similar public safety benefit as a containment filtered venting system would have provided.

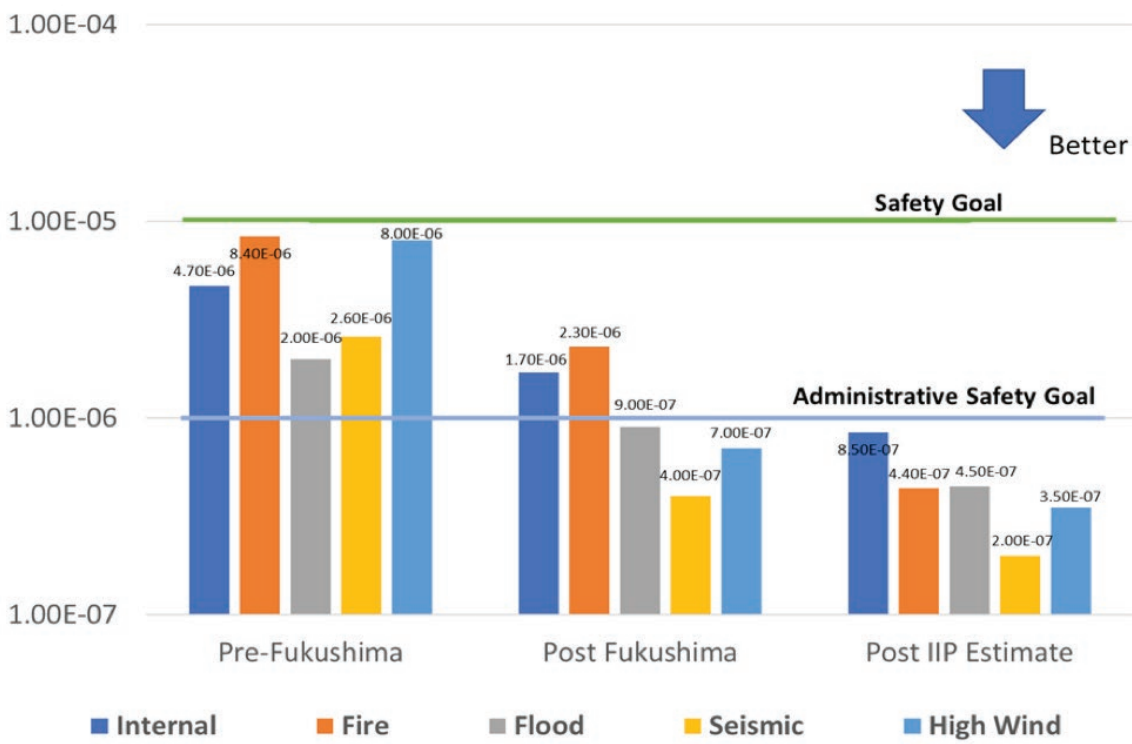


Figure A.3 - Pickering NGS 1, 4 PSA Large Release Frequency Improvements Over Time (Pre-Fukushima, Post-Fukushima mods and Estimated Post-IIP)

Expert Panel

A third-party technical Expert Panel to support the PSR2 Global Assessment process was established consisting of experienced individuals with familiarity with the design and operation of Pickering NGS (and other nuclear plants) and who have demonstrated leadership in the nuclear industry, participating in external review committees and initiatives.

The Expert Panel was subsequently requested to review the IIP and concluded that the IIP provided a balanced and comprehensive set of activities which addresses the results from the Global Assessment. The Expert Panel also concluded that the IIP had been prepared in a manner consistent with the regulatory requirements in accordance with the PSR Basis Document and that successful IIP implementation will ensure that the Pickering station will be safe to operate both in the short term, and for extended operation.

Pickering PSR2 Conclusions

The PSR process was thoroughly conducted over a two year period by external companies employing industry experts. The process identified plant modifications that will further enhance safety and reliability, and has highlighted where additional work is required to support commercial operation to the end of 2024. The PSR reviews confirmed that there are no management program gaps.

From an integrated public risk perspective, OPG concludes that the most effective means of protecting containment and minimizing large releases resulting from a BDBA is to prevent an accident from progressing to the point of challenging containment. The modifications that are currently being implemented and committed in the IIP will provide additional barriers to prevent such accident progression.

With a robust design, established mature programs in place that meet or exceed industry standards, and a leadership team that is committed to safety and continuous improvement, Pickering NGS will continue to operate safely and reliably through 2024.

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A.2 CNSC Letter, H. Khouaja to B. McGee, “Pickering NGS: CNSC Staff Acceptance of Pickering NGS A-1 Periodic Safety Review 2 (PSR2) Basis Document”, July 8, 2016, e-Doc 5037314, CD# P-CORR-00531-04789.

A.3 OPG Letter, R. Lockwood to A. Viktorov, “Pickering NGS Periodic Safety Review 2 - Submission of Global Assessment Report Revision 1”, February 12, 2018, CD# P-CORR-00531-05292.

A.4 CNSC letter, A. Viktorov to R. Lockwood, “Pickering NGS Periodic Safety Review 2 – CNSC Review of OPG Global Assessment Report (GAR) Revision 1”, February 19, 2018, CD# P-CORR-00531-05322.

A.5 OPG Letter, R. Lockwood to A. Viktorov, “Pickering NGS Periodic Safety Review 2 - Submission of Integrated Implementation Plan Revision 1”, March 1, 2018, CD# P-CORR-00531-05311.

A.6 CNSC letter, A. Viktorov to R. Lockwood, “Pickering NGS: CNSC Staff Acceptance of Pickering NGS Periodic Safety Review 2 (PSR2) Integrated Implementation Plan (IIP) Revision 1”, March 2, 2018, CD# P-CORR-00531-05333.

Addendum B
Assurance of Fuel Channel Fitness For Service

Executive Summary

OPG can confidently state that the fuel channels will remain fit for service up to their intended service life of 295,000 EFPH. This confidence is derived from a mature, well- defined life cycle management program that is based on years of operating experience and supporting research. This program produces fitness-for-service assessments that are aligned with all licensing requirements. Based on the established programmatic controls for managing fuel channel aging, which include an extensive reactor inspection program, sound technical assessments, and the implementation of mitigating measures where required, OPG is confident that Pickering fuel channels will remain fit for service to the end of 2024. OPG is documenting, in a Pickering 2024 readiness plan, the key life cycle management actions needed to support safe operation to end of 2024.

1 Introduction

OPG has requested approval from the Canadian Nuclear Safety Commission (CNSC) for a licence renewal for a ten-year term, from September 1, 2018 to August 31, 2028, and approval for operation beyond the current operating limit of 247,000 Equivalent Full Power Hours (EFPH) up to 295,000 EFPH for the lead Pickering unit, which corresponds approximately to the intended end of commercial operation (December 31, 2024). Projected EFPH for each unit at the intended end of commercial operation is provided in Table B.1.

Pickering Unit	Projected Unit EFPH as of December 31st 2024
Unit 1	192,000
Unit 4	167,500
Unit 5	287,500
Unit 6	295,000
Unit 7	287,000
Unit 8	274,000

Table B.1 – Projected EFPH for Pickering Units

OPG is committed to safe and reliable operation of the Pickering Nuclear Generating Station (NGS). OPG has programs and provisions in place to assure fitness for service (FFS) of fuel channel components on all Pickering units to the assumed service life targets.

2 Fuel Channels Overview

Fuel channels support the fuel bundles inside the reactor and are an integral part of the heat transport system that removes heat from the fuel. The fuel channels are located inside the calandria vessel assembly, as shown in Figure B.1. At Pickering NGS, Units 1 and 4 each contain 390 fuel channels, while Units 5 to 8 each contain 380 fuel channels. All fuel channel pressure tubes at Pickering units are made of a zirconium-niobium alloy.

Pressurized heavy water coolant is circulated through the fuel channels, transporting the heat produced by the nuclear fission process in the fuel to the boilers, in order to produce high-pressure steam. The pressure tube forms the primary pressure boundary containing the fuel bundles and heat transport system coolant.

Fuel channels consist of two end fittings, four annulus spacers, a calandria tube, and a pressure tube as shown in Figure B.2. The fuel channels are surrounded by heavy water, which is used to moderate the fission process within the calandria vessel. Dry carbon dioxide gas flows in the annulus space between the pressure tube and the calandria tube, and provides a thermal barrier for the heat transport system and also moisture detection capability in the unlikely event of a pressure tube leak.

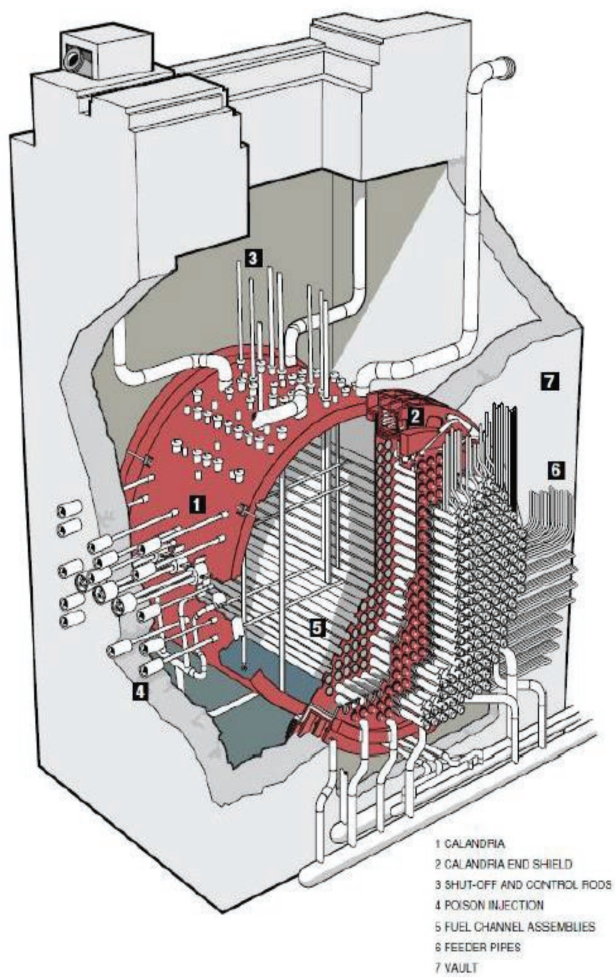


Figure B.1: Section View of CANDU Calandria Assembly

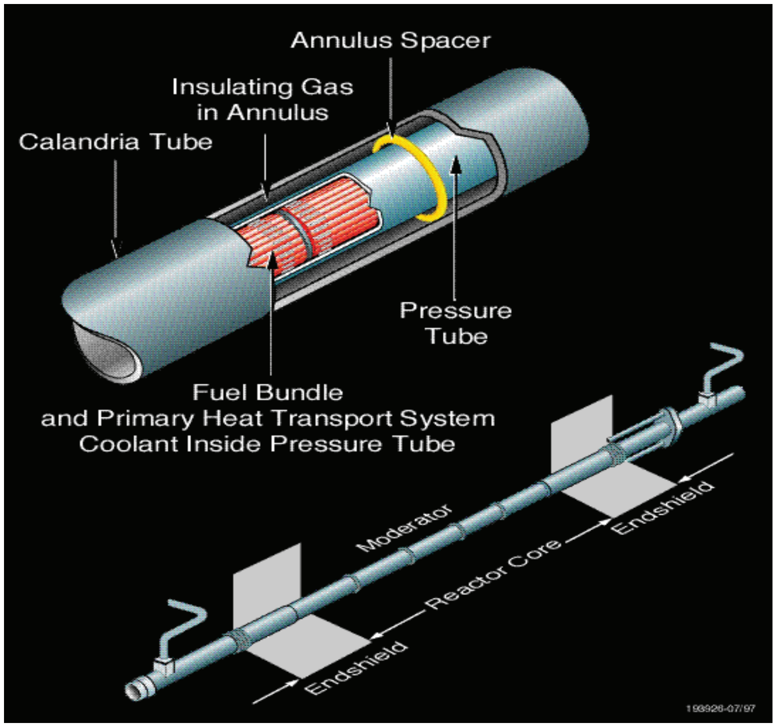


Figure B.2: Section View of Fuel Channel Assembly

3 Defence in Depth - Barriers to Fuel Channel Failure

Safe operation of fuel channels, as facilitated by the CANDU reactor design, utilizes a defense in depth framework. Defense in depth provides multiple overlapping barriers to lessen the chance of a fuel channel failure and reduce the possibility of harmful effects on the public or the environment. For pressure tubes, research and development (R&D) and testing is performed to understand degradation; inspection and surveillance is conducted to monitor for progression of degradation; degradation assessment methods are employed to demonstrate retention of design margins; heat transport system operating procedures mitigate postulated degraded conditions; and leak detection enables safe reactor shutdown and depressurization prior to pressure tube rupture. As a final set of barriers, in the unlikely event of fuel channel failure, alternative and diverse means of cooling the fuel are provided through safety systems (e.g. emergency coolant injection) and post-Fukushima modifications and emergency mitigation equipment. In the event all other measures fail, the containment system is available to limit radiation release and dose to the public and environment. The approach to defense in depth is depicted in Figure B.3.

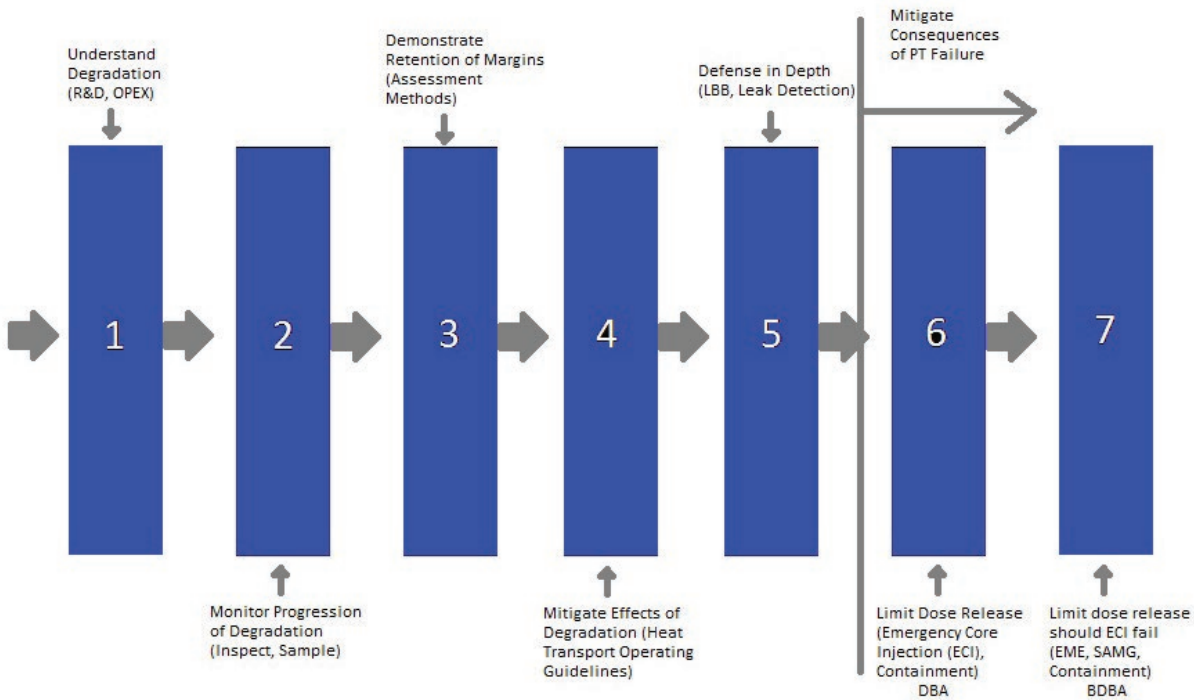


Figure B.3 – Defense in Depth Framework Employed by OPG- Barriers to Fuel Channel Failure and Mitigation of Consequence in Event of PT Failure

4 Aging Management Programs

The fuel channels are a major component in CANDU reactors and OPG utilizes an Aging Management Program compliant with IAEA Safety Guide NS-G-2.12 and CNSC REGDOC 2.6.3 to ensure fuel channel integrity is well managed throughout the operational life of the plant. This is accomplished by establishing an integrated set of programs and activities that ensure fuel channel performance and fitness for service requirements are satisfied on an ongoing basis. This program also requires preparation of life cycle management plans and condition assessments, which are discussed in Sections 5.0 and 6.0 below.

Aging Management considerations are applicable throughout the plant life cycle, including design, construction, commissioning and operation. Critical aging management considerations are included and addressed in each of these phases. The basic framework for the Aging Management process is "Plan-Do-Check-Act". This framework (illustrated in Figure B.4) ensures that planning is in place; the plant is operated in accordance with this plan; the plant condition is monitored; and that action is taken to manage the effects of aging.

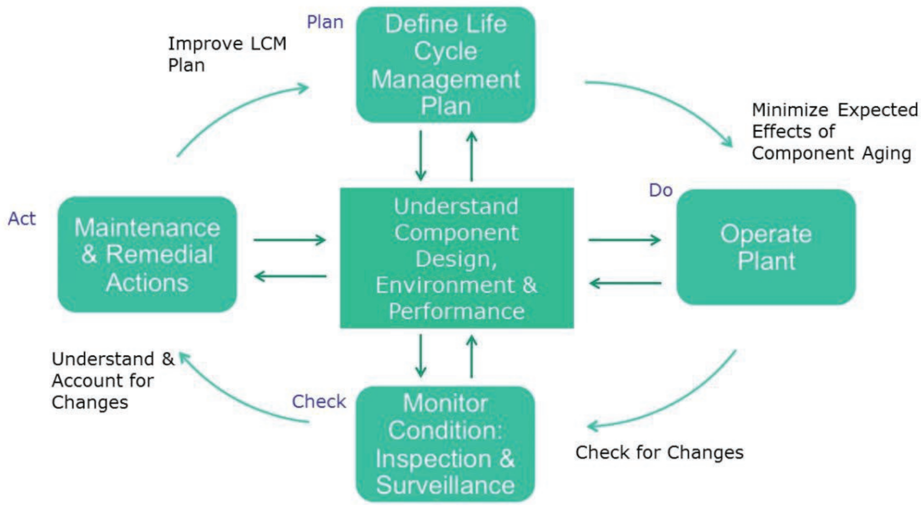


Figure B.4: Integrated Aging Management Process

The Aging Management Program and the activities it drives are key to ensuring critical equipment aging is managed such that operation of the nuclear power plant remains within the licensing basis of the facility and allows for station safety and operational goals to be met. OPG produces and regularly updates a Fuel Channels Life Cycle Management Plan (FCLCMP) which ensures deliverables are well defined and that activities are planned and coordinated. The plan is optimized based on current understanding and routine assessment of component condition. Execution of the plan allows projections to be made regarding remaining life of the components. This process ensures the effects of component aging can be minimized allowing for operation of the reactor to target end of life, with mitigating actions implemented as required.

5 Overview of Fuel Channel Fitness for Service (FFS)

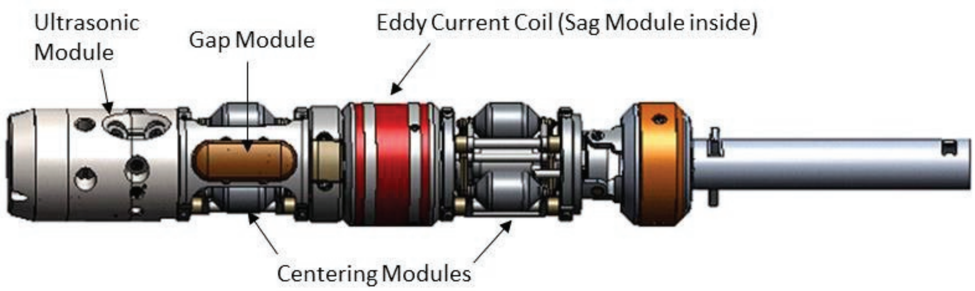
To ensure safe operation and FFS of fuel channels, life cycle management activities are rigorously performed in accordance with industry standards.

The Canadian Standards Association (CSA) Standard N285.4 (Reference B.1) prescribes requirements for monitoring fuel channel conditions via periodic inspections of multiple fuel channels. This standard also prescribes material surveillance which requires harvesting both small (thin scrape) and large (removal of entire pressure tube (PT)) samples of PT material for subsequent destructive testing at a specialized laboratory facility to confirm material properties. The CSA Standard N285.4 standard defines acceptance criteria that must be met for given fuel channel conditions. If a fuel channel condition satisfies these acceptance criteria then that condition is considered unconditionally acceptable, as the fuel channel remains within the design basis.

OPG produces and regularly updates a Fuel Channels Life Cycle Management Plan (FCLCMP) which documents planned inspection and surveillance activities for planned reactor inspection outages. The planned periodic inspections of PTs are conducted to assess degradation and monitor for change. These inspections typically exceed CSA Standard N285.4 minimum requirements.

OPG utilizes specialized engineered tooling to perform fuel channel inspections; one example is the ANDE / CIGAR hybrid inspection system tool (Advanced Non-Destructive Examination / Channel Inspection and Gauging Apparatus for Reactors). This inspection tool incorporates multiple non-destructive examination techniques, including ultrasonic testing (UT) and eddy current testing (ECT), and is deployed inside the pressure tube after the channel has been defueled.

The tool is designed to inspect the full volume of the tube along the full length of the PT, including flaw detection, sizing and characterization; measurement of PT diameter and wall thickness; measurement of PT deflection (sag); measurement of the gap between the PT and calandria tube (CT); and confirmation of annulus spacer locations. An image of the ANDE / CIGAR hybrid inspection head and a schematic of pressure tube characteristics are shown in Figure B.5.



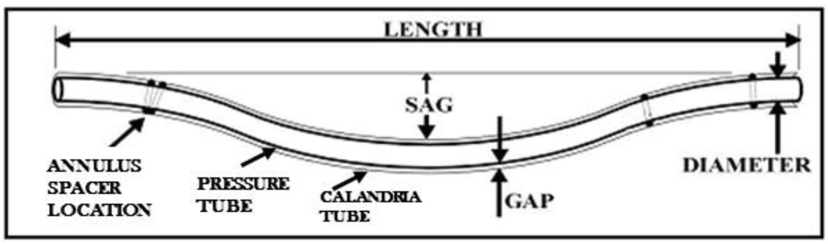


Figure B.5 – ANDE / CIGAR hybrid Inspection Tool Head used for inspection of CANDU fuel channels (top image) and schematic of fuel channel characteristics (bottom diagram not to scale, channel characteristics shown are for illustrative purposes)

When in-service inspection detects a condition (e.g. flaw, dimensional or material condition) that does not satisfy the acceptance criteria of CSA Standard N285.4 (Reference B.1), OPG must comply with the technical requirements of CSA Standard N285.8 (Reference B.2) to demonstrate continued fitness for service. CSA Standard N285.8 requires assessment of known as well as projected conditions, evaluation of material properties including any observed changes, and risk assessment of uninspected population of PTs in the reactor core. This process of evaluation requires a disposition that must be submitted to the CNSC for acceptance, as required by CSA Standard N285.4. The predictive models and assessment methodologies used to assess FFS are supported by accumulated knowledge obtained from continuing industry research and development activities, and they ensure predicted conditions remain acceptable.

The FFS assessment approach in Reference B.1 ensures that PTs have adequate integrity for continued service and that OPG continues to operate its reactors safely and within the licensing basis. Figure B.6 graphically depicts the FFS approach. The FFS framework also ensures that, through periodic inspection, OPG continually understands the condition of the fuel channels, and is able to predict fuel channel condition and ensure future operation remains within the acceptable FFS envelope.

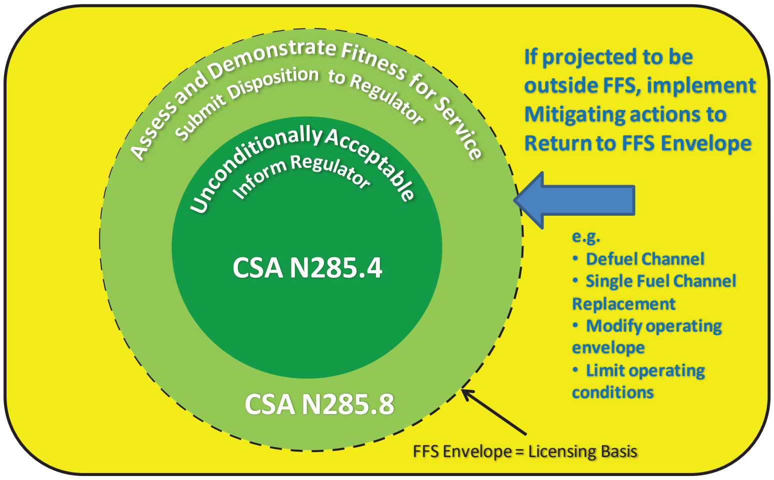


Figure B.6 - Fuel Channel Fitness For Service (FFS) Assessment Approach

If projections of fuel channel conditions suggest future departure from the FFS envelope, mitigating actions are available and will be implemented in order to remain within the envelope. For example, single fuel channel replacement may be employed in a postulated extreme case where assessment of a given pressure tube flaw is unable to satisfy FFS criteria.

6 Condition Assessment of Fuel Channels

The condition assessment process is used to evaluate the health of critical components and establish actions necessary to maintain component health and assure continued fitness-for-service (FFS) for planned future operation. This process seeks to identify and understand aging mechanisms, collect data, conduct analyses, and evaluate component condition by comparison with defined acceptance criteria. The condition assessment of fuel channels is satisfied by several FFS assessments.

Condition assessments for pressure tubes involve monitoring all of the aging mechanisms affecting fuel channels. As shown in Figure B.7, fuel channel aging mechanisms are grouped into three main categories; PT deformation, changes to PT material properties, and PT flaws. These mechanisms can result in crack initiation in the PT material. By operating in accordance with operating guidelines, the potential for crack initiation is extremely unlikely. As a defense in depth measure, crack propagation is postulated and evaluated to prepare for the unlikely event that a crack initiates in the PT. Procedures are in place to assure that a leaking crack can be detected (via moisture detection equipment) and to safely shut down the reactor prior to the postulated crack growing to a length exceeding the critical limit of stability. As described above in Section 3.0, in the unlikely event of pressure tube failure, mitigating systems are employed to provide necessary cooling to maintain integrity of the reactor core, and containment systems are in place to prevent a release of radiation to the public. OPG has not observed a leaking crack in the current generation of installed pressure tubes. This is attributed to operation within defined procedures, design improvements and application of rigorous aging management processes, in accordance with OPG's aging management governance.

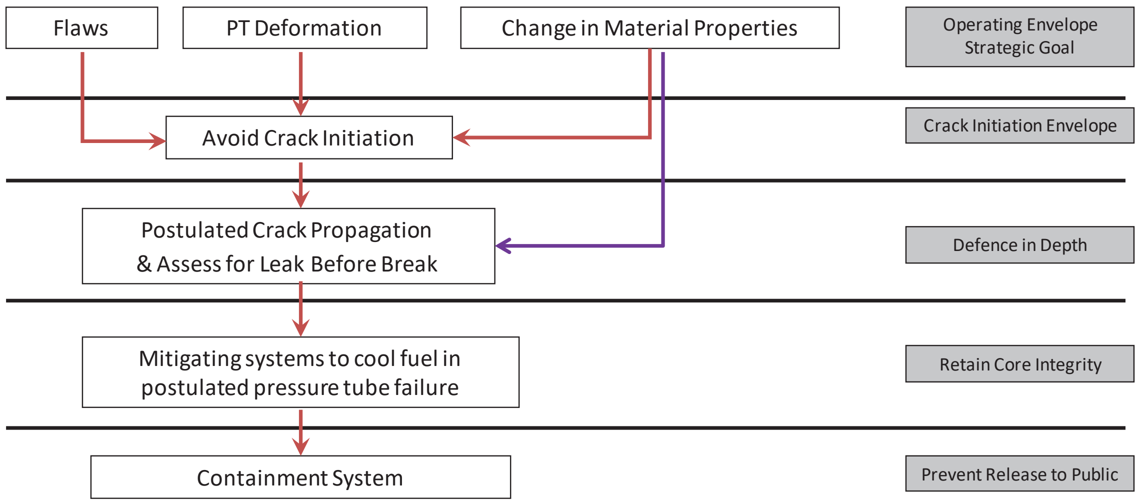


Figure B.7 - Management of Fuel Channel Aging and Defense in Dept

A summary of aging mechanisms associated with Pickering fuel channels is provided in Reference B.3. OPG has assessed the effects of fuel channel aging on all units, and confirmed that planned aging management strategies, including application of available mitigation options as required, will provide additional margin on fuel channel fitness-for-service limits for operation of the Pickering units to their assumed service life targets.

Furthermore, OPG performs in-service inspections in planned outages to verify its understanding of the condition of the core and to confirm that the unit is fit for service for the planned operating period prior to the next planned inspection. If at any time emerging results, research findings, or industry operating experience challenges the validity of existing fitness for service assessments, OPG will evaluate the impact of these results, in accordance with internal corrective action processes and licensing basis requirements.

7 A Review of Technical Issues Related to Assurance of Fuel Channel Fitness for Service

CNSC has provided comments (Reference B.4) on OPG's submission (Reference B.3) regarding assurance of fuel channel fitness for service for the planned operating period of Pickering units. OPG has a mature aging management program and tools in place to inspect and assess the condition of fuel channel components. CNSC has provided a list of issues and related additional activities required to confirm that structural integrity margins will be maintained up to the expected end of commercial operation in December 2024. A summary of the issues expressed, their relation to fuel channel degradation mechanisms and establishment of fitness for service, and OPG's responses, are provided in the following Sections.

7.1 Deuterium Ingress and Hydrogen Isotope Concentration [Heq] Measurement

The increase of hydrogen isotope equivalent concentration, [Heq] in the PT, (due to deuterium ingress) is a known aging mechanism that occurs slowly and predictably over the operating life of the plant. During reactor operation the surface of PTs is subject to corrosion. This electrochemical corrosion process results in the production of zirconium oxide and deuterium, with the primary source of deuterium being from the heavy water coolant of the heat transport system.

Some of the deuterium produced from corrosion is absorbed by the PT. The accumulation of deuterium in the PT impacts the resistance to crack initiation from in-service flaws and affects pressure tube material properties (such as fracture toughness, a measure of material resistance to propagation of a growing crack) over the life of the reactor.

Deuterium ingress is well characterized. The [Heq] level is higher at the rolled joint (RJ) regions of the fuel channel as two sources of deuterium ingress are possible in addition to ingress across the inner surface of the PT. They are: deuterium ingress from the stainless steel end fitting interacting with the pressure tube due to galvanic corrosion; and deuterium ingress from the galvanic cell that can establish in the crevice between the pressure tube and the end fitting. The locations of highest expected [Heq] represent a relatively small portion of the PT, at the rolled joint regions, and are shown in Figure B.8.

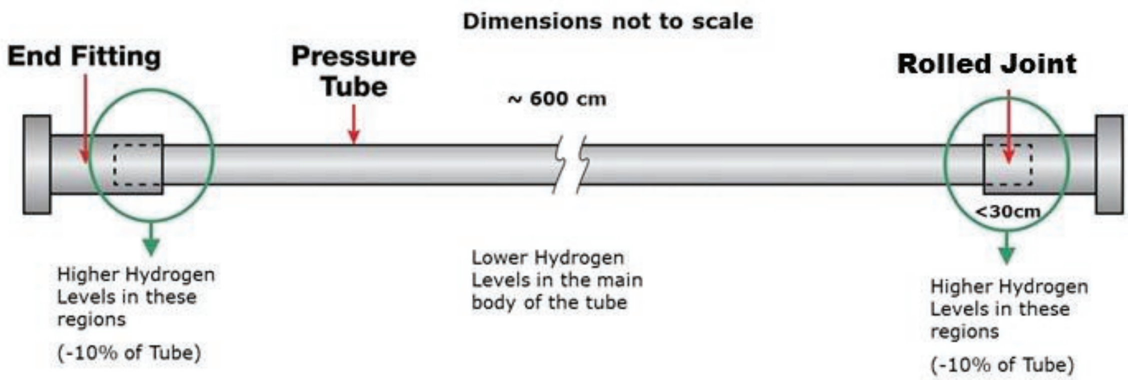


Figure B.8 – Fuel Channel schematic depicting relative level of [Heq] for given locations along a given pressure tube

The [Heq] within pressure tubes is routinely monitored by material surveillance activities which involve scraping a thin sample of the inside surface of the pressure tube in both the body of tube (BOT) and rolled joint (RJ) regions during inspection outages when the reactor is in a shutdown state. Hydrogen and deuterium concentrations are also measured in pressure tubes periodically removed from the reactor. CSA Standard N285.4 (Reference B.1) has established acceptance criteria, for measured hydrogen concentration, [Heq] in the form of maximum hydrogen concentration values and maximum allowable rate of change in hydrogen concentration.

CNSC staff provided comments related to the deuterium ingress models used by industry and the measurement of [Heq] in Reference B.4, the majority of which are related to deuterium/protium[1] measurement practices and deuterium ingress modeling methodology, which are generic issues for the CANDU industry. OPG provided responses to CNSC comments and a schedule of planned future updates in Reference B.5, and is working with its industry partners and other CANDU utilities to resolve these comments. CNSC staff responded in Reference B.6.

OPG continues to participate in the Fuel Channel Research and Development (R&D) program through the CANDU Owners Group (COG) and provides annual updates of planned work activities to CNSC. R&D related to deuterium ingress is performed with a focus on understanding the mechanisms influencing deuterium ingress in pressure tubes, and how these mechanisms change over the reactor operating life, and incorporating emerging knowledge into improved models to ensure predicted conditions remain appropriately conservative. OPG will provide a report to the CNSC, in accordance with REGDOC-3.1.1 requirements, if any emerging R&D results or industry operating experience appear to challenge the validity of existing fitness for service assessments, and will also initiate the actions necessary to ensure that fitness for service is maintained.

[1] Protium is an isotope of hydrogen, having one proton in the atomic nucleus. Deuterium is an isotope of hydrogen with a nucleus of one proton and one neutron., The primary source of ingress is from the heavy water coolant.

OPG is confident that deuterium ingress is well managed by ongoing in-service and ex-service pressure tube material surveillance and R&D activities. Accordingly, through the execution of the Life Cycle Management Plan activities, assessment of deuterium ingress will provide the information needed to manage the fitness for service and safe operation of Pickering fuel channels.

7.2 Fracture Toughness and the Predictive Models

Fracture toughness is a material property that represents the ability of a material to resist unstable crack propagation and fracture. Pressure tube fracture toughness reduces with pressure tube operating time as a result of irradiation, and accumulation of deuterium/hydrogen. Understanding the progression of this reduction in fracture toughness properties is essential in the demonstration of fitness for service of pressure tubes as fracture toughness properties directly influence the ability to demonstrate pressure tube leak-before-break (LBB) and protection against fracture.

The protection against fracture and LBB assessments conservatively postulate the existence of a through-wall flaw in the pressure tube as the starting point of the evaluation. These evaluations are used to establish operating envelopes and operating procedures which include a tolerance for postulated flaws. Several CANDU reactor units in Canada have achieved in excess of 30 years of operation. There have been no through-wall leaking cracks found in either in-service inspections or by online leak detection systems for the current set of tubes installed in these reactors. Previous leak events in early CANDU operational history were associated with either rolled-joint or manufacturing flaw issues. These issues were subsequently addressed through improvements to rolled-joint assembly practices, material fabrication, and inspection procedures. All reactors with historical rolled joint issues have had their pressure tubes replaced and have implemented improved rolled joint assembly processes.

Fracture toughness properties are influenced by operating temperature, irradiation damage, and material impurities (particularly hydrogen in the form of precipitated hydrides, and chlorine in the form of Zr-C-Cl complexes). As is the case with many other metals, zirconium exhibits a reduction in fracture toughness from upper shelf (ductile behaviour) to lower shelf (brittle behaviour) as a function of temperature. Upper shelf fracture toughness properties have been observed experimentally at temperatures associated with reactor power operation ($T > 250°C$).

As the [Heq] in the PT increases with increasing corrosion (deuterium ingress), the total hydrogen equivalent content [Heq] can exceed the solubility limit for hydrogen, at which point the hydrogen above the solubility limit can no longer remain in solution and precipitates as a localized zirconium-hydride platelet. The amount of hydride precipitates is affected by the local temperature (solubility increases with temperature) and the local concentration of hydrogen (amount of hydrogen above the solubility limit). For a given local concentration of hydrogen, there will be more hydride precipitates present at cold shutdown conditions than at hot operating conditions. The presence of hydride platelets within the zirconium metal results in small localized areas that are less resistant to fracture. As more hydride platelets are present in the metal (at high hydrogen concentrations) there is lower overall fracture toughness in the material. The morphology (shape and structure), orientation and amount of hydride platelets can influence the resultant fracture toughness of the pressure tube material.

In 2009, fuel channel experts recognized the potential for reduced pressure tube fracture toughness at high [Heq]. At that time, OPG proactively created a test program to investigate fracture behaviour in the presence of hydrides, develop a means of artificially hydriding ex-service pressure tubes (without altering the effects of irradiation damage) to produce test specimens representative of end of life pressure tube conditions, and develop engineering models to support fitness-for-service assessments.

One advantage of the CANDU PT design is that it is possible to assess fracture toughness by burst testing full size sections of pressure tube that have been removed from a reactor. With this laboratory test configuration, no correction for dimensions, specimen shape or stress state needs to be made when assessing the test results. A typical burst test is performed using a section of pressure tube material roughly 0.5m in length that is artificially hydrided to a desired target [Heq], representing future conditions. A substantial starter flaw is artificially introduced to initiate crack propagation during increasing applied pressure. Rising internal pressure is applied until the sample bursts. The burst pressure and additional measurements determine the fracture toughness of the PT material in the test specimen. An example of a PT section burst test is shown in Figure B.9.

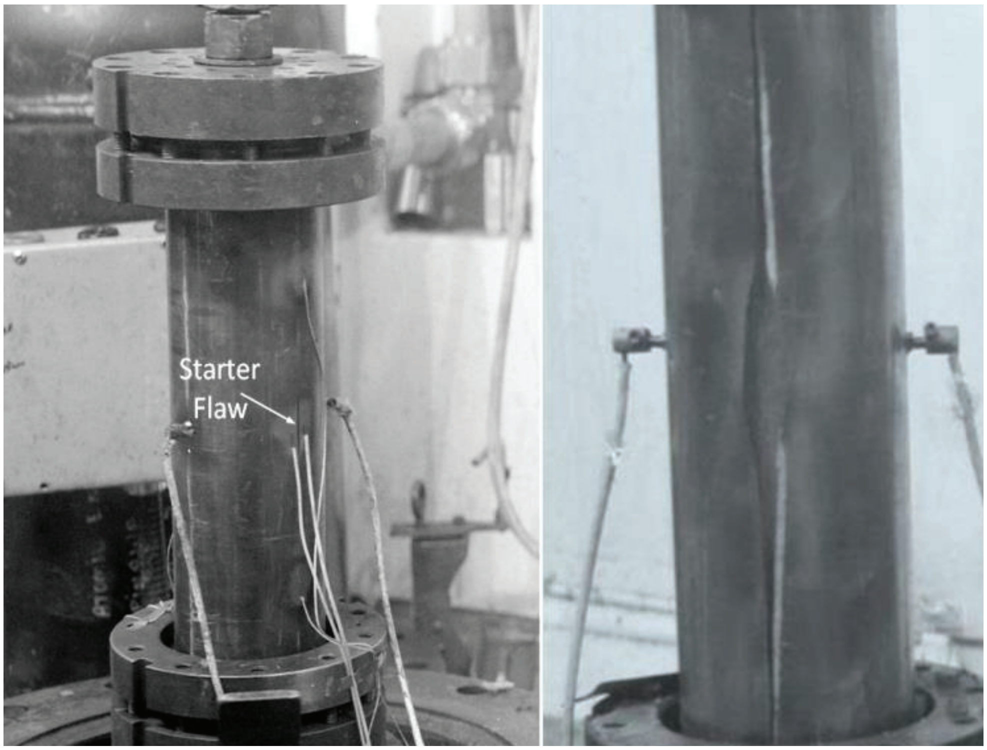


Figure B.9 – Typical example of ex-service pressure tube burst test showing start of tests (left) with artificial starter flaw noted and at test completion after tube has burst (right)

By 2014, multiple artificially hydrided ex-service irradiated pressure tube sections from different tubes had been completed at multiple test temperatures, on test specimens with [Heq] concentrations ranging between 60 to 126ppm. The results of these tests and associated observations and analysis of pressure tube metallography led to the development of new fracture toughness models for high hydrogen content. One model was created for the upper shelf, or fully ductile fracture region, which covers operation at normal operating conditions (≥ 250°C). A second model was developed for the lower shelf and transition region, which covers heat-up and cool-down of the reactors (<250°C). The lower shelf and transition region model is referred to as the Cohesive-Zone model as the reduction in fracture toughness due to bulk hydrides was simulated by a reduction in cohesive-zone restraining stress due to hydride fracture. Figure B.10 illustrates a simplified version of the fracture toughness model, illustrating the effect of high hydrogen content on the lower bound fracture toughness values.

In 2013, these improved models which account for hydrogen content were independently reviewed by third parties and determined to be adequate for current use. Industry incorporated these new models into the 2015 edition of CSA Standard N285.8 and OPG has implemented the model in updated fuel channel FFS assessments.

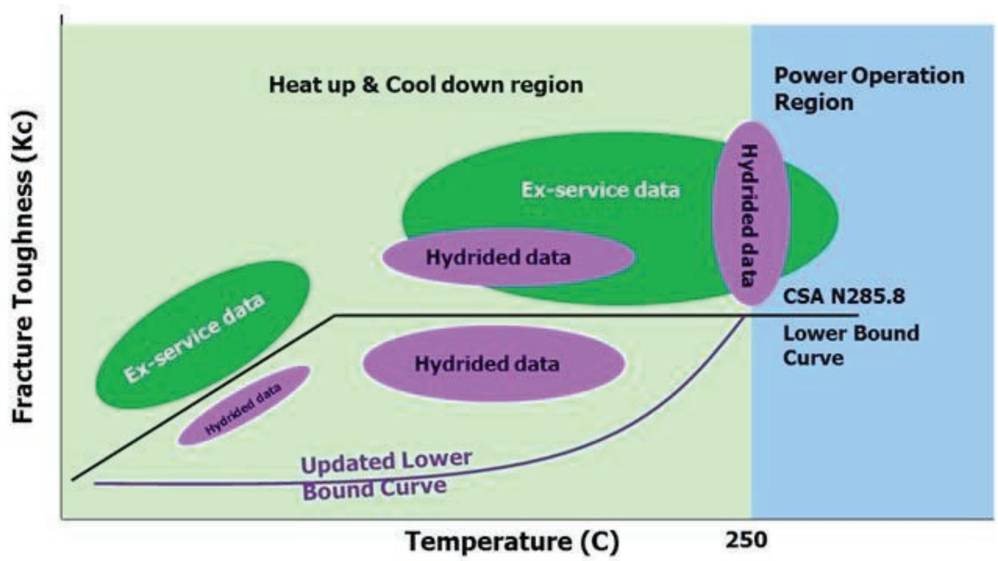


Figure B.10 – Updated Lower Bound Fracture Toughness Curve accounting for high Hydrogen Content

Using the pressure tube fracture toughness model incorporated into CSA Standard N285.8, OPG has implemented changes to operating envelopes and procedures to support continued demonstration of fracture protection and LBB for the full service life of the plant. The pressure-temperature envelope establishes a safe envelope for protection against fracture for the case of a postulated severe flaw.

Based on projected hydrogen isotope concentration levels at end of service life and the new fracture toughness model (Figure B.11), OPG has assessed the impact and implemented modifications to the pressure–temperature operating envelope, and associated operating procedures for primary heat transport system heat-up and cool down during reactor start-up and shut down (Figure B.12). The modified operating procedures have been implemented to manage the brief time period (typically a few hours) in transitioning from full power operation to reactor shutdown, and return from shutdown to at-power operation. It should be noted that for the vast majority of time (more than 99 percent), the reactors are either in full power operation or in safe shutdown state, when the fracture toughness of the pressure tubes is not of concern.

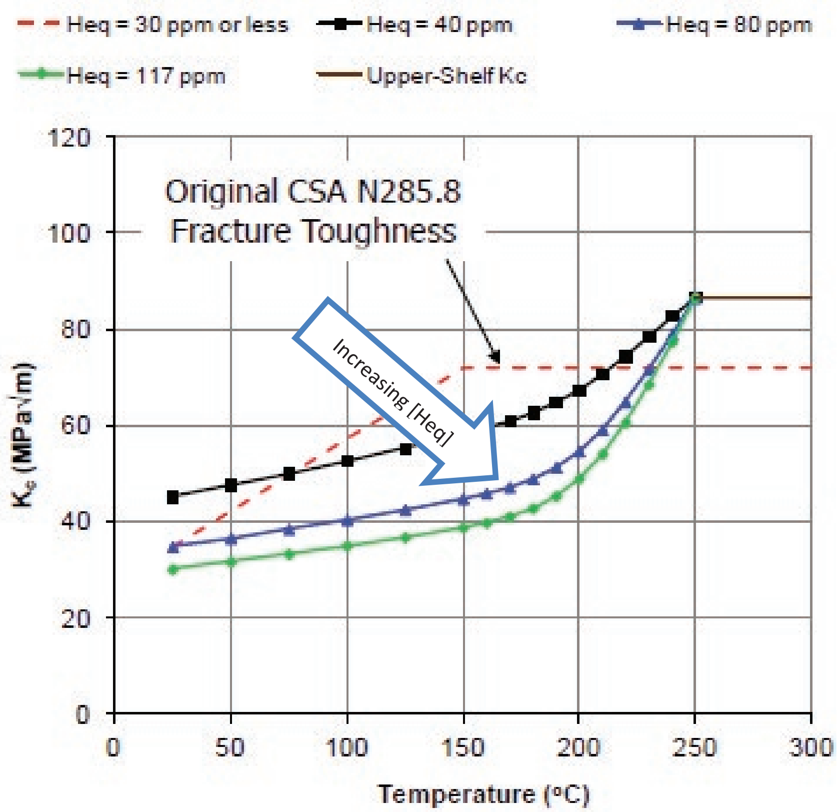


Figure B.11 – Comparison of previous CSA N285.8 Fracture Toughness Model with Cohesive Zone model predictions. 97.5% lower prediction bound on fracture toughness curves with [Heq] using Chlorine concentration of 5 ppm.

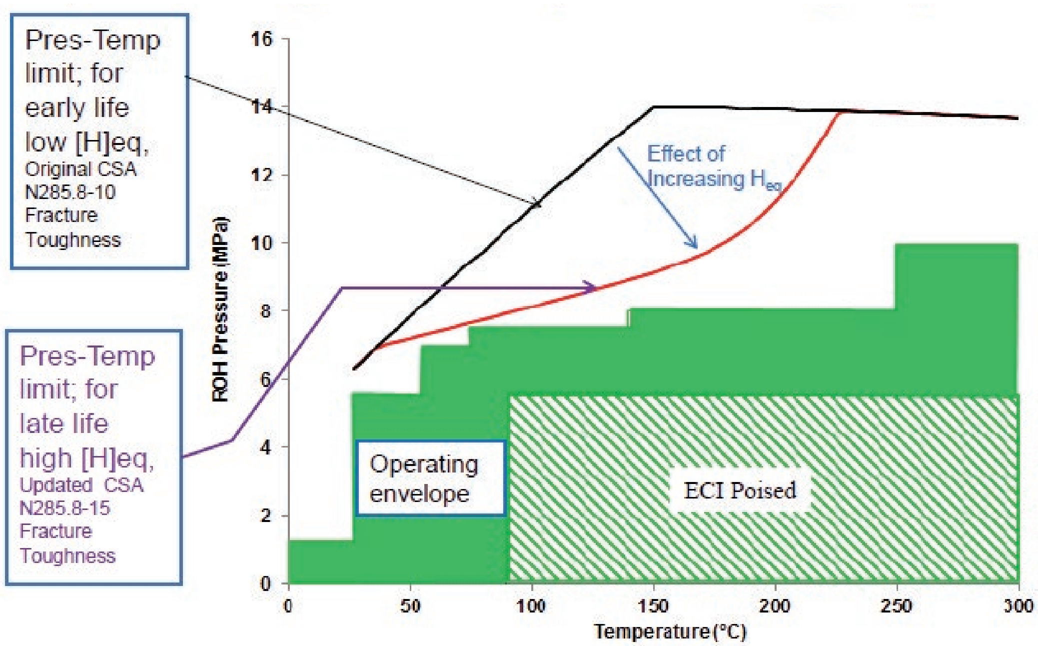


Figure B.12 – Illustrative example of revised allowable operating pressure-temperature envelope (green) as a result of a revised flaw stability curve for a postulated through-wall flaw (red) using updated lower bound fracture toughness curve for late life high [H]eq pressure tube.

Since the time of model incorporation into the CSA Standard N285.8-15, OPG has continued to perform additional tests as part of the COG Fuel Channel Life Management (FCLM) project, which is co-funded by Bruce Power and Canadian Nuclear Laboratories. The FCLM project planned and conducted two series of tests to support fracture toughness model development. The purpose of the Series 1 tests was to validate the Cohesive Zone model in the range of transition temperatures between 150°C and 250°C. The purpose of the Series 2 tests was to assess fracture toughness under end of life conditions targeted by project partners. OPG has also performed additional R&D work in response to feedback received from CNSC staff and third party reviewers to demonstrate continuing conservatism of the model and determine potential improvements.

OPG routinely communicates updates on work progress, including burst test results, to the CNSC under an OPG Action Item 2014-OPG-4782. In Reference B.4 CNSC staff requested that OPG provide a path forward to address the impacts of recent burst tests on the validity of the Cohesive Zone model. One of the recent burst tests (identified as BT-29) on ex-service tube material artificially hydrided to 100 ppm [Heq] had a fracture toughness value below the lower bound predictions of the Cohesive Zone model. This is the only irradiated burst test conducted since creation of the Cohesive Zone model in 2013 to have had a fracture toughness value below the lower bound prediction. The burst test program to date has been performed using a conservative set of conditions for hydriding and testing tube sections. As a result, OPG considers the predictions from the models that were built using the test data to be conservative. OPG evaluated the BT-29 test result and determined that existing FFS assessments remain valid on the basis that the [Heq] and sample preparation conditions used for the test were more severe than conditions expected for pressure tubes in Pickering Units for the planned operational life (up to 295k EFPH). Specifically, preparation of the BT-29 sample yielded hydride morphology and orientation more severe than anticipated in the Pickering fuel channels to the end of the planned operational life.

Industry experts on pressure tube fracture toughness judged that improved fracture toughness properties would be expected at lower [Heq], and results from subsequent burst test samples that are more reflective of late-life conditions have confirmed fracture toughness properties within the models that are in use in current fitness for service assessments. OPG has increased the number of planned burst tests to further validate the existing Cohesive Zone model at [Heq] expected prior to target operational life. OPG provided a detailed response to the CNSC in Reference B.5 regarding continuing plans for additional burst tests to further validate the existing Cohesive Zone model, with tests to be performed in 2018, 2019, and 2020. These additional tests will also support ongoing efforts for the development of an improved model that explicitly accounts for actual variation of hydride morphology and hydride orientation from pressure tube inlet to outlet. This improved model, which will include enhancement of mechanistic parameters influencing fracture toughness, is planned to be completed in 2018.

OPG is confident that planned activities provide for appropriate management of pressure tube fracture toughness in support of continuing demonstration of fuel channel fitness for service for the planned operating period of Pickering units.

7.3 Fuel Channel LCMP Compliance with REGDOC-2.6.3 Aging Management

OPG's aging management program and the FCLCMP have been based on the attributes of REGDOC-2.6.3, Aging Management (Reference B.8). REGDOC-2.6.3 sets out CNSC requirements for managing aging of structures, systems, and components of a power reactor facility, and also provides guidance as to how these requirements may be met. The REGDOC-2.6.3 document is built upon industry best practices, IAEA Safety Guide NS-G-2.12 (Reference B.9) and supersedes CNSC documents RD-344 (Reference B.10) on aging management.

One of the outputs of Pickering's Periodic Safety Review is an action to update the structure and comprehensiveness of OPG's Fuel Channel Life Cycle Management Plan (FCLCMP) to better demonstrate compliance with REGDOC-2.6.3.

OPG has developed Integrated Implementation Plan (IIP) actions to provide an update to the FCLCMP and related supporting technical basis documentation.

In support of Pickering operation to 2024, OPG is preparing a Readiness Plan that complements the FCLCMP, and which will contain a REGDOC-2.6.3 compliance roadmap to demonstrate that OPG's aging management program for fuel channel components satisfies the requirements of the REGDOC for effective aging management. The Plan will also include detailed assessments of all fuel channel degradation mechanisms and action plans for completing the activities necessary to support fitness for service assessment to the end of 2024. The Readiness Plan will be issued in March 2018 and submitted to CNSC for a regulatory determination, and will be updated on an annual basis.

OPG will also update the structure of the FCLCMP in the next planned update of the plan, to clearly demonstrate that the requirements outlined in REGDOC-2.6.3 are satisfied. To this end the FCLCMP will incorporate aging management actions described in the Readiness Plan, including a summary table that identifies the various fuel channel degradation mechanisms associated with aging, and mitigation strategies to support operation to 2024. The table will also provide the current status of each of the degradation mechanisms and the acceptance criteria to ensure the effects of aging will be managed to the expected end of commercial life. The summary will also identify the FFS assessments that provide assurance for continued operation, required R&D, and improvements to assessments required to support fuel channel FFS for extended life.

In Reference B.6, the CNSC provided feedback regarding OPG's plan to demonstrate compliance with REGDOC-2.6.3. OPG is confident that compliance with REGDOC-2.6.3 is addressed through the IIP actions and in future updates and through a complementary Readiness Plan which together demonstrate that OPG's aging management program for fuel channel components satisfies the requirements of the REGDOC for effective aging management.

8 Summary

This addendum briefly provides an overview of how fitness for service of fuel channels is established and monitored throughout the operational life of a fuel channel.

OPG can confidently state that the fuel channels will remain fit for service up to their intended service life of 295,000 EFPH. This confidence is derived from a mature, well-defined life cycle management program that is based on years of operating experience and supporting research. This program produces fitness-for-service assessments that are aligned with all licensing requirements. Based on the established programmatic controls for managing fuel channel aging, which include an extensive reactor inspection program, sound technical assessments, and the implementation of mitigating measures where required, OPG is confident that Pickering fuel channels will remain fit for service to the end of 2024. OPG is documenting, in a Pickering 2024 Readiness Plan, the key life cycle management actions needed to support safe operation to end of 2024.

OPG is committed to safe and reliable operation of fuel channels at Pickering NGS throughout the planned commercial operating, estimated to be up to 295,000 EFPH.

References

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[B.4] CNSC letter, A. Viktorov to R. Lockwood, "Pickering NGS - Assurance of Fuel Channel Fitness-for-Service for the Assumed Target Service Life of the Pickering Units", August 25, 2017, e-Doc # 5309704, CD# P-CORR-00531-05127.

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[B.9] IAEA publication, "Aging Management for Nuclear Power Plants", International Atomic Energy Agency (IAEA), Safety Standards Series, Safety Guide NS-G-2.12, 2009.

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Addendum C
Pickering Whole-Site Risk Assessment

Introduction

This addendum summarizes the Pickering whole-site risk assessment, which represents a substantial effort that is first-of-a-kind and at the forefront of whole-site probabilistic safety assessment (PSA) development.

OPG understands and deeply appreciates the importance of nuclear safety, and recognizes that assuring the low risk of the site is of great public interest. As such, site risk has always been considered and managed at OPG's nuclear facilities, including at Pickering. In the course of further exploring this topic, the present study has enabled OPG to revisit the topic from a fundamental and holistic perspective, and to better characterize whole-site risk.

Background

PSA has long served as an important tool for assessing and managing nuclear power plant risk. A major benefit of PSA is the identification of risk insights which can be used to improve plant design and operation. PSAs are conducted separately for internal and external types of hazards, in particular for internal events, internal fires, internal floods, seismic hazards, and high wind hazards. Many other hazards are also considered and dispositioned as part of the PSA hazard screening process.

During the previous relicensing hearings for Pickering, the topic of "whole-site" risk was raised in light of the fact that – for each of the hazard PSAs – results have been expressed on a "per reactor unit" basis. Whole-site risk refers to the characterization of the overall risk of the site due to:

- multiple reactor units;
- internal and external hazards;
- other reactor operating modes (besides full power and outage states); and
- other on-site sources of radioactivity (such as the irradiated fuel bays).

One of the key issues concerns the numerical aggregation of PSA results. For instance, if aggregating across all reactor units, for a given hazard, the multi-unit PSA value is generally not equal to the per-unit PSA value multiplied by the number of units on site.

Moreover, the simple addition of PSA values across all hazards (internal events + fire + flood +...etc.) - might not be appropriate. Caution must be exercised as it is recognized that when risk metrics for external events are conservatively estimated, their summation with risk metrics for other events can lead to misinterpretation, in particular if the aggregated total exceeds the safety goal.

Another key issue is around the lack of international consensus on whole-site PSA methodology. Whole-site PSA remains an area of ongoing development outside of Canada.

Furthermore, not all hazards are quantified in terms of PSA risk metrics (for example, security threats), and hence, they do not lend themselves to aggregation by simple summation of common risk metrics. As such, there are broader considerations in the risk assessment of nuclear facilities (including programmatic, deterministic, and defense-in-depth aspects, in addition to PSA).

It is important to emphasize, given the extensive sharing of safety-related systems including shared containment, that the OPG "per-unit" based PSAs have always addressed multi-unit effects and hence, are "multi-unit" PSAs. This is briefly described in "OPG's PSAs are multi-Unit PSAs" on page 115.

OPG's PSAs are multi-Unit PSAs

For each type of hazard (internal events, fire, flood, etc.), the detailed PSAs are used to estimate severe core damage frequency (SCDF) and large release frequency (LRF) on a per- hazard, per-unit basis. To facilitate the estimation of a per-unit risk metric, one of the units at the station is chosen as the reference unit and the risk metrics are estimated for that unit. As there are few design differences between the units in a station, the SCDF and the LRF for the reference unit are representative of the SCDF and the LRF for the other units. However, each hazard PSA is broken down into a range of initiating events that also include multi-unit scenarios. The initiating events include those that:

1. Occur on the reference unit and affect only the reference unit, e.g. loss of reactor power control.
2. Occur on an adjacent unit and affect the reference unit as well as the adjacent unit e.g. steam from a large steam line failure on an adjacent unit causing a transient on the reference unit.
3. Affect all units simultaneously, e.g. a loss of off-site power, a main control room fire, or a seismic event.

An event tree is prepared for each initiating event and a fault tree is prepared for each of the safety functions defined in the event tree. While the focus of the PSA is the reference unit, the event trees and the fault trees take into account multi-unit dependencies, for example:

1. A common initiating event can affect the reliability of the safety functions on all units and affect the reliability of inter-unit safety functions. For example, failures associated with a common service water intake can cause an initiating event and affect the reliability of the unitized, shared and inter-unit emergency service water supplies.
2. The PSA takes into account the number of units participating in the sequence. For example, more emergency service water pumps may be required to operate following an initiating event affecting multiple units than for an initiating event affecting a single unit.
3. The range of post-operator actions required to be performed in a sequence affecting multiple units might be greater than the range of actions required to be performed in a single unit sequence. This might increase the probability of failure to perform the required actions either as a result of increased complexity or increased time pressure.

Sequences that result in severe core damage are grouped according to similar characteristics, i.e., plant damage states (PDS). The attributes of a PDS include the number of units participating in the sequence, in addition to other factors such as the type of initiating event, the severity and timing of core damage, and the mitigating system status.

Thus, the OPG PSAs have always been multi-unit PSAs (MUPSA) in that they explicitly account for multi-unit interactions, even though PSA results are expressed on a per-unit, per-hazard basis. Through careful risk aggregation, the per-unit based PSA results may be combined to more fully quantify MUPSA (or whole-site PSA) risk metrics for a given hazard type.

Efforts Related to Whole-Site Risk Estimation

OPG has fulfilled its commitment to provide the Pickering whole-site PSA. The work is complete and was submitted to CNSC staff in December 2017. Much of this work was performed in collaboration with industry via the CANDU Owners Group (COG). Furthermore, OPG and industry members have met regularly with CNSC staff to provide updates on progress and to present results.

In January 2014, COG hosted an international workshop on topics related to whole-site risk.

COG members have also actively participated in CNSC workshops and other international initiatives, such as by the IAEA. These workshops were well attended by many experts from around the world, and they served to provide valuable exchanges of information and insights for consideration in the Pickering whole-site PSA.

In February 2014, COG issued an initial, concept-level paper on whole-site PSA, COG-13-9034 Development of a Whole-Site PSA Methodology. This paper provided a general methodology that was accepted by CNSC staff. The paper was made publicly available on OPG's external website.

Furthermore, a COG joint project was launched to further develop the initial concepts in support of the Pickering whole-site PSA. The participants who have been involved and funded this joint project include:

- from within Canada: OPG, Bruce Power, New Brunswick Power; and Canadian Nuclear Laboratories; and
- from overseas: SNN, of Romania, and the Korea Hydro and Nuclear Power Company Limited.

The output of this work has been utilized as part of the overall approach for Pickering whole-site risk assessment, as outlined further below.

Risk and Safety Concepts

The topic of risk is complex and has been studied extensively. In trying to evaluate risk, it is useful to refer to the following excerpts which provide some high-level, qualitative guidance in the form of overarching objectives.

- Nuclear Safety Control Act - prevent unreasonable risk, to the environment and to the health and safety of persons associated with development and use of nuclear energy.
- IAEA Fundamental Safety Principles - The Fundamental Safety Objective is to protect people and the environment from harmful effects of ionizing radiation. Measures for controlling radiation risks must ensure that no individual bears an unacceptable risk of harm.
- US NRC - Individual members of the public should be provided protection from the consequences of nuclear power plant operation such that individuals bear no significant additional risk to life or health. Societal risks to life and health from nuclear power plant operation should be comparable to or less than the risks of generating electricity by viable competing technologies and should not be a significant addition to other societal risks.

In the above, there are some universal themes around protection of the public and the environment, using the terms "risk" and "safety", and notions on the acceptability and relativity of risks - that is, compared to other risks that the public is normally exposed to.

The word "risk" is commonly used in everyday language, in some context or another. Risk can be used to indicate the degree of safety of an activity - recognizing that there are inherent risks in many human activities, such as driving a car. In very general terms, risk is the likelihood of an undesirable event multiplied by the consequence of the event.

As a simple illustration, Figure C.1 shows how risk can be qualitatively characterized in terms of high, medium, and low risks – depending on both the likelihood and consequences of events.

Likelihood	Potential Consequence				
	Negligible	Minor	Moderate	Major	Extreme
Almost Certain	Medium	High	High	Very high	Very high
Likely	Medium	Medium	High	High	Very high
Possible	Low	Medium	Medium	High	High
Unlikely	Low	Medium	Medium	Medium	High
Rare	Low	Low	Low	Medium	Medium

Key for black & white print:

Green	Low
Yellow	Medium
Amber	High
Red	Very high

Figure C.1 - Example of qualitative characterization of risk in terms of likelihood and potential consequences of events

In the assessment of risk for any activity, the criteria that define tolerable versus intolerable risk are often quite challenging to determine. As a case in point, the excerpt below is from a Canadian Federal Court ruling for an incident that occurred outside of the nuclear industry; the excerpt can be found on the CNSC's public website.

...safety is not measured. It is judged and it is judged according to an assessment of an acceptable risk: ... An acceptable risk is essentially a value-based proposition determined by policy and/or by those authorized by governments to judge safety and/or by those exposed to the risk.

A key point to highlight is that safety is not measured. Rather, it is a judgement that is based on an assessment of what is deemed to be an acceptable risk associated with the activity. These concepts apply to nuclear safety as well.

Pickering Whole-Site Risk: Overall Approach and Key Results from the Whole-Site PSA

The overall approach for the Pickering whole-site risk assessment is basically comprised of two elements: a qualitative assessment to describe how nuclear safety is assured and a quantitative set of studies associated with whole-site PSA.

1. How nuclear safety is assured at a nuclear power plant site

The first element involves setting the appropriate context and broad perspective for the discussion of whole-site risk and the role of PSA. Site risk has always been considered and managed at OPG's nuclear facilities, including at Pickering.

As explained in a COG white paper (COG-JP-4499-025-R1, Whole-Site Risk Considerations for Nuclear Power Plants), the evaluation of whole-site risk involves the consideration of both qualitative and quantitative information that facilitates a value judgment of the reasonableness of risk and is informed by many factors within a broad perspective that includes various programmatic, deterministic, and defense in depth considerations, as well as PSA. This is consistent with the general principles of risk-informed decision making.

Hence, whole-site PSA is distinguished as a supporting tool and subset of whole-site risk assessment. That is, PSA plays an important complementary role to other factors. Its main benefit is to help identify risk insights for improvement of plant safety. Furthermore, calculated PSA risk metrics provide an indication of the level of plant risk – not an absolute measure of safety.

OPG and other utilities have always considered various sources of risk at their nuclear power plant (NPP) sites when making a determination on the adequacy of safety. OPG demonstrates the reasonableness of site risk by means of various programs that:

a. are in place for all aspects of operation;

b. comply with applicable regulatory requirements;

c. collectively, assure NPP safety; and

d. manage risk to be reasonably low.

Whole-site risk should not be characterized by a single number. Rather, as explained in the COG white paper, whole-site risk evaluation is supported by an integrated assessment using quantitative and qualitative information in 14 Safety and Control Areas (SCAs). At Pickering NGS, the aforementioned programs are in place for each SCA to ensure effective risk management (for example, via the Risk and Reliability Program). These programs are robust and are briefly described the Pickering NGS Licence Application (Reference C.1).

OPG maintains oversight and regularly assesses the performance of these programs, and periodically improves the programs as necessary. Collectively, the programs serve to assure nuclear safety and that the overarching objectives on protection of public health and the environment are met. Furthermore, the annual CNSC Integrated Plant Rating for each station is viewed as an independent indication that the overall risk associated with each site is limited to a reasonable level. Recent Integrated Plant Ratings for Pickering NGS have been Fully Satisfactory, which supports that the Pickering whole-site risk is low.

In the most general sense of the term, risk aggregation (whole-site risk) is addressed holistically as discussed above. Caution must be exercised with any form of numerical risk aggregation. For instance, the simple addition of PSA risk values across all hazards may yield a biased result due to the large uncertainties and conservative assumptions associated with external hazards such as seismic and high winds (i.e., the sum of the means may not equal the mean of the sum). Furthermore, as indicated earlier, for a given hazard type, a multi-unit PSA risk result (such as LRF) is generally not equal to the per-unit risk value multiplied by the number of units on site. Moreover, not all hazards are quantified in terms of PSA risk metrics (for example, malevolent acts) and hence, they do not lend themselves to risk aggregation by arithmetic summation of common risk metrics. The COG white paper also discusses numerical risk aggregation of the different hazard PSA results and the manner in which such risk aggregation results can be meaningfully presented - as part of a whole-site PSA (which is in support of the broader approach to whole-site risk).

With respect to the current OPG per-unit PSA safety goals (SCDF and LRF), it is important to note that their underlying basis was originally rooted in serving as surrogates for meeting health objectives while also providing a reasonable basis to address other potential impacts; in particular, large releases of long-lived radioactivity leading to extensive land contamination of the environment.

The per-unit LRF goal ($1x10^{-5}$/yr) is more directly linked to these aspects. However, these PSA goals are targets, not "hard limits"; the values are somewhat arbitrary and represent a broad consensus for individual reactor units. A LRF value on the order of 10^{-5}/yr (i.e., somewhat greater than $1x10^{-5}$/yr) can still provide margin to quantitative health objectives, QHOs (such as the US NRC QHOs), and is a reasonable basis for other considerations discussed above.

2. Whole-Site PSA

This element of the overall approach focusses on the application of whole-site PSA, as a means of providing a quantitative perspective on the whole-site risk. For the Pickering whole-site PSA, the major tasks involved the following:

- The development of guidance for the assessment of lower power reactor operating states, recognizing that the PSAs have traditionally assessed 100% full-power conditions, and not the intermediate operating states between the Guaranteed Shutdown State and full power;
- The application of this guidance for the Pickering "A" and "B" reactor units;
- The development of a general method to determine which other sources of on-site radioactivity, besides the reactors, need to be addressed within a whole-site PSA;
- The systematic and detailed walkdowns of the Pickering site to identify the non-reactor sources;
- The development and application of risk assessment methodology for the irradiated fuel bays at Pickering;
- A risk assessment of the Pickering used fuel dry storage facility;
- The comprehensive updating of the Pickering 1, 4 and Pickering 5-8 reactor PSAs and risk estimates, to reflect modelling enhancements and physical plant improvements; and
- The numerical aggregation of PSA results, across the site.

Results for lower power reactor operating modes and other non-reactor sources of radioactivity

With respect to other reactor operating modes, the current PSAs explicitly cover the 100% full-power (FP) operating state and the Guaranteed Shutdown State (GSS). CNSC REGDOC-2.4.2 requires the assessment of other states where the reactor is expected to operate for extended periods of time. As part of the Pickering whole-site PSA, such states have been comprehensively assessed following the COG guideline for selection of the "other states", called plant operating states (POS). The applications of this guideline for Pickering 'A' and Pickering 'B' have been submitted to CNSC staff. All stages of the reactor start-up and shutdown procedures were reviewed, and it was confirmed that the risk is bounded by the 100% Full Power and outage PSAs. Based on this work, the overall conclusion is that the risk associated with these operating states is low.

With respect to other sources of radioactivity on the Pickering site, i.e., besides the reactors, comprehensive work was performed to assess the associated risk. OPG followed the COG general approach for source identification and screening, i.e., to identify sources of radioactive material that potentially fall within the scope of a whole-site PSA and to develop criteria for deciding if a source should be included within the scope of a whole-site PSA. The systematic application of this approach for the Pickering site was documented and submitted to CNSC staff, and included detailed walkdowns at the site. The whole site was checked for sources that could result in a large release of cesium-137 – whether releasable by the sources themselves, or in combination with other sources. Based on this work, various non-reactor sources of radioactivity were screened out as being insignificant risk sources at Pickering, with the exception of two sources identified for further study: the irradiated fuel bays (IFB) and the used fuel dry storage facility.

An IFB risk assessment methodology was developed by COG, and a risk assessment of the Pickering IFBs has been conducted, generally consistent with the COG method. The IFB risk assessment involves both deterministic and probabilistic considerations, and was submitted to CNSC staff. The overall conclusion is that the risk associated with the Pickering IFBs is low.

OPG also submitted its assessment of the Pickering used fuel dry storage facility. The overall conclusion is that the risk associated with this facility is low.

Results of PSA risk aggregation

The current per-unit, per-hazard based PSAs have provided risk insights that have led to improvements in plant design and operation. It was recognized that further risk insights might be obtained through the calculation of PSA results on a station-wide basis for each hazard type (i.e., a set of all-units, per- hazard results).

The primary figure of merit is the site-based LRF, as it is a more direct indicator of risk to the public than a site-based SCDF. The COG white paper outlines the general methodology for the arithmetic aggregation of per-unit LRF results to express the LRF on a per-station basis for a given hazard type (i.e., how to obtain an all-units, per-hazard LRF value). Essentially, the LRF aggregation across all units is a form of extrapolation of the per-unit based LRF results, leveraging the multi-unit contributions that have already been accounted for in the per-unit based PSA (as described earlier). As such, it represents a pragmatic approach to estimating the site LRF for a given hazard type.

It is noted that the approach requires careful decomposition of the per-unit based PSA results and that some assumptions may be necessary in lieu of more detailed PSA modelling of all units. One needs to very carefully utilize the per-unit based large release frequency information so as to avoid overcounting events in the aggregation. For example, if the per-unit large release frequency calculation already accounts for a seismic event that causes all units to simultaneously undergo severe core damage and result in a large release - then, in the per-site large release frequency aggregation, that same event should only be counted once and not multiple times for each of the non-reference units.

To summarize the key terms, the OPG per-unit based PSA is in fact a multi-unit PSA (MUPSA) in that:

- the *per-unit LRF* represents the likelihood of an off-site large release due to severe accidents that involve the “reference unit”, either that unit alone or simultaneously with one or more of the other (non-reference) units.

The LRF aggregation approach enables a more comprehensive MUPSA quantification in that:

- the *per-site LRF* represents the likelihood of an off-site large release due to severe accidents that involve “any” one or more of the units (whether the reference or non-reference units).

The PSA risk aggregation calculations consider all six operating units from the “A” & “B” sides of the station and are based on a number of items, including:

- Pickering “B” PSA results from the 2017 S-294 PBRA updates for internal and external hazards;
- Pickering “A” risk estimates based on the 2014 PARA updates with Fukushima Action Plan items and various elements of the Pickering risk improvement plan;
- Emergency mitigation equipment (EME);
- Plant modifications being pursued in relation to the Periodic Safety Review; and
- Severe Accident Management Guidance (SAMG).

While there is no site LRF safety goal per se, the calculated values of site LRF are conservatively compared against the per-unit LRF safety goal of 1×10^{-5}/reactor-yr. For each hazard, the corresponding Pickering NGS site LRF is less than 1×10^{-5}/yr (see Table C.1), i.e., well below the per-unit LRF safety goal.

As discussed above under Element 1, whole-site risk should not be characterized by a single number and risk aggregation across all hazards is not technically appropriate. Notwithstanding, the simple addition of the per-site LRF aggregation results across all hazards is calculated to be 0.82 x 10^{-5}/yr, as shown in Table C.1, i.e., this is still lower than the per-unit LRF safety goal, which is normally applied on a per-hazard basis. These results serve to indicate that the Pickering whole-site risk is acceptably low.

Hazard	Large Release Frequency (x 10^{-5} per year)
	per site
Internal Events	0.18
Internal Floods	0.07
High Wind	0.31
Internal Fires	0.17
Seismic	0.09
Total	0.82

Table C.1 - Summary of Pickering NGS LRF Aggregation

Risk Aggregation Calculation

Detailed calculation of Pickering NGS LRF aggregation

For each hazard type:

Pickering NGS LRF = PNGS ‘A’ LRF + PNGS ‘B’ LRF

For each side of station:

LRF = LRF from single-unit events + LRF from multi-unit events

PNGS ‘A’ LRF = 2 x single-unit LRF + 1 x two-unit LRF

PNGS ‘B’ LRF = 4 x single-unit LRF + 2 x two-unit LRF + 1 x four-unit LRF

where, for each side of the station (as applicable):

- the “single-unit” LRF is a subset of the per-unit LRF that includes initiating events for which only a single unit is affected (i.e., reference unit only)
- the ”two-unit” LRF is a subset that includes accident sequences where two units are simultaneously affected, i.e., the reference unit + one other unit [note: for a four-unit station, there are 3 such combinations, out of a possible 6 two-unit combinations in total]
- the “four-unit” LRF is a subset that includes initiating events that affect all four units simultaneously
- three-unit sequences are very few; lumped with four-unit cases

Total Whole-Site LRF = Sum across hazards of Pickering NGS LRF for each hazard

Note: Need to carefully interpret the result.

Insights

Detailed breakdowns and graphical displays of the various Pickering LRF values were provided to the CNSC staff in OPG's submission of December 2017. This facilitates the identification of some additional insights from the whole-site PSA.

For instance, with respect to the Pickering B per-unit LRFs reproduced below in Figure C.2:

- The composite (blue and orange portion) shows the "per-unit" LRF as traditionally calculated in the hazard PSA, where multi-unit effects are taken into account; and
- The "single unit only" (blue portion) represents the LRF contributions for which only the reference unit is involved in accidents leading to large off-site releases.

These results are based on the 2017 S-294 PBRA update (which includes EME) and credit of SAMG and PSR modifications. The proximity of the "per-unit" LRF value relative to the "single-unit only" LRF value illustrates the extent to which multi-unit effects factor into the per-unit LRF. In this case for Pickering B, Figure C.2 shows that the "per-unit" LRF is well above the "single-unit only" LRF for internal events and seismic, indicating that additional multi-unit sequences significantly contribute to the per-unit LRF for both of these hazards (i.e., although the per-unit LRF is "per unit" based, it includes more than just events involving the reference unit only). In contrast, for the case of internal floods, Figure C.2 shows that the "per-unit" LRF is very close to the "single-unit only" LRF value, indicating that although some additional multi-unit sequences are captured – they are not major contributors to the per-unit LRF for Pickering B flood hazards (single-unit events dominate for this hazard type).

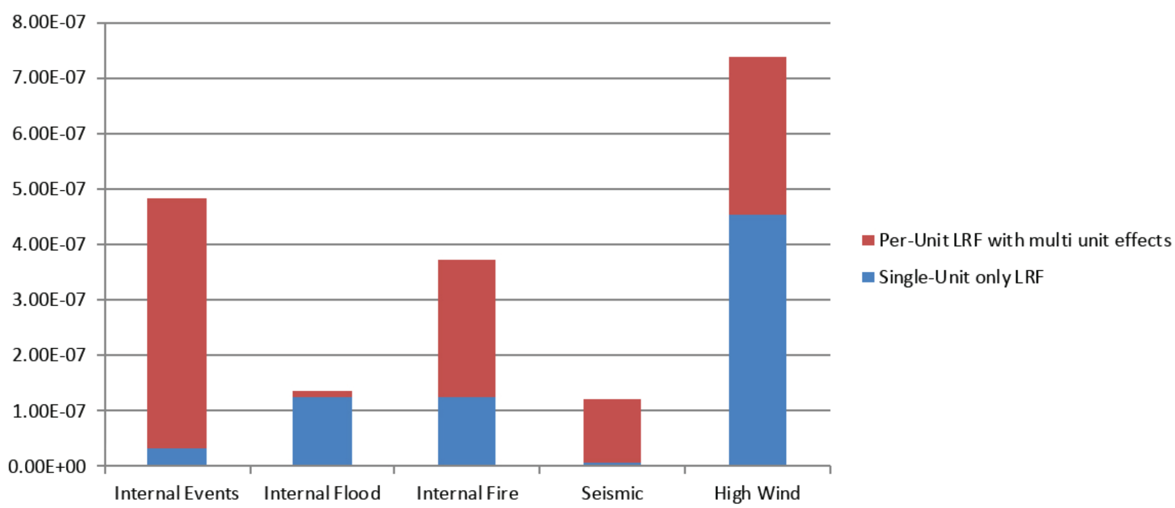

Figure C.2 - Pickering 5-8 per-unit vs single-unit LRFs

On a per-site (or per-station) basis, the calculated LRF more fully accounts of multi-unit effects, i.e., by consideration of LRF contributions directly from the non-reference units. The proximity of the "per-unit" LRF relative to the "per-site" LRF value represents the extent to which the per-unit LRF covers multi-unit sequences across the station. For example, by inspection of the detailed results from this study, the Pickering B per-unit LRF largely encompasses the LRF aggregated across all units on the Pickering B side of the station, indicating that the Pickering B seismic risk is dominated by sequences where all units are simultaneously affected. Such a comparison of per-unit LRF vs per-station LRF sheds light on the extent of inclusion of multi-unit effects in the per-unit LRF.

As another example, consider the summary of the Pickering NGS per-site LRFs shown below in Figure C.3 Here, the per-site, per-hazard results have also been broken down into the purely “single unit” and “multi unit” contributions. For a given hazard, the ”single units only” (blue portion) represents the site-wide large release frequency associated with events where only a single unit is involved (whether it is the reference unit or one of the non-reference units). The “multi units” (orange portion) represents the additional large release frequency contribution for events which involve more than one unit; and the composite (blue plus orange portions) represents the full value of the site-wide large release frequency, for the given hazard.

Figure C.3 shows that, depending on the hazard, the site risk associated with a hazard may be dominated by multi-unit scenarios (as in the case of internal events) or by single-unit type of events (as in the case of internal fires).

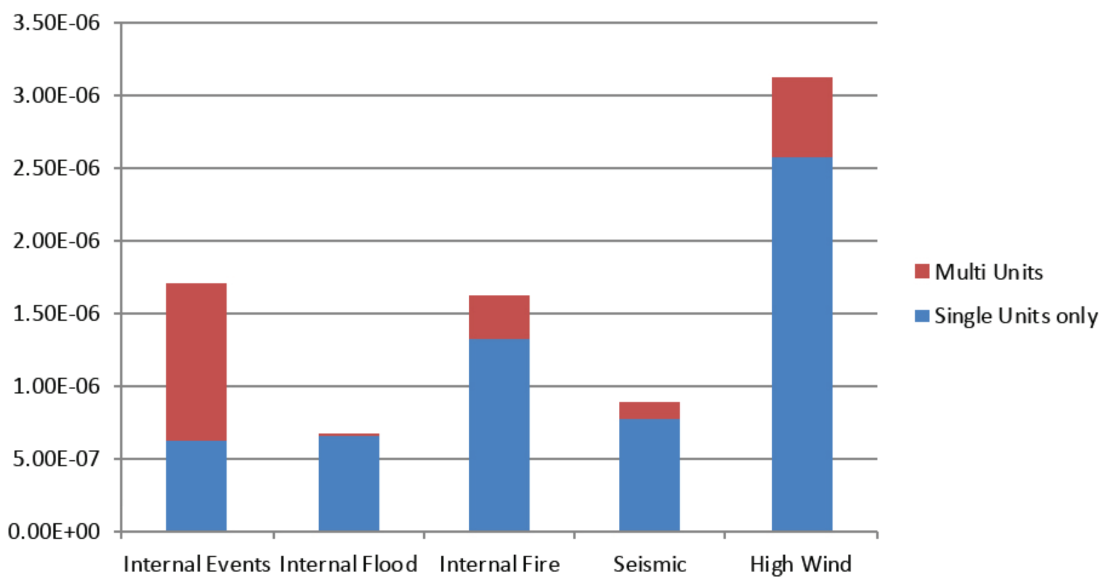

Figure C.3 - Pickering NGS site-wide LRF summary

Lastly, careful examination of the per-unit vs. per-station LRF results may also shed new light on the relative risk of different hazards. That is, the hazard risk profile may look different when results are viewed from a per-station basis rather than a per-unit basis. For example, based on inspection of the present results:

- for Pickering 5-8, internal flood appears as a comparable LRF risk to internal events and fire when viewed from a Pickering B per-station perspective, and high wind is still dominant; and
- for Pickering 1, 4, high wind appears as a comparable LRF risk to internal events as the dominant risk, when viewed from a Pickering 1, 4 per-station perspective.

Summary

A substantial amount of work has been conducted in support of Pickering whole-site risk. OPG has worked in collaboration with COG and has kept CNSC informed of progress.

Site risk has always been considered and managed at OPG's nuclear facilities, including at Pickering. Nonetheless, the present study has enabled a new perspective on the characterization of whole-site risk. The overall evaluation of whole-site risk involves the consideration of both qualitative and quantitative information that informs the judgement of risk, and this includes many factors within a broad perspective that encompasses various programmatic, deterministic, and defense-in-depth considerations, as well as PSA.

The traditional OPG PSAs have always been multi-unit PSAs in that they explicitly account for multi-unit interactions, even though the PSA results are expressed on a per-unit basis. Whole-site PSA is an important tool that supports whole-site risk assessment. Through careful risk aggregation, the per-unit based PSA results have been combined to more fully quantify multi-unit PSA risk metrics separately for each hazard type.

Further to the detailed technical insights that were previously gleaned from the per-unit PSAs on a hazard by hazard basis, the Pickering whole-site PSA has identified some additional insights, particularly around the understanding of the relative contributions of purely single vs. multi-unit risks and of the relative risk of different hazards from a site perspective.

The risks associated with other on-site sources of radioactivity, such as the IFBs, as well other (low power) modes of reactor operation, have also been systematically assessed.

The overall conclusion, based on the information provided in this submission, is that the Pickering whole-site risk is low.

OPG will continue to share its learnings with the international community, for example, through IAEA initiatives on multi-unit PSA, and will monitor the best industry practices in this subject area.

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Securing Ontario's Clean Power Future

Enclosure 1

Application for Renewal of Pickering Nuclear Generating Station Power Reactor Operating Licence

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(Total pages including cover sheet 198)

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August 28, 2017

CD# P-CORR-00531-05055

MR. M. A. LEBLANC
Commission Secretary

Canadian Nuclear Safety Commission
280 Slater Street
Ottawa, Ontario
K1P 5S9

Dear Mr. Leblanc:

Application for Renewal of Pickering Nuclear Generating Station Power Reactor Operating Licence

The purpose of this letter is to submit the licence renewal application for the Pickering Nuclear Generating Station (NGS) Power Reactor Operating Licence, PROL 48.03/2018, which expires on August 31, 2018.

Ontario Power Generation (OPG) Incorporated is a Canadian corporation located at 700 University Avenue, Toronto, Ontario, M5G 1X6.

OPG requests a ten-year licence renewal, from September 1, 2018 to August 31, 2028. The Pickering facility consists of eight nuclear reactors and their associated equipment, which were designed to produce electrical power. Six of the units are operational (Units 1 and 4 and Units 5-8) and two units (Units 2 and 3) have been placed in a safe storage state.

OPG also requests Commission approval to operate beyond the current Commission approved limit of 247,000 Effective Full Power Hours (EFPH) on the Pickering 5-8 fuel channels, up to 295,000 EFPH for the lead Pickering unit which corresponds approximately to the intended end of commercial operation (December 31, 2024).

The management and control of operation of the Pickering facility and the nuclear substances, prescribed equipment, and associated prescribed information, are the overall responsibility of Mr. Randy Lockwood, Senior Vice-President of the Pickering NGS.

This licence renewal application demonstrates that Ontario Power Generation is qualified to operate the Pickering NGS and will 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.

Attachment 1 is included for convenience, to assist in locating specific information within the application corresponding to the requirements of the Nuclear Safety and Control Act and applicable regulations as well as other information that was requested in Reference 1.

Attachment 2 describes, for the 14 CNSC Safety and Control Areas (SCAs), OPG's programs, station performance during the current licence period and planned improvements. The information that is included with this application is in accordance with the requirements of the Nuclear Safety and Control Act and applicable Regulations and further requirements as provided by the CNSC in Reference 1.

This application also provides information to support the Environmental Assessment (EA) under the Nuclear Safety and Control Act (NSCA) that will be conducted by CNSC staff.

Enclosure 1 fulfils the requirements of Section 3(e) of the Class I Nuclear Facilities Regulations by providing information on non-radiological hazardous substances at the nuclear facility.

As communicated in Reference 2, OPG intends to cease commercial operation of all Pickering units on December 31, 2024. Also, note that this licence renewal application encompasses three phases of operational activities over the proposed licence term: continued commercial operation, a stabilization phase (post-shutdown defueling and dewatering), and the early period of a safe storage phase.

OPG's responses to the preliminary list of new CNSC regulatory documents and CSA standards for inclusion in the Pickering LCH under Compliance Verification Criteria (CVC) listed in Attachment 2 of Reference 1, was submitted in Reference 3.

In support of this licence renewal, OPG is undertaking a Periodic Safety Review (PSR) per the requirements of regulatory document RegDoc-2.3.3, "Periodic Safety Reviews". PSR deliverables are being submitted to CNSC staff per the mutually agreed upon schedule outlined in Reference 4.

In summary, OPG is requesting approval from the Canadian Nuclear Safety Commission for a licence renewal for a ten-year term, from September 1, 2018 to August 31, 2028, and approval for operation beyond the current operating limit of 247,000 EFPH up to 295,000 EFPH for the lead Pickering unit which corresponds approximately to the intended end of commercial operation (December 31, 2024).

The information provided within this licence application supports these requests and demonstrates that OPG is qualified to carry on the licensed activities and makes adequate provisions to protect the health, safety and security of persons, and the environment. OPG is committed to safe and reliable operation of the Pickering NGS and continues to meet or exceed all of the legal requirements of the NSCA and the associated regulations.

Consistent with OPG's approach towards open and transparent public communications, OPG will be posting this application on its external web-site www.opg.com.

If you have any questions, please contact Dr. Jack Vecchiarelli, Manager Pickering Relicensing, at (905) 839-6746 extension 5444.

Randy B. Lockwood

Randy Lockwood
Senior Vice President
Pickering Nuclear

cc: A. Viktorov - CNSC Ottawa
CNSC Site Office - Pickering

References:

1. CNSC letter, A. Viktorov to B. McGee, "Application Requirements for Renewal of the Pickering Power Reactor Operating Licence" September 8, 2016, e-Doc #5034082, CD# P-CORR-00531-04833.

2. OPG Letter, R. Lockwood to G. Frappier, "End Date of Commercial Operations for Pickering NGS", June 28, 2017, CD# P-CORR-00531-04930.

3. OPG Letter, R. Lockwood to A. Viktorov, "Pickering Licence Renewal: Regulatory Documents and Standards Proposed for Inclusion in the Licence Conditions Handbook", August 11, 2017, CD# P-CORR-00531-05087.

4. Protocol, "OPG-CNSC Protocol for the Conduct of a Periodic Safety Review in Support of Pickering NGS Licence Renewal", January 17, 2017, e-Doc 5143721, CD# P-CORR-00531-04725 R001.

Attachments:

1. "Licence Renewal Application Matrix"

2. "Pickering Nuclear Generating Station Power Reactor Licence Application"

Enclosure:

1. OPG Report, "Pickering NGS Hazardous Substances", July 28, 2017, CD# P-REP-08965-0633695 R001

Attachment 1

Licence Renewal Application Matrix

(15 pages including this coversheet)

Table 1: Licence Application Matrix – Applicable Regulations

NOTE: Unless otherwise specified, all sections cross-referenced below refer to Attachment 2.

General Nuclear Safety and Control Regulations	
Requirement(s)	**Application Cross-Ref.**
3. (1) An application for a licence shall contain the following information: (a) the applicant’s name and business address;	Cover Letter
(b) the activity to be licensed and its purpose;	Appendix A
(c) the name, maximum quantity and form of any nuclear substance to be encompassed by the licence;	Appendix A
(d) a description of any nuclear facility, prescribed equipment or prescribed information to be encompassed by the licence;	1.2
(e) the proposed measures to ensure compliance with the *Radiation Protection Regulations* and the *Nuclear Security Regulations*;	2.7 & 2.12
(f) any proposed action level for the purpose of section 6 of the *Radiation Protection Regulations*;	2.7.5
(g) the proposed measures to control access to the site of the activity to be licensed and the nuclear substance, prescribed equipment or prescribed information;	2.12
(h) the proposed measures to prevent loss or illegal use, possession or removal of the nuclear substance, prescribed equipment or prescribed information;	2.12 & 2.13
(i) a description and the results of any test, analysis or calculation performed to substantiate the information included in the application;	1.2, 2.4.2
(j) the name, quantity, form, origin and volume of any radioactive waste or hazardous waste that may result from the activity to be licensed, including waste that may be stored, managed, processed or disposed of at the site of the activity to be licensed, and the proposed method for managing and disposing of that waste;	2.11, Appendix A, & Enclosure 1
(k) the applicant’s organizational management structure insofar as it may bear on the applicant’s compliance with the *Act* and the regulations made under the *Act*, including the internal allocation of functions, responsibilities and authority;	2.1.2
(l) a description of any proposed financial guarantee relating to the activity to be licensed;	Appendix B
(m) any other information required by the *Act* or the regulations made under the *Act* for the activity to be licensed and the nuclear substance, nuclear facility, prescribed equipment or prescribed information to be encompassed by the licence; and	Throughout

General Nuclear Safety and Control Regulations (cont)	
Requirement(s)	**Application Cross-Ref.**
(1.1) The Commission or a designated officer authorized under paragraph 37(2)(*c*) of the *Act*, may require any other information that is necessary to enable the Commission or the designated officer to determine whether the applicant: (a) is qualified to carry on the activity to be licensed, or	See Tables 2 & 3 in this Attachment 1
(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.	2.8, 2.9, 2.10, 2.12 & 2.13
5. An application for the renewal of a licence shall contain (*a*) the information required to be contained in an application for that licence by the applicable regulations made under the *Act (i.e. in this case: General Nuclear Safety and Control Regulations section 3, Class I Nuclear Facilities Regulations sections 3 and 6, and Nuclear Security Regulations section 3)*; and	Throughout
(*b*) a statement identifying the changes in the information that was previously submitted.	Letter
15. Every applicant for a licence and every licensee shall notify the Commission of (*a*) the persons who have authority to act for them in their dealings with the Commission;	2.1.13
(*b*) the names and position titles of the persons who are responsible for the management and control of the licensed activity and the nuclear substance, nuclear facility, prescribed equipment or prescribed information encompassed by the licence; and	Letter and 2.1.13
(*c*) any change in the information referred to in paragraphs (*a*) and (*b*), within 15 days after the change occurs.	2.1.13

Class I Nuclear Facilities Regulations	
Requirement(s)	**Application Cross-Ref.**
3. An application for a licence in respect of a Class I nuclear facility, other than a licence to abandon, shall contain the following information in addition to the information required by section 3 of the *General Nuclear Safety and Control Regulations*: (*a*) a description of the site of the activity to be licensed, including the location of any exclusion zone and any structures within that zone;	1.2 & Appendix A
(*b*) plans showing the location, perimeter, areas, structures and systems of the nuclear facility;	1.2
(*c*) evidence that the applicant is the owner of the site or has authority from the owner of the site to carry on the activity to be licensed;	1.2
(*d*) the proposed quality assurance program for the activity to be licensed;	2.1
(*e*) the name, form, characteristics and quantity of any hazardous substances that may be on the site while the activity to be licensed is carried on;	Enclosure 1
(*f*) the proposed worker health and safety policies and procedures;	2.7 & 2.8
(*g*) the proposed environmental protection policies and procedures;	2.9
(*h*) the proposed effluent and environmental monitoring programs;	2.9
(*i*) if the application is in respect of a nuclear facility referred to in paragraph 2(*b*) of the *Nuclear Security Regulations*, the information required by section 3 of those Regulations;	2.12
(*j*) the proposed program to inform persons living in the vicinity of the site of the general nature and characteristics of the anticipated effects on the environment and the health and safety of persons that may result from the activity to be licensed; and	3.0
(*k*) the proposed plan for the decommissioning of the nuclear facility or of the site.	2.11.4
6. An application for a licence to operate a Class I nuclear facility shall contain the following information in addition to the information required by section 3: (*a*) a description of the structures at the nuclear facility, including their design and their design operating conditions;	1.2, 2.3.9, 2.4.1 & 2.4.2
(*b*) a description of the systems and equipment at the nuclear facility, including their design and their design operating conditions;	1.2, 2.3.9, 2.4.1 & 2.4.2

Class I Nuclear Facilities Regulations (cont)	
Requirement(s)	**Application Cross-Ref.**
(*c*) a final safety analysis report demonstrating the adequacy of the design of the nuclear facility;	2.4.2
(*d*) the proposed measures, policies, methods and procedures for operating and maintaining the nuclear facility;	Throughout
(*e*) the proposed procedures for handling, storing, loading and transporting nuclear substances and hazardous substances;	2.9, 2.11, 2.14 & 2.4.7
(*f*) the proposed measures to facilitate Canada's compliance with any applicable safeguards agreement;	2.13
(*g*) the proposed commissioning program for the systems and equipment that will be used at the nuclear facility;	2.5.2
(*h*) the effects on the environment and the health and safety of persons that may result from the operation and decommissioning of the nuclear facility, and the measures that will be taken to prevent or mitigate those effects;	1.7, 1.8, 2.7, 2.8, 2.9 & 2.11
(*i*) the proposed location of points of release, the proposed maximum quantities and concentrations, and the anticipated volume and flow rate of releases of nuclear substances and hazardous substances into the environment, including their physical, chemical and radiological characteristics;	2.9
(*j*) the proposed measures to control releases of nuclear substances and hazardous substances into the environment;	2.9
(*k*) the proposed measures to prevent or mitigate the effects of accidental releases of nuclear substances and hazardous substances on the environment, the health and safety of persons and the maintenance of security, including measures to (i) assist off-site authorities in planning and preparing to limit the effects of an accidental release,	2.10 & 2.12
(ii) notify off-site authorities of an accidental release or the imminence of an accidental release,	2.10.2
(iii) report information to off-site authorities during and after an accidental release,	2.10.2
(iv) assist off-site authorities in dealing with the effects of an accidental release, and	2.10.2 & 2.12.3
(v) test the implementation of the measures to prevent or mitigate the effects of an accidental release;	2.10.2 & 2.12.2
(*l*) the proposed measures to prevent acts of sabotage or attempted sabotage at the nuclear facility, including measures to alert the licensee to such acts;	2.12.1
(*m*) the proposed responsibilities of and qualification requirements and training program for workers, including the procedures for the requalification of workers; and	2.2.2, 2.2.3, & 2.2.4
(*n*) the results that have been achieved in implementing the program for recruiting, training and qualifying workers in respect of the operation and maintenance of the nuclear facility.	2.1.2, 2.1.3, 2.2.1, 2.2.2 & 2.2.3

Nuclear Security Regulations	
Requirement(s)	**Application Cross-Ref.**
3. An application for a licence in respect of Category I or II nuclear material, other than a licence to transport, and an application for a licence in respect of a nuclear facility referred to in paragraph 2(*b*) shall contain the following information in addition to the information required by section 3 of the *Nuclear Substances and Radiation Devices Regulations* or sections 3 to 8 of the *Class I Nuclear Facilities Regulations*, as applicable: (*a*) a copy of the written protection arrangements made with a response force, referred to in section 35;	2.12.3
(*b*) the site plan referred to in section 16;	1.2
(*c*) a description of the proposed security equipment, systems and procedures;	2.12.1
(*d*) a description of the proposed on-site and off-site communications equipment, systems and procedures;	2.12
(*e*) a description of the proposed structure and organization of the nuclear security guard service, including the duties, responsibilities and training of nuclear security guards; and	2.12.1
(*f*) the proposed plan and procedures to assess and respond to breaches of security.	2.12.1
(*g*) the current threat and risk assessment.	2.12.1

Table 2: Licence Application Matrix - Additional Information Requested by the CNSC

No.	Item	Application Cross-Ref.
1	Environmental Assessment	1.7, 1.8, 2.9.9 & 2.9.10
2	Cost Recovery	Appendix B
3	Financial Guarantees	Appendix B
4	Improvement Plans and Significant Future Activities	Throughout
5	Licensee Public Information program	3.0
6	Nuclear Liability Insurance	Appendix B
7	Aboriginal Consultation	3.2
8	Summary of OPG programs organized by SCA	See Table 3 of this Attachment 1
9	Documents describing the organizational structure	2.1.2
10	Information on the station performance	1.3
11	Current status of all open Action Items	Appendix D
12	Current status of all open CANDU Safety Issues	Appendix F
13	Current status of all open issues that were discussed during the last Pickering licence renewal	Throughout
14	Current status of all of the reassessment of the FAIs previously closed based on Pickering end of commercial operation of 2020	Appendix E.9

No.	Item	Application Cross-Ref.
15	Proposed operating strategy for Pickering including major challenges and initiatives for the next licensing period	1.1, 1.4, 1.5, 1.6 & Appendix E
16	Results of the Periodic Safety Review (PSR)	Appendix E
17	Effective dates for implementation of the CNSC regulatory documents and CSA standards	Letter (in Reference 4)
18	Information on the end of commercial operation of the facility, including the final shutdown date of each unit.	Letter (in Reference 2)
19	Decommissioning strategy for Pickering NGS, including the applicable decommissioning plans.	2.11.4
20	A plan describing the management of the impact on the organization, human performance, and fitness for service while approaching the shutdown of such units, with the expectation that the plan be implemented 3 years prior to the actual date of shutdown of any unit.	1.6.1
21	A plan describing the preparation for and implementation of the stabilization activities that will be conducted to ensure the safe transition of such units from permanent shutdown to the eventual safe storage state, including information on managing the configuration of Pickering NGS as well as the tasks and processes to implement such configuration.	1.6.2
22	Reference to any regulations by other authorities besides the CNSC, as well as any permits, certificates or licences that have been issued.	Appendix C
23	Description of any other activity to be authorized under the operating licence and the purpose of that activity.	Appendix A
24	Information regarding the receipt, handling and transfer, to an off-site commercial facility, of Cobalt-60 produced at Pickering B, as well as the receipt of spent Cobalt-60 from an off-site facility and storage in the Auxiliary Irradiation Fuel bay at Pickering A.	4.0

Table 3: Licence Application Matrix - SCA Specific Areas

Management System SCA	
Specific Areas Addressed in Application	**Section(s)**
Management System	2.1.1
Organization	2.1.2 & 2.1.3
Performance Assessment, Improvement And Management Review	2.1.6
Operating Experience (OPEX)	2.1.7
Change Management	2.3.2 & 2.5.2
Safety Culture	2.1.5
Configuration Management	2.1.8
Records Management	2.1.10
Management of Contractors	2.1.4
Business Continuity	2.1.12
Applicable OPG Programs	**Section(s)**
Nuclear Management System	2.1.1
Nuclear Safety Policy	2.1.1
Managed Systems	2.1.1
Records and Document Control	2.1.10
Business Planning	2.1.11
Nuclear Organization	2.1.2
Organizational Change Control	2.1.2
Contractor Management	2.1.4
Materials Management	2.1.9
Nuclear Safety Oversight	2.1.5
Independent Assessment	2.1.6
Nuclear Safety Culture Assessment	2.1.5

Human Performance Management SCA	
Specific Areas Addressed in Application	**Section(s)**
Human Performance Programs	2.2.1
Personnel Training	2.2.2
Initial certification examinations and requalification tests	2.2.4
Work organization and job design	2.2.5
Fitness for Duty	2.2.6
Applicable OPG Programs	**Section(s)**
Human Performance	2.2.1
Technical Procedures	2.3.4
Continuous Behaviour Observation Program	2.2.6
Limits of Hours of Work	2.2.6
Minimum Shift Complement Training	2.2.5
Leadership and Management Training	2.2.2

Operating Performance SCA	
Specific Areas Addressed in Application	**Section(s)**
Conduct of licensed activity	2.3.1
Procedures	2.3.4
Reporting and trending	2.3.10 & 2.3.11
Outage management performance	2.3.7
Safe operating envelope	2.3.9
Severe accident management and recovery	2.4.6
Accident management and recovery	2.4.6
Applicable OPG Programs	**Section(s)**
Nuclear Operations	2.3.1
OP&Ps	2.3.1
Safe Operating Envelope	2.3.9
OSRs	2.3.9
Plant Status Control	2.3.2
Chemistry	2.6.6
Operating Experience Process	2.1.7
Corrective Action	2.3.10
Reactor Safety Program	2.4.1
Reactivity Management	2.3.5
Heat Sink Management	2.3.8
Response to Transient	2.3.6

Safety Analysis SCA	
Specific Areas Addressed in Application	**Section(s)**
Deterministic Safety Analysis	2.4.2
Hazard analysis	2.4.4
Probabilistic safety analysis	2.4.4
Criticality safety	2.4.7
Severe accident analysis	2.4.6
Management of safety issues (including R&D programs)	2.4.8
Applicable OPG Programs	**Section(s)**
Reactor Safety Program	2.4.1
Risk and Reliability Program	2.4.4
Safety Report (all parts)	2.4.2
Analyses of Record	2.4.2

Physical Design SCA	
Specific Areas Addressed in Application	**Section(s)**
Design governance	2.5.1
Site characterization	1.2 & 2.9.10
Facility design	2.5.1
Structure design	2.5.1
System design	2.5.1
Component design	2.5.1
Applicable OPG Programs	**Section(s)**
Conduct of Engineering	2.5.1
Engineering Change Control	2.5.2
Procurement Engineering	2.5.3
Design Management	2.5.1
Configuration Management	2.1.8
Fuel	2.5.4
Pressure Boundary Program	2.5.5
Environmental Qualification	2.5.6
Software	2.5.7

Fitness for Service SCA	
Specific Areas Addressed in Application	**Section(s)**
Equipment fitness for service/equipment performance	2.6.1
Maintenance	2.6.7
Structural integrity	2.6.4
Aging management	2.6.3
Chemistry control	2.6.6
Periodic inspection and testing	2.6.4
Applicable OPG Programs	**Section(s)**
Conduct of Maintenance	2.6.7
Integrated Aging Management	2.6.3
Production Work Management	2.6.7
Equipment Reliability	2.6.1
Component and Equipment Surveillance	2.6.2
Reliability and Monitoring of Systems Important to Safety	2.4.3
Major Components	2.6.2
Life Cycle Management Plans	2.6.2
Non-Destructive Examination	2.6.5

Radiation Protection SCA	
Specific Areas Addressed in Application	**Section(s)**
Application of ALARA	2.7.2
Worker dose control	2.7.3
Radiation protection program performance	2.7.1 thru 2.7.4
Radiological hazard control	2.7.4
Estimated dose to public	2.9.5
Applicable OPG Programs	**Section(s)**
Radiation Protection	2.7.1
Controlling Exposure ALARA	2.7.2
Occupational Action Levels	2.7.5
Dose Limits and Exposure Control	2.7.5

Conventional Health and Safety SCA	
Specific Areas Addressed in Application	**Section(s)**
Performance	2.8.1
Practices	2.8.1
Awareness	2.8.1
Applicable OPG Programs	**Section(s)**
Health and Safety Policy	2.8.1
Conventional Safety	2.8.1
Work Protection	2.3.3

Environmental Protection SCA	
Specific Areas Addressed in Application	**Section(s)**
Effluent and emissions control (releases)	2.9.3 & 2.9.4
Environmental management system (EMS)	2.9.2
Assessment and monitoring	2.9.3
Protection of the public	2.9.3
Environmental risk assessment	1.7 & 1.8
Applicable OPG Programs	**Section(s)**
Environmental Policy	2.9.1
Environmental Management	2.9.2
Derived Release Limits and Environmental Action levels	2.9.3

Emergency Management and Fire Protection SCA	
Specific Areas Addressed in Application	**Section(s)**
Conventional emergency preparedness and response	2.10.1
Nuclear emergency preparedness and response	2.10.2
Fire emergency preparedness and response	2.10.1
Applicable OPG Programs	**Section(s)**
Emergency Management Policy	N/A*
Nuclear Pandemic Plan	2.1.12
Consolidated Nuclear Emergency Plan	2.10.2
Fire Protection	2.10.1

**OPG-POL-006, "Emergency Management Policy" no longer exists and was removed from the Pickering LCH in 2013.*

Waste Management SCA	
Specific Areas Addressed in Application	**Section(s)**
Waste characterization	2.11.1
Waste minimization	2.11.1
Waste management practices	2.11.1
Decommissioning plans	2.11.4
Applicable OPG Programs	**Section(s)**
Nuclear Waste Management Program	2.11.1
Waste Management	2.11.1
Decommissioning Planning	2.11.4
Preliminary Decommissioning Plan	2.11.4

Security SCA	
Specific Areas Addressed in Application	**Section(s)**
Facilities and equipment	2.12.1
Response arrangements	2.12.3
Security practices	2.12.1
Drills and exercises	2.12.2
Applicable OPG Programs	**Section(s)**
Nuclear Security	2.12.1
Pickering NGS Security Report	2.12.1
Cyber Security	2.12.4

Safeguards SCA	
Specific Areas Addressed in Application	**Section(s)**
Nuclear material accountancy and control	2.13.1
Access and assistance to the IAEA	2.13.1
Operational and design information	2.13.2
Safeguards equipment, containment and surveillance	2.13.3
Import and export	2.13.4
Applicable OPG Programs	**Section(s)**
Nuclear Safeguards	2.13.1

Packaging and Transport SCA	
Specific Areas Addressed in Application	**Section(s)**
Package design and maintenance	2.14.1
Packaging and transport	2.14
Registration for use	2.14.3
Applicable OPG Programs	**Section(s)**
Radioactive material Transportation	2.14.2
Transport Security Plan	2.14.4

Attachment 2 to OPG Letter, R. Lockwood to M. Leblanc, “Application for Renewal of Pickering Nuclear Generating Station Power Reactor Operating Licence”, CD# P-CORR-00531-05055.

Attachment 2

Pickering Nuclear Generating Station Power Reactor Licence Application

(163 pages including this coversheet)

Pickering Nuclear Generating Station
Power Reactor Operating Licence Application
August 2017

Randy Lockwood
Senior Vice President
Pickering

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Executive Summary

The current Pickering Power Reactor Operating Licence (PROL) 48.03/2018 expires on August 31, 2018. OPG is applying for a 10-year licence renewal of the Pickering[1] Nuclear Generating Station (NGS) to include continued commercial operation of all reactor units until the end of 2024 as well as post-shutdown activities associated with removal of fuel and water in preparation for the safe storage of all units.

This licence application provides the information required to demonstrate that the Pickering NGS meets or exceeds all of the applicable requirements of the *Nuclear Safety and Control Act* (NSCA) and the associated regulations. The application describes the management system and the various programs, processes, and personnel that Pickering has in place to ensure that all work is performed with quality to the appropriate standard and with minimal impact to the public and the environment. Collectively, these elements ensure that safety is the overriding priority in all of the necessary activities undertaken to maintain safe and reliable operation of the station.

Pickering NGS continues to have strong safety performance with a conventional safety performance rating that is in the industry's top quartile. Operational reliability has improved significantly, with two of Pickering's units having record operational runs for Unit 5 and Unit 1 at 632 days and 622 days, respectively. Combined with the best forced loss rate performance in site history at approximately 3% and 4% in 2015 and 2016, respectively, Pickering NGS is continuing to achieve improved and more reliable operation.

Safety analyses demonstrate that the Pickering NGS design is safe, robust and that accident risk is very low. Furthermore, Pickering has strengthened its defence-in-depth by continuing to incorporate the lessons learned from the Fukushima event; by ensuring equipment and procedures are in place and incorporated into periodic drills and exercises for emergency response. Pickering has a comprehensive emergency response plan which also provides the framework for interaction with external agencies. OPG is planning a multi-agency interoperability exercise in December 2017 to test on-site and off-site capabilities to provide emergency response focused on the Pickering site.

In addition, a Periodic Safety Review (PSR) is being completed to further support the 10-year licence renewal. The PSR is a comprehensive assessment of the Pickering NGS design and operation, and it includes reviews of current standards and safety factors in determining what reasonable and practical enhancements will be made to further improve safety. The current PSR results further support the continued safe operation of the Pickering NGS until December 2024.

Moreover, the condition of the plant has been reviewed through component condition assessments, which also ensures that the appropriate maintenance, testing and monitoring is ongoing at Pickering. OPG continues to invest in the plant and continues to perform periodic component inspection to ensure that Pickering meets or exceeds industry standards.

[1] In this document, the terms "Pickering NGS", "Pickering Nuclear", and "Pickering" are used interchangeably. Unless otherwise indicated, they all refer to the Pickering nuclear power plant facility.

OPG is also requesting approval to operate Pickering NGS beyond the current Commission approved limit of 247,000 Effective Full Power Hours (EFPH) on the Unit 5-8 fuel channels, up to 295,000 EFPH for the lead Pickering unit which corresponds approximately to the intended end of commercial operation (December 31, 2024). Pickering has assessed the operation of the fuel channels on all units and assures their fitness for service to the target service life of December 2024 on the basis of sound technical reviews, the established programmatic controls within OPG for managing fuel channel aging, and the availability of mitigating measures where required.

Pickering's relationship with its host community remains strong through healthy, open relationships and sustainable partnerships with community stakeholders, including government, media, business leaders, educational institutions, interest groups, and community organizations. In addition, Pickering strives to ensure transparent disclosure of operations and their potential impacts. OPG also meets with Indigenous communities on an ongoing basis to provide details of nuclear operations and reports, and to discuss interests and any potential concerns over current and future operations of the Pickering NGS.

In support of this licence application, Pickering Nuclear has updated its Environmental Risk Assessment (ERA) which evaluated and confirmed that the risk to human and ecological receptors from exposure to contaminants and physical stressors related to the Pickering NGS and its activities is low. As well, a Predictive Effects Assessment (PEA) was completed in which the potential for adverse effects to human health and the environment from the activities associated with transitioning the station from operation to a safe storage state was evaluated. These studies support the overall conclusion that the Pickering site operates in a manner that is protective of human and ecological receptors residing in the surrounding area. The ERA and PEA reports have been provided to the CNSC staff as inputs for an Environmental Assessment under the NSCA.

As evident throughout the application, OPG asserts that:

- Nuclear safety will be assured such that plant personnel, the public and the environment are protected;
- Systems, structures and components at the plant are fit to continue commercial operation to the end of 2024, and that inspection programs will ensure fitness-for-service during the next licence period;
- Staff are qualified and competent to operate the plant, and this will be maintained through the next licence period, including sufficient staffing numbers;
- Impacts of plant operation to the public, workers, and the environment will continue to be of low risk and adequately mitigated, while continuing to provide the various societal and environment benefits of plant operation;
- Transparency and appropriate public and indigenous consultations will continue, and
- OPG continues to invest in Pickering to support the above objectives, including to improve equipment reliability, assure fitness for service until the end of commercial operations, and to further enhance nuclear safety.

In summary, this licence application contains sufficient information to demonstrate that Pickering NGS meets all of the legal requirements of the NSCA and the associated regulations, and to demonstrate that OPG is qualified to carry on the licensed activity and makes adequate provisions to protect the health, safety and security of persons, and the environment.

Table of Contents

1.0 Overview 11

1.1 Introduction 11

1.2 Site Description and Ownership 13

1.3 Station Performance 14

1.4 Nuclear Safety and Equipment Reliability Improvements 15

1.5 Continued Operations 16

1.5.1 Fuel Channels 16
1.5.2 Periodic Safety Review (PSR2) 17

1.6 End of Commercial Operation 18

1.6.1 Sustainable Operations Plan 18
1.6.2 Preparation for Safe Storage 19

1.7 Environmental Risk Assessment 20

1.8 Predictive Effects Assessment (PEA) 2017 21

1.9 Applicable OPG Documents 21

2.0 Safety and Control Areas (SCA) 22

2.1 Management System 22

2.1.1 Management System 22
2.1.2 Organization 24
2.1.3 Staffing Management 26
2.1.4 Management of Contractors 27
2.1.5 Safety Culture 27
2.1.6 Performance Assessment and Improvement 28
2.1.7 Operating Experience (OPEX) 29
2.1.8 Configuration Management 29
2.1.9 Materials Management 29
2.1.10 Records Management 30
2.1.11 Business Planning 31
2.1.12 Business Continuity 32
2.1.13 Applicable OPG Documents 33

2.2 Human Performance Management 33

2.2.1 Human Performance Management Program 34
2.2.2 Personnel Training 35
2.2.3 Certification 37
2.2.4 Initial Certification and Requalification 38
2.2.5 Minimum Shift Complement (Work Organization and Job Design) 38
2.2.6 Fitness for Duty 39
2.2.7 Applicable OPG Documents 40

2.3 Operating Performance 41

2.3.1 Operations 41

2.3.2 Plant Status Control ... 42
2.3.3 Work Protection ... 43
2.3.4 Operating Procedures ... 43
2.3.5 Reactivity Management ... 43
2.3.6 Response to Transients ... 44
2.3.7 Outage Management Performance ... 45
2.3.8 Heat Sink Management ... 45
2.3.9 Safe Operating Envelope ... 46
2.3.10 Corrective Action Program ... 46
2.3.11 Regulatory Reporting ... 47
2.3.12 Applicable OPG Documents ... 47

2.4 Safety Analysis ... 49
2.4.1 Reactor Safety Program ... 49
2.4.2 Deterministic Safety Analysis ... 50
2.4.3 Heat Transport System Aging ... 50
2.4.4 Risk and Reliability Program ... 51
2.4.5 Probabilistic Safety Assessment ... 51
2.4.6 Severe Accident Management ... 53
2.4.7 Criticality Safety ... 54
2.4.8 Management of Safety Issues ... 54
2.4.9 Applicable OPG Documents ... 54

2.5 Physical Design ... 57
2.5.1 Conduct of Engineering and Design Management ... 57
2.5.2 Engineering Change Control ... 57
2.5.3 Procurement Engineering ... 58
2.5.4 Fuel ... 58
2.5.5 Pressure Boundary Program ... 59
2.5.6 Environmental Qualification ... 59
2.5.7 Software ... 59
2.5.8 Applicable OPG Documents ... 60

2.6 Fitness for Service ... 61
2.6.1 Equipment Reliability ... 61
2.6.2 Major Components ... 62
2.6.3 Aging Management ... 64
2.6.4 Periodic Inspection and Testing ... 65
2.6.5 Non-destructive Examination ... 66
2.6.6 Chemistry Control ... 66
2.6.7 Maintenance ... 67
2.6.8 FH Reliability ... 68
2.6.9 Maintenance Backlog ... 68
2.6.10 Applicable OPG Documents ... 69

2.7 Radiation Protection ... 71
2.7.1 Radiation Protection Program ... 71
2.7.2 Application of ALARA ... 72
2.7.3 Worker Dose Control ... 73

2.7.4 Radiological Hazard Control 75
2.7.5 Occupational Radiation Protection Action Levels 76
2.7.6 Applicable OPG Documents 76

2.8 Conventional Health and Safety 76
2.8.1 Conventional Health and Safety Program 76
2.8.2 Applicable OPG Documents 78

2.9 Environmental Protection 79
2.9.1 Environmental Policy 79
2.9.2 Environmental Management System (ISO 14001) 80
2.9.3 Protecting the Public 80
2.9.4 Spill Management Program 85
2.9.5 Environmental Monitoring Program 86
2.9.6 Regulatory Compliance 88
2.9.7 Fish Impingement and Entrainment 89
2.9.8 Thermal Plume 90
2.9.9 Environmental Risk Assessment 90
2.9.10 Predictive Effects Assessment 92
2.9.11 Biodiversity and Wildlife Habitat Council 94
2.9.12 Fisheries Act Authorization 95
2.9.13 Applicable OPG Documents 95

2.10 Emergency Management and Fire Protection 96
2.10.1 Fire Protection and Conventional Emergency Preparedness and Response 96
2.10.2 Nuclear Emergency Preparedness Program 98
2.10.3 Applicable OPG Documents 104

2.11 Waste management 104
2.11.1 Waste Minimization, Segregation and Characterization 105
2.11.2 Waste Storage and Processing 107
2.11.3 Interim Dry Storage of Irradiated Fuel 107
2.11.4 Decommissioning Plans 107
2.11.5 Preparation for Management of Waste from Transition to Safe Storage State 108
2.11.6 Applicable OPG Documents 109

2.12 Security 109
2.12.1 Nuclear Security Program 109
2.12.2 Drills and Exercises 111
2.12.3 Response Arrangements 111
2.12.4 Cyber Security 112
2.12.5 Applicable OPG Documents 113

2.13 Safeguards and Non-Proliferation 113
2.13.1 Nuclear Safeguards Program 113
2.13.2 Operational and Design Information 114
2.13.3 Safeguards Equipment and Surveillance 114
2.13.4 Import and Export 115
2.13.5 Applicable OPG Documents 115

2.14 Packaging and Transport 115

2.14.1 Package Design and Maintenance ... 115
2.14.2 Radioactive Material Transportation ... 116
2.14.3 Registration for Use ... 117
2.14.4 Transport Security Plan ... 118
2.14.5 Applicable OPG Documents ... 118

3.0 Licensee Public Information Program ... 119

3.1 Public Information Program ... 119
3.1.1 Key Yearly Activities ... 119
3.1.2 Station reporting ... 120
3.1.3 Welcoming Visitors ... 120
3.1.4 Community Outreach ... 121
3.1.5 Community Committees ... 122
3.1.6 Environmental Partnerships and Programs ... 123
3.1.7 Employee Communications ... 123
3.1.8 Applicable OPG Documents ... 124

3.2 Aboriginal Consultation ... 125

4.0 Program for Cobalt-60 ... 127

4.1 Cobalt-60 ... 127

4.2 Applicable OPG Documents ... 127

5.0 References ... 128

Appendix A – Activities and Nuclear Substances to be Encompassed by the Licence ... 130

Appendix B - Financial Guarantee, Nuclear Liability Insurance and Cost Recovery ... 132

Appendix C - Licences, Internal Authorizations, Certificates and Summary of Environmental Regulatory Requirements ... 135

Appendix D – CNSC Action Items ... 141

Appendix E – Periodic Safety Review (PSR2) ... 145

Appendix F - CANDU Safety Issues ... 161

Table of Figures

Figure 1 - Pickering NGS Timeline 12
Figure 2 - Nuclear Management System 23
Figure 3 - Pickering Organizational Chart 25
Figure 4 - Pickering Event Free Day Resets 35
Figure 5 - Misposition Type by Year 42
Figure 6 - Equipment Reliability Index (ERI) 62
Figure 7 - Chemistry Performance Index (CPI) 67
Figure 8 - Maintenance Backlog 69
Figure 9 - Site Collective Radiation Exposure 73
Figure 10 - Precursor Tritium Uptakes 74
Figure 11 - Whole Body EPD Dose Alarms 74
Figure 12 - Pickering All Injury Rate vs. Target 77
Figure 13 - Radiological Emissions to Water 81
Figure 14 - Radiological Airborne Emissions 82
Figure 15 - Radioactive Dose to the Public 87
Figure 16 - Radioactive Dose Relative to Natural Background Radiation 87
Figure 17 - Fish Diversion System 89
Figure 18 - Biodiversity 94
Figure 19 - Exercise Unified Response Montage 100
Figure 20 - Pickering Emergency Mitigation Equipment 100
Figure 21 - Sample Wireless Public Alerting Service 101
Figure 22 - 2015 Pickering Nuclear Community Information Session 121
Figure 23 - Information Sharing Session and Station Tour 121
Figure 24 - Tuesdays on the Trail – Summer 2016 122
Figure 25 - Joint DNGS and PNGS CAC meeting June 2015 122
Figure 26 - Students helping to raise salmon eggs in the Pickering Information Centre. 123

Tables

Table 1 - Summary Data for Pickering NGS 14
Table 2 - Pickering In-service Dates 14
Table 3 - Records Management Performance 31
Table 4 - Number of Pickering Certified Staff (May 1, 2017) 37
Table 5 - Document Numbers for Pickering Safety Analysis 50
Table 6 - Environmental Infractions for the Period 2013-2017 88
Table 7 - Emergency Response Performance Indicators 99
Table 8 - Radioactive Material and Packaging 117

1.0 Overview

1.1 Introduction

Ontario Power Generation (OPG) is responsible for approximately half of the electricity generation in the Province of Ontario. Nuclear power from the Pickering Nuclear Generating Station (NGS) supplies 14% of Ontario's electricity needs. Its major benefits include - low operating costs and virtually no Greenhouse Gas (GHG) emissions.

The current Pickering Power Reactor Operating Licence (PROL) 48.03/2018 expires on August 31, 2018. OPG is applying for a 10-year licence renewal of the Pickering NGS, including continued commercial operation of all reactor units until December 2024 as well as post-shutdown activities associated with removal of fuel and water in preparation for the safe storage of all units.

As explained in OPG's submission to the 2017 provincial government's *Long Term Energy Plan*, continued commercial operation of Pickering until 2024 will ensure the province has a reliable source of GHG-free, baseload electricity to carry it through the refurbishment of the Darlington NGS and the initial Bruce NGS units, saving ratepayers as much as $600 million. That represents an estimated reduction of GHG emissions of 17 million tonnes, and the equivalent environmental impact of removing 3.4 million cars per year from Ontario's roads. Continuing to operate the Pickering NGS until 2024 is also associated with 4500 direct and indirect jobs across Durham Region.

This application provides the information required to demonstrate that Pickering meets or exceeds all of the requirements of the *Nuclear Safety and Control Act* (NSCA) and the associated regulations. As well, a Periodic Safety Review (PSR) will be completed to support the 10-year licence period. A PSR is a comprehensive assessment of Pickering's design and operation. Its purpose is to confirm that there is a high level of safety throughout the operating life and, through a review of current codes and standards and safety factors, determine what reasonable and practical enhancements can be made to further improve safety.

An integrated safety review was completed for Pickering Units 1-4 prior to the return to service in the early 2000's (Reference 1). At that time, extensive modifications to improve safety and reliability were installed on Units 1 and 4 (Units 2 and 3 were placed in the safe storage state).

An integrated safety review for Pickering Units 5-8 was completed in 2009 for continued operation of the station (Reference 2). OPG committed to complete safety enhancements and reliability improvements; all of which have been completed.

The objective of this subsequent PSR, referred to as PSR2, is to build on the previous assessments and to confirm that the design, operation and safety-significant structures, systems, and components support continued safe operation of the Pickering units to the end of 2024 (Reference 3). The PSR2 is a forward looking assessment focusing on changes to requirements since the last applicable assessment. The current PSR2 results confirm that the condition of Pickering NGS supports the additional years of commercial operation in consideration of new operating experience since the last assessments. Moreover, the PSR2 seeks to identify additional practical safety enhancements to further improve the already low risk of plant operation, beyond those that have been implemented or that are committed to be implemented.

OPG is also requesting approval to operate beyond the current Commission approved limit of 247,000 Effective Full Power Hours (EFPH) for the Pickering 5-8 fuel channels, to 295,000 EFPH for the lead Pickering unit which corresponds approximately to the intended end of commercial operation (December 31, 2024). Pickering has assessed the operation of the fuel channels on all units and assures their fitness for service to the target service life of December 2024 on the basis of sound technical reviews, the established programmatic controls within OPG for managing fuel channel aging, and the availability of mitigating measures where required.

Pickering NGS Timeline

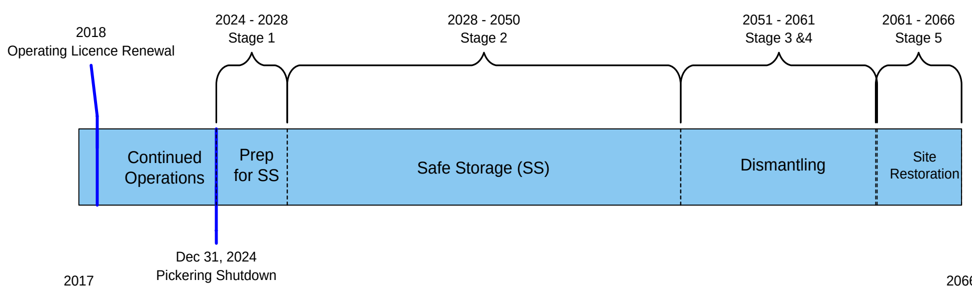


Figure 1 - Pickering NGS Timeline

Figure 1 shows the planned timeline for Pickering NGS, starting at licence renewal.

During the 10-year licence term, Pickering NGS plans to continue commercial operation and shut down all units by December 31, 2024 (Reference 4). After shutdown, the fuel and the heavy water will be removed from the reactors and the safe storage phase will begin.

The long term post-shutdown activities involve multiple stages.

Stage 1: Activities which are required to place the units in the safe storage state, as described in the Stabilization Activity Plan (SAP). These will be completed in order to place the units into a state that will be maintained until decommissioning (Reference 5).

Stages 2 – 5: These stages are covered in the Preliminary Decommissioning Plan (PDP). (Reference 6)

In support of this licence application, Pickering Nuclear has an updated Environmental Risk Assessment (ERA) which evaluated and confirmed that the risk to human and ecological receptors from exposure to contaminants and physical stressors related to the Pickering NGS and its activities is very low. As well, a Predictive Effects Assessment (PEA) was completed which evaluated the potential for adverse effects to human health and the environment from the activities associated with transitioning the station from operation to a safe storage state. These studies support the conclusion that the environment in the vicinity of the Pickering NGS is adequately protected. The ERA and PEA reports have been provided to the CNSC as inputs for an Environmental Assessment under the NSCA.

1.2 Site Description and Ownership

Pickering NGS has eight reactor units. Currently, six units are operating and two of the units are in the state of safe storage.

The Pickering nuclear facility is located on the north shore of Lake Ontario in the City of Pickering in the regional municipality of Durham, Province of Ontario. The site is approximately 32 km east-northeast of downtown Toronto and 21 km southwest of the City of Oshawa at latitude 43° 49´N and longitude 79° 04´W. The site occupies a land area of 240 ha in lots 17 to 22 inclusive in the Broken Front Concession. The total frontage of the site along the Lake Ontario shoreline is approximately 2260 m. The transmission egress right-of-way which leads north from the site boundary is 155 m in width and occupies part of lots 19 and 20 in the Broken Front Concession.

There are a number of watercourses in the vicinity of Pickering NGS. The two major ones closest to the site are Duffins Creek, 2.2 km to the east, and the Rouge River, 4 km to the west.

The Pickering A and Pickering B safety reports provide detailed and extensive information on the facility and the systems, structures and component design. This information can be found in Part 1 of the safety reports. Further information is provided below in Table 1 and Table 2.

The Pickering site is shown in the following OPG drawing, NK30-D0A-10200-0001, *Building Development Site Plan.*

The reactor units are numbered 1 to 4, from east to west, and the other reactor units are numbered 5 to 8, from west to east starting from the center of the plant.

The Pickering site is owned by Ontario Power Generation Inc, and owned by the Province of Ontario; the title/deed is available upon request.

Summary Data - Pickering NGS	
Number of Units	8
Operational Units	6
Safe Storage Units	2 (Units 2 and 3)
Net Power Output (Electrical)	2 x 515 MWe (Units 1 and 4)
Net Power Output (Electrical)	4 x 516 MWe (Units 5,6,7, and 8)
Maximum Power (Thermal) per Unit	1744 MW(t) to yield 540 MWe (gross)
Nuclear Steam Supply System	CANDU Pressurized Heavy Water Reactor
Containment Structure	Reinforced Concrete

Table 1 - Summary Data for Pickering NGS

	In-Service Dates (Operational Units)
Unit 1	July 29, 1971
Unit 4	June 17, 1973
Unit 5	May 10, 1983
Unit 6	February 1, 1984
Unit 7	January 1, 1985
Unit 8	February 26, 1986

Table 2 - Pickering In-service Dates

1.3 Station Performance

At the Pickering NGS, the safety of the employees, neighbours and the environment is the overriding priority.

OPG’s drive towards achieving zero injuries remains at the forefront of the business. During the current licensing period, Pickering NGS has demonstrated excellent safety performance throughout its operations.

In 2014, Pickering reached 11 million hours without a lost time accident with an All Injury Rate of 0.22 which represented best ever performance for the station. In November 2016, OPG received the Canadian Electricity Association’s President’s Gold Award of Excellence for Employee Safety in recognition of the company-wide All Injury Rate and Accident Severity Rate performance for 2013, 2014 and 2015.

Pickering NGS has achieved excellent operating performance in the current licensing period with two units attaining records for continuous on-line operation for Unit 5 with 632 days and Unit 1 with 622 days. Combined with the best forced loss rate performance in site history at 3% and 4% in 2015 and 2016, respectively, this shows that Pickering NGS is continuing to achieve improved and more reliable operation.

Human Performance is a station priority at Pickering. Pickering has achieved its best ever performance in this area, with the lowest number of Site Event Free Day Resets (SEFDR). In 2016, Pickering had 1 event against a target of 2. The 2017 target is 2 SEFDR and at the end of the second quarter, Pickering has 0 SEFDR which is in the top quartile of the industry.

In the CNSC annual evaluation of industry performance, Pickering has achieved a rating of Fully Satisfactory (FS) for operating performance in 2015 and 2016 and an overall rating of FS for both years.

In 2017, Pickering achieved excellent outage performance for the Unit 5 maintenance outage. Pickering met its conventional safety, nuclear safety, radiation safety and environmental targets while executing the maintenance work and returning the unit back to service, in time to meet the committed date to the public.

In summary, Pickering NGS has maintained a strong track record of safe and reliable operation, and is qualified to carry on the activities and make adequate provisions to protect the public, workers, and the environment over the requested 10-year licence term.

1.4 Nuclear Safety and Equipment Reliability Improvements

During the previous licence renewal process for Pickering in 2013, OPG indicated that it would continue to invest in the Pickering plant to improve safety and reliability through to the end of commercial operation. At that time, in addition to the regulatory work to ensure safe operation of the fuel channels, OPG committed to including $200M in the business plan, for reliability improvements (Reference 7). Over the course of four years from 2011 - 2014, the work that was completed targeted reliability improvements to equipment, material condition improvements to the plant, and additional inspection and maintenance activities to continue to confirm fitness for service of major components in the life extension period. Additionally, 2000 reliability and material condition improvements initiatives were completed by either replacing or maintaining equipment, including 129 pumps, 106 motors, and 688 valves. Completion of this maintenance helps to ensure that the station will operate reliably to deliver the electrical generation forecast until the end of commercial operation.

Furthermore, OPG committed to finish the modifications for the quick-connections of electrical and water tie-in points to the station systems in order to streamline the deployment of the Emergency Mitigating Equipment (EME). As well, OPG committed to implement field modifications to ensure power is restored to essential station equipment in order to protect containment and post-event monitoring. The design modifications to complete all of the field installations have been completed and implementation is in progress and is expected to be completed in 2017 (Reference 8).

In addition, in 2014 at the request of the Commission, OPG committed to a risk improvement plan that encompassed a combination of physical improvements, changes to operating procedures, and improvements to analysis methodology in order to further reduce the calculated risk for Pickering, focusing on the Pickering A units. Pickering has provided an annual update to the CNSC on the risk improvement plan, and significant risk reductions have been shown (Reference 9).

The results of the fifteen safety factor reviews which were defined for the PSR process have been completed and included in the PSR2. These safety factors cover all aspects important to the safety of an operating nuclear power plant. The results have been reviewed and summarized in Safety Factor Reports that have been submitted to the CNSC. These reports conclude that there are no fundamental safety issues and that OPG has in place effective programs and processes for continued safe operation of the Pickering NGS until 2024. Also, the PSR2 seeks to identify additional practical safety enhancements to further improve the already low risk of plant operation, beyond those that have been implemented or that are committed to be implemented.

In summary, nuclear safety will continue to be assured and plant reliability maintained such that the risk of Pickering NGS operation remains low and plant safety and reliability improves during the next licence term. This is supported by continued investment for the Pickering NGS.

1.5 Continued Operations

This section substantiates that the key systems, structures, and components at Pickering are fit to continue commercial operation to the end of 2024, and that inspection and maintenance programs will ensure fitness-for-service during the next licence term.

1.5.1 Fuel Channels

Pickering has assessed the operation of the fuel channels on all units and the assessment has shown there is additional margin on fuel channel fitness-for-service limits to the original target service life of December 2020 (References 10 and 11). Therefore, safe operation is assured beyond the current operating limit of 247,000 Effective Full Power Hours (EFPH) with continued demonstration of fitness for service.

Pickering has also assessed the operation of the fuel channels on all units and assures their fitness for service to the new target service life of December 2024 on the basis of sound technical reviews, the established programmatic controls within OPG for managing fuel channel aging, and the availability of mitigating measures where required (Reference 12). Based, in part, on Reference 12, fitness for service of the fuel channels is assured up to 295,000 EFPH.

The condition of the fuel channel components is regularly monitored via inspection programs, consistent with the life cycle management approach used for all major components, ensuring that fuel channel component condition remains within the licensing basis and fitness-for-service criteria of the CSA N285.4 and N285.8

standards. OPG has robust processes in place for responding to inspection or surveillance results should they not satisfy the prescribed acceptance criteria, and to relevant OPEX that could impact fuel channel fitness-for-service or plant operability or safety.

Aging mechanisms in Pickering Unit 5-8 fuel channels have been reviewed and the results provided to CNSC staff. Observed degradation rates are consistent with predictions and no new degradation mechanisms have been identified. OPG has provided a preliminary burst test plan for CNSC staff review that covers the required range of test parameters to further validate the cohesive zone fracture toughness model and expand its validity to cover projected hydrogen equivalent concentrations at the target operating life. The plan accounts for projected conditions in inlet and outlet regions at the target operating life, operating and transition temperature conditions, inter-tube variability, and as-found states. This plan will be finalized and submitted to CNSC by the fall of 2017. It should be noted that the plan will be subject to change depending on ongoing test results and identified research requirements, and it will be adapted, if required to continually demonstrate fitness for service.

In consultation with industry, OPG will continue to discuss fuel channel-related issues with CNSC staff to ensure regulatory expectations are understood and met.

In summary, based on inspections, reviews, research and development work, confirmatory actions in the life management plans for assuring ongoing fitness-for-service, and use of mitigating actions, OPG is confident of continued demonstration of fitness for service of fuel channels for safe operation of all Pickering units to the end of 2024 and up to 295,000 EFPH for the lead Pickering unit.

1.5.2 Periodic Safety Review (PSR2)

The PSR process serves to further support continued operation over the licence renewal term. In the PSR2 for Pickering, the fifteen safety factors that have been reviewed cover all aspects important to the continued safe operation of the plant. It has been concluded that there are no fundamental safety issues and that OPG has in place effective programs and processes for continued safe operation of the Pickering NGS until 2024.

The results have been reviewed and summarized in Safety Factor Reports that have been submitted to the CNSC. Gaps identified from these safety factor reviews are currently being assessed in a global assessment. The objective of the global assessment is to provide an overall assessment of the safety of the plant, and to arrive at a judgement of the plant’s suitability for continued operation on the basis of a balanced view of the results from the reviews of the separate safety factors. Consistent with the requirements of IAEA SS-25, the global assessment is being conducted by an interdisciplinary team with appropriate expertise in operations, design and plant safety, including appropriate participants from the safety factor reviews, and members who are independent from the safety factor review teams.

Preparation of the Global Assessment Report (GAR) is being conducted to summarize the assessments and document the global assessment by presenting the results, assessing the overall defence-in-depth of the plant, and documenting the conclusions, corrective actions, and enhancements to be considered. The GAR will include a ranked list of the global issues with identified actions, and with rationale for the ranking. In accordance with Reference 13, the GAR will be submitted to the CNSC by October 31, 2017.

The enhancements resulting from the global assessment that will be implemented, will be documented in an Integrated Implementation Plan (IIP) which will provide the proposed timeline for the implementation of the enhancements. In accordance with Reference 13, the Pickering PSR2 IIP will be submitted to CNSC staff, for acceptance, by November 30, 2017.

1.6 End of Commercial Operation

The *Pickering Site Strategic Plan*, P-PLAN-09314-00003 R0, provides an overall view of Pickering's strategy, as it approaches the end of commercial operation. It references the primary documents that govern the timeline from operation to decommissioning; namely the *Sustainable Operations Plan*, the *Stabilization Activity Plan* and the *Preliminary Decommissioning Plan.*

1.6.1 Sustainable Operations Plan

OPG will continue to ensure safe, reliable operation of Pickering as it transitions to the end of commercial operation. Processes will remain in place to ensure Pickering NGS is operated and maintained using sound nuclear safety and defence-in-depth practices.

A Sustainable Operations Plan (SOP) is developed to address the challenges that arise due to the transition from an operating station to the End of Commercial Operation (ECO). The SOP is based on each of the 14 Safety and Control Areas (SCA). Pickering NGS recognizes that safe operation is based on the maintenance of both a healthy safety culture and the programs associated with each of the 14 SCAs. In the SOP, OPG will document actions and define stand-alone supplemental measures to existing programs (arrangements, activities or actions) which will be implemented as resolutions.

This plan will be submitted to the CNSC 5 years prior to the shutdown of the Pickering station. A progress update will then be provided annually, in mid-December.

The 2016 SOP (Reference 14) submitted to the CNSC, was prepared based on an assumed end of commercial operations date of 2020. There are currently stand-alone supplemental measures in three SCAs with plans in development. These are in the areas of Organizational Change, Human Performance, and Maintenance and Reliability.

For Organizational Change, OPG will develop a plan to ensure capable, competent staff remains at Pickering through the transition to ECO, safe storage and decommissioning. It will include a change management plan which will look at the impacts of the Pickering shut down on both Pickering operations and on the broader Nuclear and OPG organization and staff. The plan will cover activities related to leadership alignment, engagement of staff, internal and external communications, training and development, assessing and managing impact on the business policies, processes and practices, assessing and managing impact on people, assessing and managing business readiness. Oversight will be provided and metrics will be established to monitor performance of the transition to the new organization and ensure continued safe operations.

The Human Performance Initiative involves maintaining continuous monitoring and improvement of human performance to minimize the likelihood of nuclear safety events throughout the transition to the end of commercial operation. This will be achieved by systematically identifying and addressing error likely situations, reducing organization vulnerability and by challenging the integrity of defenses. Initiatives within the program also include communications, field presence and surveillance to promote human performance improvement, as well as utilizing benchmarking of similar plants and internal operating experience to maintain or improve human performance while in transition to the end of commercial operations.

The Maintenance and Reliability Strategy involves determining the maintenance plans and activities to be performed prior to and after the shutdown of the units. In order to ensure safe and reliable operation of each unit at Pickering, existing programs and procedures will be used for equipment maintenance and reliability strategies during the transition to the end of commercial operation. Procedures and processes will ensure that all of the maintenance necessary to ensure safe and reliable operation up to the shutdown of each unit is identified, as well as the maintenance necessary to sustain the systems that will be relied upon during the stabilization and safe storage phases.

Any supplementary actions which are not covered under these three areas will be addressed in the SOP in order to support safe and reliable operation of Pickering.

In summary, nuclear safety will be assured through to the end of commercial operation and staffing levels and competency will be appropriately maintained, while maintaining reliable plant operation and protecting the public, workers and the environment.

1.6.2 Preparation for Safe Storage

Preparation for Safe Storage includes the period leading up to the end of commercial operations as planning activities are carried out, as well as the execution of Stabilization activities which will safely transition the station from its current electricity generating state to its Safe Storage State (SSS).

The goal of Stabilization is to defuel the reactors of spent fuel, dewater systems containing tritiated heavy water, and remove from service systems no longer required to support the operation of the station. Although the station will no longer generate power, an operational footprint will be required to continue to support operational and regulatory requirements, such as the storage and removal of fuel from the irradiated fuel bays, storage of heavy water, and ongoing monitoring and security activities.

The Stabilization of the station from its current electricity generating state to its SSS will follow a phased approach, where the phases will be characterized by milestones in hazard reduction. The operational need for Structures, Systems and Components (SSCs) at each phase will be determined by a thorough and systematic review process, considering both regulatory and system requirements across all 14 CNSC safety and control areas. SSCs not required for the operation of the station in the SSS will be placed in a passive safe state.

OPG operating experience (particularly from Darlington Refurbishment and Pickering Units 2 and 3 Safe Storage) as well as benchmarking of local and international industry experience has been integral to informing preparations for Safe Storage and will continue to do so as planning efforts progress.

OPG will continue to provide periodic updates to the CNSC with regards to the preparations for the execution of the Stabilization of the Pickering station.

More information on OPG's planning efforts for the stabilization of station and the SSS can be found in the Stabilization Activity Plan. (Reference 5)

Information on the Safe Storage phase can be found in the Preliminary Decommissioning Plan (PDP). (Reference 6)

In summary, nuclear safety will be assured during this transitional period and staffing levels and competency will be appropriately maintained, while continuing to protect the public, workers and the environment during this phase of operation.

1.7 Environmental Risk Assessment

OPG has completed an updated Environmental Risk Assessment (ERA) for Pickering Nuclear. The ERA includes a Human Health Risk Assessment (HHRA), and an Ecological Risk Assessment (EcoRA), for radiological and non-radiological contaminants and physical stressors.

The ERA evaluated the risk to relevant human and ecological receptors from exposure to contaminants and physical stressors related to Pickering and its activities. The ERA report P-REP-07701-00001, *Environmental Risk Assessment for Pickering Nuclear* was submitted to the CNSC (Reference 15).

In summary, the studies confirm that Pickering is continuing to operate in a manner that is protective of human and ecological receptors residing in the surrounding area.

A more detailed summary of the ERA is provided in Section 2.9.9.

1.8 Predictive Effects Assessment (PEA) 2017

OPG undertook a Predictive Effects Assessment (PEA) to evaluate the potential for adverse effects to human health and the environment from the activities associated with transitioning the station from operation to a Safe Storage with Surveillance state.

The PEA encompasses both the Stabilization Phase and the Safe Storage with Surveillance Phase. The PEA report, P-REP-07701-00002, *Predictive Effects Assessment for Pickering Nuclear Safe Storage* was submitted to the CNSC (Reference 15).

Overall the change from power generation to the Stabilization and Safe Storage with Surveillance Phases will result in reductions in emissions from the Pickering NGS. Noise, atmospheric emissions, waterborne emissions and thermal discharges will all be reduced as Pickering NGS moves from the current operational condition to a safe storage state.

No interactions were identified that are predicted to pose an unacceptable risk to humans or the environment during the Stabilization and Storage with Surveillance activities proposed. Therefore, no new mitigation is required based on the conclusions of the Predictive Effects Assessment.

During both the Stabilization and Storage with Surveillance Phases, OPG's environmental programs will be maintained, and updated as needed. Emission control measures and discharge limits are specified within specific permits. These permits and in-design mitigation measures will remain in place until such a time that it can be demonstrated, in discussion with the regulator as applicable, that they are no longer required.

The PEA concludes that there are no predicted potential adverse effects from the Stabilization and Safe Storage with Surveillance activities proposed.

In summary, this supports that the impacts of the post-shutdown operational activities on people and the environment will continue to be of low risk and adequately managed. A more detailed summary of the PEA is provided in Section 2.9.10.

1.9 Applicable OPG Documents

The following documents are the applicable OPG documents which support the licensing basis and are to be listed in the Licence Conditions Handbook. Further applicable documents are identified in Sections 2 to 4.

Document Number	Document Title
NK30-D0A-10200-0001	Building Development Site Plan
NA44-SR-03120-00001	Pickering Nuclear 1-4 Safety Report – Facility Description
NK30-SR-03120-00001	Pickering Nuclear 5-8 Safety Report – Part 1
OPG-PROG-0001	Information Management
N-PROG-RA-0012	Fire Protection
P-LIST-71400-00001	Application of CSA N293-07 to Structures, Systems and Components for Pickering Nuclear

2.0 Safety and Control Areas (SCA)

2.1 Management System

Pickering has a fully mature and effective management system that meets or exceeds all applicable regulatory requirements and related objectives. It enables OPG to continuously monitor and manage performance against those objectives, and maintain a healthy safety culture.

The following subsections describe the objectives, key results from the current licensing period, and planned improvements over the next licensing period. These discussions also support that:

- nuclear safety will continue to be assured such that plant personnel, the public and the environment are protected (e.g., Sections 2.1.1 and 2.1.5),
- staff are qualified and competent to operate the plant, and this will be maintained though the next licence period, including staffing numbers (Sections 2.1.2 and 2.1.3)
- OPG continues to invest in Pickering NGS to improve plant safety and reliability and to assure fitness for service until the end of commercial operations (Sections 2.1.11)

2.1.1 Management System

The *Nuclear Safety Policy*, N-POL-0001 establishes guiding principles for OPG nuclear employees stating that nuclear safety shall be the overriding priority in all activities performed in support of OPG nuclear facilities and that nuclear safety shall have clear priority over schedule, cost and production. The policy requires that everyone demonstrate respect for nuclear safety and conduct themselves in a manner consistent with the traits of a healthy nuclear safety culture. In accordance with the policy, the Nuclear President and Chief Nuclear Officer (CNO) is accountable to the CEO and the Board of Directors to establish a management system that fosters nuclear safety as the overriding priority.

The charter N-CHAR-AS-0002, *Nuclear Management System* takes authority from the *Nuclear Safety Policy*, and is in compliance with Canadian Standard Association (CSA) N286-12, *Management System Requirements* for Nuclear Facilities.

OPG's nuclear management system provides the framework for programs, standards and other governing documents and processes which collectively ensure that OPG's Pickering Nuclear Generating Station operates safely and that safety is the foremost consideration in management decisions and actions (see Figure 2 - Nuclear Management System).

Every employee in the organization is responsible and held accountable for complying with the expectations of the charter and referenced programs, and for ensuring their actions are deliberate and consistent with protecting worker health and safety, the health and safety of the public, and the environment.

The *Managed Systems* program, N-PROG-AS-0001 provides direction to management to develop and implement management practices and controls. Programs and processes are created such that all applicable regulatory requirements and codes and standards are embedded and integrated within the nuclear management system including aspects of health, safety, environment, security, economics and quality.

The management system effectiveness is reviewed by the Nuclear Executive Committee (NEC) as part of ongoing oversight. Program performance is assessed in the areas of management and leadership, performance execution and continual improvement. The oversight by the NEC members ensures that problem areas are identified and corrective actions established.

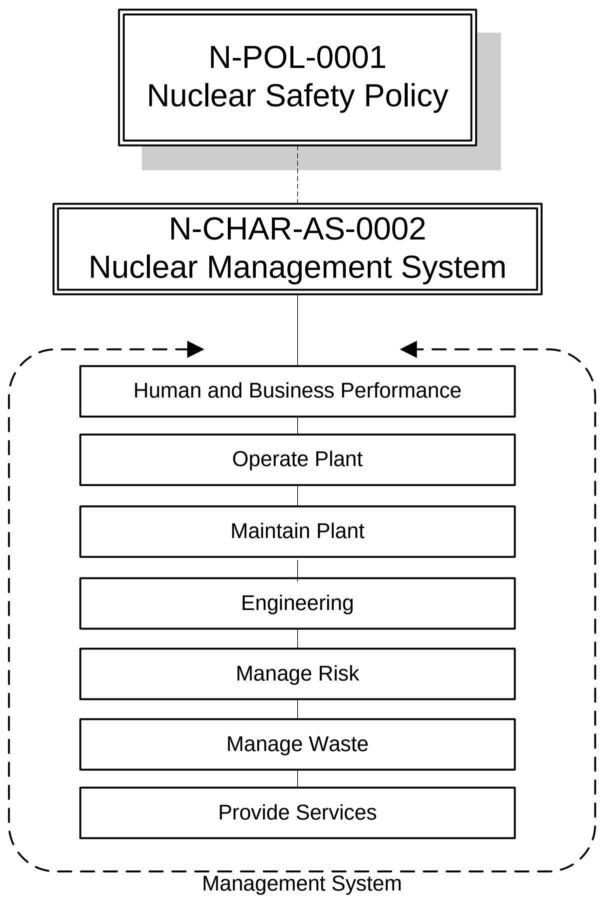


Figure 2 - Nuclear Management System

The Nuclear Management System has evolved over the past licence period, to support the OPG business model. Several programs have transitioned from being nuclear only, to being owned by corporate business units (for example, Items and Services Management, Information Management and Worker Health and Safety). The transition involved careful review and oversight of the changes by the CNO and the Nuclear Executive Committee to ensure that the roles and accountabilities under CSA N286 requirements were understood and captured in the corporate program governance and management systems. Oversight and review of the health and effectiveness of these corporate programs continue to be part of the Nuclear Management System.

For these programs, ownership and accountability for the program resides with the corporate program owner but the CNO remains accountable for the effectiveness of the implementation of these programs for the nuclear management system, and in meeting the requirements of CSA N286-12.

OPG's Nuclear Management System is reviewed through inspections, self-assessments, benchmarking, and independent audits. In 2015, OPG performed an assessment and also in 2015 an external review was performed of the overall OPG program in support of nuclear operations. Where opportunities for improvements were identified, action plans were developed and implementation is on-going.

2.1.2 Organization

Nuclear standard, N-STD-AS-0020, *Nuclear Management Systems Organizations*, describes the organization and responsibilities of OPG in support of its nuclear management system.

The objectives are to maintain a sufficient number of qualified staff to safely operate, maintain, and support the nuclear generating stations, and to maximize the efficiency and effectiveness of its workforce.

The *Organization Design Change* procedure (OPG-PROC-0166) ensures consistent organization design change processes and alignment across OPG, which includes utilizing change management resources, tools and expertise to support the business in making effective organization design changes. The process for managing changes to the organization structure includes gated criteria to evaluate the complexity of the change; minor or material and required communications.

Stakeholder feedback indicates that the procedure has improved organization change consistency and documentation across the organization, as well as enabled the business to meet their operational needs in a more timely manner. The process ensures that the correct steps are being taken, and that records and systems are being updated accordingly.

Figure 3 provides the current Pickering organizational structure. The Pickering organizational chart information is updated each year and submitted to the CNSC (Reference 16 and Reference 17).

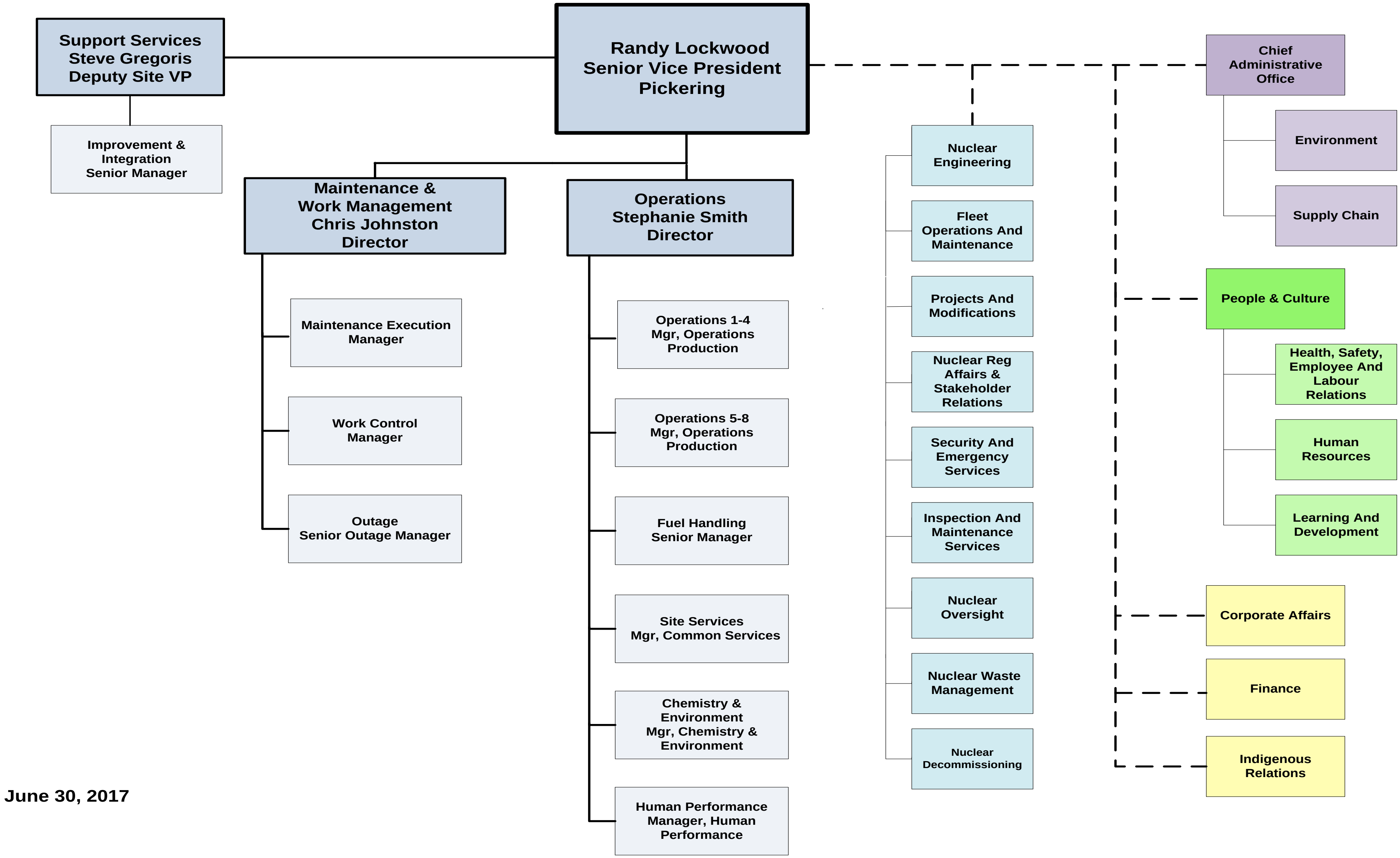


Figure 3 - Pickering Organizational Chart

2.1.3 Staffing Management

Workforce planning in OPG Nuclear looks at current staff and business plans and makes projections regarding hiring to ensure that sufficient qualified staff are available to operate and maintain the stations. Staff projections for continued operations of Pickering and the end of commercial operations form part of the overall people strategy for OPG.

Recruiting

OPG has a number of internal, external and student recruiting programs that are administered through the Talent Attraction team within the People and Culture organization. Talent Attraction partners work with hiring managers to attract and retain a diverse and high performing workforce.

The sourcing strategies are multi-faceted and include partnerships with educational institutions, apprenticeship programs, use of hiring halls for trades, internal and external job posting and career sites, talent pipelining, direct sourcing, retained/contingent recruitment agencies and succession planning discussions.

On-boarding is a strategic personnel process designed to support new employee integration with the goal to increase the speed to performance, engagement, retention and build a shared corporate culture. OPG has implemented an Onboarding Centre to ensure all new hires are qualified within the shortest amount of time possible, have the required systems in place and ensure new employees fully understand OPG behaviours, values and the importance of safety to OPG.

Knowledge Management

OPG has many well established methods to ensure people have the qualifications, knowledge and skills required to perform competently. The knowledge management program complements these foundational programs by providing tools and techniques to consider and share tacit knowledge.

Given OPG's demographics, employee attrition and the lengthy training and development required for specialized roles, OPG has invested in knowledge management for ongoing operations as well as the delivery of projects and initiatives to ensure that the critical knowledge and expertise of employees is sustained.

Talent and Succession Planning

The OPG talent review and succession planning program is a foundational element of OPG's strategic corporate human resources plan and business model. The talent management strategy includes the retention and knowledge transfer that is used to ensure that necessary talent and skills will be available when needed, and that essential knowledge and abilities will be maintained. Succession planning is one component of this strategy and the objective is to identify and develop future leadership and to integrate this with the staffing needs to ensure continuity in critical roles.

The OPG succession planning process follows an annual talent review cycle that includes two succession reviews per year. Nuclear Executive Committee members are an integral part of the process.

The Nuclear organization has an additional complementary integrated succession planning process that includes identifying critical positions and determining the priority of each role. The level of management oversight of the succession planning of these critical positions is determined by the priority given to the role.

The OPG talent review and succession planning program is fully integrated into the broader human resources management programs within OPG that include performance measurement, individual development planning, leadership development, skills and capability development, diversity and inclusion, and culture.

2.1.4 Management of Contractors

Pickering NGS is using Engineer, Procure, and Construct (EPC) contractors to perform the majority of the project work at site. Contractors are pre-qualified by OPG supply chain quality services under a process that ensures the contractor has developed and implemented a management system that meets the applicable requirements outlined in the CSA Standard N286-12.

When requesting materials or services from vendors, Pickering NGS clearly specifies in the scope of work document the technical and quality requirements and selects vendors capable of satisfying these requirements.

Contractor performance is continually monitored through a robust score carding process and presented quarterly to OPG senior management. Contractors are scored on their ability to maintain good standing in safety, human performance and cost/schedule adherence.

2.1.5 Safety Culture

The nuclear standard, N-STD-AS-0023 *Nuclear Safety Oversight* summarizes the framework and accountabilities for the program as well as the external and internal processes used for oversight and assessment of nuclear safety. This standard applies to all aspects of nuclear operations, and to all work and other activities undertaken at or in support of the stations. Nuclear safety oversight is conducted in a manner consistent with the *Traits of a Healthy Nuclear Safety Culture*. A variety of oversight forums and processes are used to review, evaluate, and critique the safety culture at Pickering NGS.

In February 2015, Pickering NGS conducted a station wide nuclear safety culture assessment which consisted of both a staff survey followed by an on-site evaluation by an assessment team who conducted document reviews, staff interviews, and observations. The assessment focused on perceptions, attitudes and behaviours of the organization.

The assessment concluded that Pickering NGS has a healthy nuclear safety culture, respect for nuclear safety is evident in the organization, and that nuclear safety is not compromised by production priorities. Station personnel feel they can challenge any decision if needed, without fear of retaliation. Areas for improvement were documented following the assessment and actions taken to address the findings are tracked. On July 15, 2015 and June 21, 2016 meetings took place with the CNSC to discuss and share the findings and actions taken.

OPG will continue to conduct these station wide assessments periodically as per N-PROC-AS-0077, *Nuclear Safety Culture Assessment*. The next assessment is scheduled for 2018.

OPG has implemented a nuclear safety culture monitoring panel to monitor the process inputs that are indicative of the health of the organization's nuclear safety culture. The panel, made up of the senior plant leadership team, meets quarterly to discuss the 10 nuclear safety culture traits.

2.1.6 Performance Assessment and Improvement

Quality management oversight of the nuclear management system is performed in accordance with the process described in N-PROG-RA-0010, *Independent Assessment.* The objective is to assess whether the station systems, equipment and activities are of the required quality throughout the plant life cycle and whether the established programs are being effectively implemented.

Nuclear Oversight has implemented a 5-year audit plan using a risk based process that identifies when programs are to be audited based on key risk areas, legal and regulatory requirements. The specific scope of the planned audits is determined through a risk assessment performed prior to audit conduct. This ensures that audits have the appropriate scope. An on-site independent assessment group has been established which provides on-going feedback to program owners. Based on the feedback received, the program owners take corrective action as required.

Nuclear Oversight performance itself has also been assessed through independent assessments such as the 2016 Nuclear Industry Evaluation Program (NIEP) evaluation. This team determined that OPG independent assessment functions for nuclear oversight are effective.

Alliances with a number of industry peer groups have enabled the participation of OPG employees on external assessments, creating opportunities for growth and benchmarking. Peers from other utilities have had similar opportunities in OPG.

2.1.7 Operating Experience (OPEX)

The objective of the Operating Experience (OPEX) program is to prevent the reoccurrence of significant internal and external events in accordance with N-PROC-RA-0035, *Operating Experience Process*.

The OPEX process is comprised of three elements: external OPEX, internal OPEX, and the use of OPEX. Combined, these elements meet the objectives by ensuring that lessons learned are reviewed and appropriate actions taken, internal lessons are shared, and lessons learned are incorporated into training and qualifications.

Over the licensing period Pickering made improvements to its OPEX process and tools, use of OPEX and the sharing of internal lessons. The process and tools improvements include revision of the program governance. The updates were made to simplify/clarify requirements, reflect organizational changes, and incorporate suggested improvements from internal/external assessments. Sharing of internal lessons learned with other OPG stations was improved by updating the evaluation process for applicability of significant lessons learned.

2.1.8 Configuration Management

Configuration Management at OPG is governed by the standard N-STD-MP-0027, *Configuration Management*. This program ensures the station physical configuration for all essential Structures, Systems and Components (SSC) match the configuration documents for all states of the plant. In addition, the program ensures configuration information is maintained accurate, consistent and readily accessible along with defining clear scope, responsibilities, authorities and interfaces among organizations.

Change control programs such as the Engineering Change Control (ECC) support configuration management by ensuring design changes, document changes and physical configuration changes that impact design and the licensing basis are tracked to completion and are traceable throughout the life of facility.

2.1.9 Materials Management

Materials management activities are performed in accordance with OPG-PROG-0009, *Items and Service Management.* This program establishes a governing document framework that meets regulatory requirements and ensures effective and efficient planning for, and procurement of, items and services.

The supply chain organization is responsible for providing the necessary services and materials in a timely manner and of the appropriate quality to the Pickering site. Supply Chain confirms all the quality aspects for receipted materials based on designated quality requirements.

Vendor quality is maintained through audits and receiving inspections. OPG has implemented a Counterfeit, Fraudulent and Suspect Items (CFSI) Program which is aligned to industry best practices. All suppliers to OPG are required to have a CFSI program implemented and this is verified by supplier audits carried out by OPG. Enhanced purchasing clauses and receiving inspections have been in place for several years to prevent CFSI material from being supplied to or received by OPG.

Standardized training on CFSI was developed and implemented to support this program. External reviews and benchmarking has indicated that OPG's CFSI Program is an Industry leading, well established and effectively implemented program.

Supply Chain has seen improvement in the daily operational activities. Since 2013, stock-out related to critical spares has been improved from 17.3% to 8.6% in 2016. Similarly, scope removal due to unavailable parts in Pickering has also improved from 6.1% to 1.1%.

The Whitby warehouse upgrades were completed in 2016 to address the reduction of the warehouse footprint, elimination of the duplication of processes and provision of a modern facility capable of maintaining the integrity of the inventory. By the end of 2016, all inventories were moved to the Whitby facilities.

Improved performance areas include:

- Receiving backlog moved from an average of 8-10 days to 2 days, reducing congestion and moving material into the hands of the station quickly;
- Inventory accuracy is a world class 99.2% at the end of 2016, supporting the improvement in station execution.

2.1.10 Records Management

OPG-PROG-0001, *Information Management* establishes a set of standards and procedures for the management of OPG's information throughout its life-cycle, regardless of media. It includes electronic systems such as e-mail, central storage software, and the internal network to ensure consistent and appropriate use.

Another objective of the program is the advancement of electronic, digital, and mobility solutions that provide tools that effectively and efficiently capture, change, issue, and make content available.

Nuclear Oversight performed an audit of records and documentation in 2016 to ensure that the requirements of the program were met. This performance based audit of the records and documentation program identified that the managed system controls are fully effective.

Some key measures of information management showing that records management meets or exceeds performance targets, are shown in Table 3. (Data shown are for May 2017)

Measure	Performance	Target
Document Turnaround	Within 5 days 98.6% of time	Within 5 days 95% of time
Client Rejection Rate	1.9%	5%
Quality Check Program (Validate accuracy of controlled copies)	99.6%	95%

Table 3 - Records Management Performance

In 2015, a new application called Smart Form was introduced to nuclear facility workers to electronically submit and file their records and documents in Asset Suite/Curator rather than waiting on a Records Centre to manually index and upload images. The tool significantly reduces turnaround time on availability and cuts manual entry of key information (metadata) about the record/document by 50% or more. Average turnaround time has dropped from 30 days to less than 5 days.

Planned Improvements

An initiative for a new records repository is targeted to be in place by the end of 2020. The repository will have improved capture, retrieval, and work flow capabilities, and will expand on storage options to include various other file formats such as encrypted data, software, videos, photographs and AutoCAD.

2.1.11 Business Planning

Business planning is conducted to set strategic direction for the business and establish challenging but attainable operational and financial goals in accordance with N-PROG-AS-0005, *Business Planning*. Performance targets are established as part of the Pickering business planning process and nuclear benchmarking as outlined in N-PROC-AS-0080, *Nuclear Business Planning*.

Performance benchmarking is the process of comparing performance against industry leaders in order to identify areas of improvement and develop improvement plans to achieve targeted performance. A top-down gap-based business planning process was used to establish the 2017-2019 performance targets. A three-year horizon is assessed in detail and is supported by a complementary long term (20 years) outlook based on higher level information to better identify and react to emerging strategic shifts within the nuclear industry.

Pickering aims for continuous improvement in all areas. Where gaps in performance are identified, improvement initiatives are developed to ensure the established targets are met. These initiatives, and their associated milestones, are monitored and discussed at weekly meetings and other station oversight meetings on a routine basis. Plans address how initiatives will be implemented by the various station departments. Once implemented, results are monitored continuously through review of the station performance metrics, and if performance gaps still exist, initiative plans are revisited or further developed as required.

The Pickering Generation Plan specifies the major outage scope and durations as well as the operational performance targets, such as Forced Loss Rate, established during the business planning process. The generation planning process is designed to incorporate outage scope requirements and changes based on major component life cycle management plans and up-to-date inspection results and unit conditions.

Major Projects

Major Projects are executed to improve plant safety and reliability, and to address regulatory requirements. Project spending is subject to ongoing review and approval by the OPGN Asset Investment Screening Committee (AISC) as directed in N-PROG-AS-0007, *Project Management*.

Major projects represent a significant investment in the continuing operation of Pickering NGS with a budget for total projects of $231M over the period 2017 - 2019.

The fuel channel life assurance project, the periodic safety review update and component condition assessments show that Pickering can be safely operated until 2024. Future work is expected to include increased critical component inspections and maintenance and safety enhancements from the IIP. This work forms part of the incremental costs that would enable the extension of Pickering operations beyond 2020. The enabling costs have been estimated at approximately $307M over the period 2016 to 2020.

2.1.12 Business Continuity

The objective of OPG-PROG-0033, *Business Continuity Program* is to establish a managed system for business continuity, and to provide direction related to business and operational continuity, and recovery planning.

The business continuity program ensures that approved response strategies and recovery guidance are in place for critical functions during incidents that threaten business continuity. Approved strategies are intended to protect employee and public health and safety, limit significant impacts to the environment and operational continuity and maintain financial viability.

OPG Nuclear has continuity plans in place for Pickering NGS which were revised in 2015 to reflect an approach which considers many different natural and technological hazards, as well as the pandemic influenza scenario. These plans will continue to be reviewed every other year for updates as required.

OPG has an enterprise-wide Infectious Disease Guideline (IDG) which replaces previous pandemic plans, making them obsolete. The updated hazard continuity plan addresses response to infectious disease.

OPG held an integrated Nuclear Continuity Plan Tabletop Exercise that engaged all Nuclear Continuity Plan procedures in November 2015 and will be testing the new Infectious Disease Guideline (IDG) in September 2017 with an OPG-wide tabletop.

The program document N-PROG-RA-0018, Nuclear Pandemic Plan was made obsolete in June 2017 and CNSC notification was completed as per Reference 18.

2.1.13 Applicable OPG Documents

The following documents are the applicable OPG documents which support the licensing basis and are to be listed in the Licence Conditions Handbook.

Document Number	Document Title
N-POL-0001	Nuclear Safety Policy
N-CHAR-AS-0002	Nuclear Management Systems
N-STD-AS-0020	Nuclear Management Systems Organizations
OPG-PROC-0166	Organization Design Change
N-STD-AS-0023	Nuclear Safety Oversight
N-PROC-AS-0077	Nuclear Safety Culture Assessment
N-PROG-RA-0010	Independent Assessment
N-PROG-AS-0001	Managed Systems
OPG-PROG-0001	Information Management
OPG-PROG-0009	Items and Services Management
OPG-PROG-0010	Health And Safety Management System Program
N-PROC-RA-0097	Self Assessment and Benchmarking
N-PROC-RA-0035	Operating Experience Process
OPG-PROG-0033	Business Continuity Program
N-CORR-00531-18829	Letter “Persons Authorized to Act on Behalf of OPG in Dealings with the CNSC”, July 17, 2017 or the most recent version
N-GUID-09100-10000	Guideline for Maintaining Staff in Key Positions When Normal Station Access is Impeded

2.2 Human Performance Management

Pickering NGS has an effective human performance management program that meets or exceeds all applicable regulatory requirements and related objectives. It ensures that sufficient personnel numbers are maintained in all relevant job areas to safely operate the station. Human performance is managed so that all workers are qualified and have the necessary knowledge, skills, procedures, and tools to safely and competently carry out their duties.

For specific areas within this SCA, the following subsections describe the objectives, key results from the current licensing period, and planned improvements over the next licensing period. These discussions also support that:

- nuclear safety will continue to be assured (e.g., Sections 2.2.1. 2.2.5 and 2.2.6),
- staff are qualified and competent to operate the plant, and this will be maintained though the next licence period, including staffing numbers (e.g., Sections 2.2.1 to 2.2.5)

2.2.1 Human Performance Management Program

The objective of the *Human Performance* program, N-PROG-AS-0002 is to continually reduce the frequency and severity of events through the systematic reduction of human error and the management of defenses in pursuit of zero events of consequence. In support of this, the *Pickering Site Human Performance Strategic Plan*, P-PLAN-01900-00005 forms the basis for guiding Pickering Nuclear toward human performance excellence.

The current strategy for Human Performance at Pickering focuses on the topics of 'People' and 'Behaviours'. Training is being delivered to managers to provide a framework for performing field observations and engaging workers and supervisors in developing their leadership skills, knowledge and reinforcement of standards.

Also, a pilot program to reinforce peer-to-peer coaching called *Coach Me*, was completed in 2016. The results of the pilot showed an increase in employees coaching others as well as receiving coaching. The resulting self assessment recommended that the program be rolled-out station wide, which has been completed.

The measures used to evaluate overall health, reliability and robustness of the Human Performance strategic plan are Site Event Free Day Resets (SEFDR) and SEFDR rate.

As seen in Figure 4, Pickering has achieved its best ever performance in regards to SEFDR. In 2016, Pickering had 1 event against a target of 2, and a SEFDR rate of 0.0019 against a target of 0.038. The 2017 target is 2 SEFDR and at the end of the second quarter of 2017 Pickering has 0 SEFDR. The SEFDR rate for Pickering is top quartile for the nuclear industry in the last two years.

The reduction over the past licensing period speaks to the improvements implemented under the human performance strategic plan.

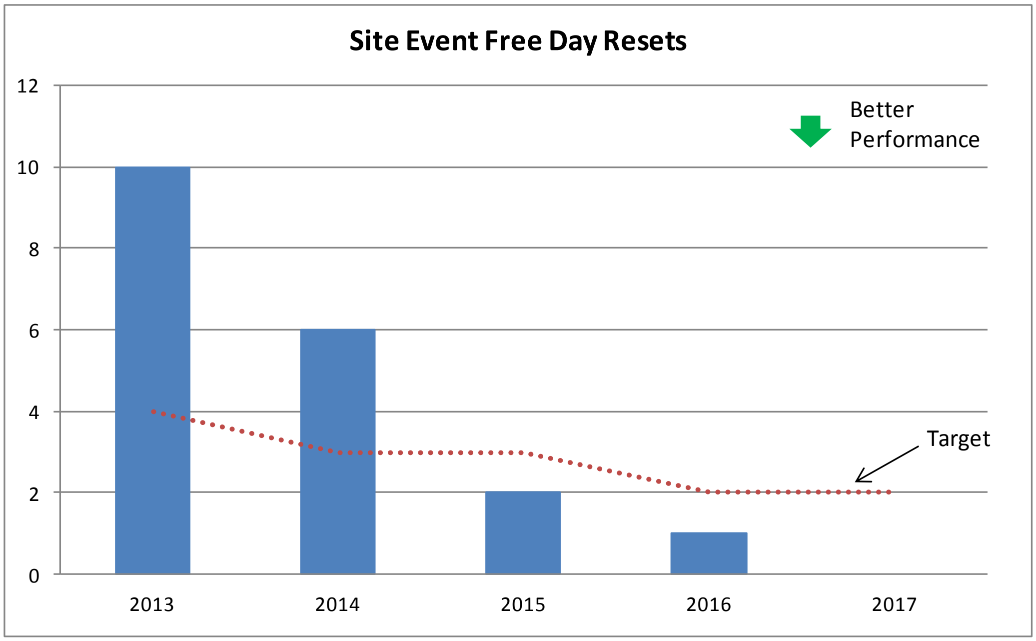


Figure 4 - Pickering Event Free Day Resets

Planned Improvements

An initiative to improve event communication and analysis is being developed in 2017 in order to improve identification of systemic issues. This will facilitate lessons learned from events to prevent event re-occurrence and foster an open reporting culture. This initiative leads to increased ability to develop leading indicators by recognizing adverse trends in low consequence events.

2.2.2 Personnel Training

The training program for regular staff, contractors, temporary personnel and other staff assigned work at OPG is defined by N-PROG-TR-0005, *Training*. The training program provides the structure, processes, and tools for defining, developing, implementing, documenting, assessing, and improving the training required to ensure staff have the appropriate knowledge, skill, and attitudes for safe and efficient plant operation.

The health of training is carefully monitored with a defined program to ensure that there is a Systematic Approach to Training (SAT) foundation for OPG's nuclear training programs upon which it continues to build and improve. Operations, maintenance and engineering departments have a robust continuing training program, and continuing training plans are revised and reissued on a 5-year cycle.

Engineering Training

Significant improvement was made in engineering training, specifically in the initial training program. To enhance the knowledge of the design basis, a one-day classroom course was added to the curriculum. This course has received substantial positive feedback not only from trainees but also from line managers who conduct observations of training.

Engineering training has a very robust continuing training program. An important component of this training program is the Conduct of Engineering Workshops. Every year senior engineering leaders select a new topic and the material is developed and delivered to approximately 1000 OPG engineers. The feedback about this element of continuing training is consistently positive.

Maintenance Training

The maintenance continuing training plan has the flexibility to focus on key performance issues tailored to the individual groups or needs. For example, continuing training topics for 2015 and 2016 were on leak management and valve assembly. Specific workshops were developed on these topics and delivered to 300 maintenance staff at Pickering.

Operations Training

The Operations training plan is a comprehensive and integrated plan that provides an overview of the current status and planned improvements. This plan is aligned and integrated with the fleet plan.

As of the end of 2016, there were 444 qualified Operators for Units 1,4 and 5-8 including 87 Supervising Nuclear Operators and 25 Field Shift Operating Supervisors. There are 88 operators in the initial training program, and all qualified operators participate in the continuing training program.

Leadership Training

In 2015, OPG re-designed and implemented new leadership development programs for First Line Managers (FLM), First Line Manager Assistants (FLMA) and middle level managers based upon international benchmarking and industry best practices. The program is a company-wide program which integrates participants from across the company to bring diverse thoughts, ideas and perspectives, to enhance the learning.

OPG has offered the International Senior Nuclear Plant Manager (ISNPM) program to senior leaders since 1996 with alumni being promoted to positions that include Chief Nuclear Officer, Chief Nuclear Engineer, Site Vice President and similar positions. Senior managers from major contract suppliers have also attended to support the pursuit of nuclear excellence. With the ISNPM program being recognized worldwide, OPG entered into collaboration with EDF Energy in 2016 and is now also providing the program in England.

Emergency Response Organization Training

In 2016, the Emergency Response Organization Betterment Project was implemented and successfully completed. Achievements include consistent application of the systematic approach to training to all ERO role-related documentation as well as creation or revision of over 200 training documents and trial delivery of selected materials.

2.2.3 Certification

The Pickering Power Reactor Operating Licence (PROL) requires individuals who are appointed to the following positions to have a valid CNSC certification:

(i) Responsible Health Physicist;

(ii) Authorized Nuclear Operator;

(iii) Control Room Shift Supervisor; and

(iv) Shift Manager.

Table 4 contains the number of Pickering certified staff, as of May 1, 2017.

The initial training programs are in accordance with N-PROC-TR-0008, *Systematic Approach to Training*. As shown in Table 4, there are adequate numbers of individuals for each position that requires CNSC certification. As well, there are on-going training programs preparing trainees to move into these positions.

Training programs are in accordance with CNSC regulatory document RD-204, *Certifications of Persons Working at Nuclear Power Plants*.

Certified Position	Pickering 1 & 4			Pickering 5 to 8		
	# of Certified Staff	# of Trainees	Minimum Required	# of Certified Staff	# of Trainees	Minimum Required
Shift Manager and Control Room Shift Supervisor	15	16	10	19	10	10
Authorized Nuclear Operator	32	20	20	58	18	30
Responsible Health Physicist	4					1

Table 4 - Number of Pickering Certified Staff (May 1, 2017)

Continuing training includes refresher training of knowledge and skills required for the certified position, and update training based on changes to the plant and procedures. Certified Operations staff, on average, complete greater than 200 hours per year of continuing training.

Recent improvements to the initial and continuing training programs have resulted in an increased focus on operator fundamentals, reactivity management and emergency response, including response to beyond design basis events. Full-scope main control room simulators are now being used during the conduct of emergency preparedness drills and exercises in order to achieve more realism in the exercises.

2.2.4 Initial Certification and Requalification

The Initial Certification Examinations are conducted in accordance with the following documents:

N-INS-08920-10002, *Simulator-Based Initial Certification Examinations for Shift Personnel*,

N-INS-08920-10004, *Written and Oral Initial Certification Examinations for Shift Personnel*.

As per CNSC Regulatory Document RD-204, *Certification of Persons Working at Nuclear Power Plants*, the initial certification examinations and requalification tests for the Responsible Health Physicist continue to be administered by CNSC staff.

The initial certification examinations provide assurance that, at the time of their certification, candidates for certified positions have acquired the level of knowledge and skills required to work competently in their assigned position.

Requalification Testing is conducted in accordance with N-INS-08920-10001, *Requalification Testing Of Certified Shift Personnel*. Adherence to this instruction ensures requalification tests are administered in a consistent manner and in accordance with the requirements endorsed by CNSC.

OPG will continue to demonstrate its capability to administer initial examinations and requalification tests for Operations certified staff, and to ensure sufficient numbers of certified staff are available for the safe and reliable operation of the Pickering station. This includes having sufficient trained and qualified staff available to deliver the examination and testing programs throughout Pickering's continued operation.

2.2.5 Minimum Shift Complement (Work Organization and Job Design)

Pickering Minimum Shift Complement (MSC) is the minimum number of qualified workers who must be present at all times to ensure the safe operation of the Pickering facility, to respond to all station emergencies that may arise, and to ensure adequate emergency response capability for the most resource intensive conditions.

Minimum staff requirements and associated qualifications are identified in Pickering instruction P-INS-09100-00003, *Pickering Minimum Shift Complement*, and are in compliance with CNSC guidelines G-323, *Ensuring the Presence of Sufficient*

Qualified Staff at Class I Nuclear Facilities – Minimum Staff Complement and G-278, *Human Factors Verification and Validation Plans*.

Pickering instruction P-INS-09260-00008, *Duty Crew Minimum Complement Assurance*, details the MSC assurance program which is in place to ensure compliance and to maintain historical data.

During the current license period, Pickering NGS completed an assessment for the impact the stock keeper role has on the MSC while responding to the credited design basis events. The assessment concluded that there is no requirement for specialized equipment for which a stock keeper has specialist knowledge or skill that cannot be transferred to Operations, or other workgroup. Therefore the stock keeper role was removed from Pickering MSC with actions to ensure any required tools remained readily available to Operations staff.

In response to the Fukushima lessons learned, OPG completed an assessment of the Emergency Response Team complement and capabilities to respond to beyond design basis events. Based on this assessment, initiatives such as installation of Emergency Mitigating Equipment (EME) and the establishment of Severe Accident Management Guidance (SAMG) were implemented. During the aforementioned assessment, the requirements for Minimum Shift Complement at Pickering NGS were deemed adequate.

2.2.6 Fitness for Duty

N-PROC-HR-0002, *Limits of Hours of Work* identifies the expectations and the process for monitoring and controlling hours worked. This procedure documents the regulatory limits pertaining to hours of work and shift assignments in order to control the effects of fatigue of OPG staff in support of safe reactor operation.

Under this governance, supervisors are required to ensure that their employees are aware of their prescribed limit and are also responsible for monitoring their employees' hours of work. The process requires that employees are aware of their time limitations, track work hours and promptly notify the first line manager in advance of a potential violation.

Information on the limits of hours of work is provided in the Nuclear *Operations & Maintenance Handbook*. This handbook is a small carry-around guide of expectations and information written with the operations and maintenance staff in mind. The handbook describes the steps to be taken for the unlikely situation in which someone is found unfit for duty, and also has the limits for hours of work.

For certified and security staff, regulatory documents RD-204 and RD-363 also outline specific fitness for duty requirements.

The Continuous Behaviour Observation Program (CBOP) is designed to develop a supervisor's ability to recognize and respond to behaviours that may indicate a risk to the security, safety, or health of employees, facilities and the public. All OPG supervisors must complete this training during initial training and complete refresher training every 36 months. The CBOP process is to be followed if a worker reports to work and is suspected to be unfit for duty. Steps to deal with Unfit for Duty situations are covered in the CBOP training and outlined in the operations and maintenance handbook, which is updated yearly.

OPG Security monitors all personnel entering the protected area for indications of being unfit for duty or under the influence of intoxicants; if they suspect a worker is unfit they deny access to the facility. OPG is using periodic canine drug monitoring at the security monitors as an additional barrier to ensure the fitness for duty of all staff entering the protected area.

2.2.7 Applicable OPG Documents

The following documents are the applicable OPG documents which support the licensing basis and are to be listed in the Licence Conditions Handbook.

Document	Title
N-PROG-AS-0002	Human Performance
N-STD-AS-0002	Procedure usage and Adherence
N-STD-OP-0002	Communications
N-STD-OP-0004	Self-Check
N-STD-OP-0012	Conservative Decision Making
N-INS-09030-10004	Observation and Coaching
N-STD-RA-0014	Second Party Verification
N-PROC-OP-0005	Pre-Job Briefing and Post-Job Debriefing
N-PROC-HR-0002	Limits of Hours of Work
N-CMT-62808-00001	Continuous Behaviour Observation Program (CBOP) – Participants Materials – Workbook Components
N-TQD-601-00001	Leadership and management Training and Qualification Description
P-INS-09100-00003	Pickering Minimum Shift Complement
P-INS-09260-00008	Duty Crew Minimum Complement Assurance
N-INS-03490-10003	Minimum Shift Complement Resources, Qualifications and Procedures Required for Responding to Resource Limiting Events
N-PROG-TR-0005	Training
N-PROC-TR-0008	Systematic Approach to Training
N-LIST-08920-10001	Trained Performance Areas
N-INS-08920-10004	Written and Oral Initial certification examination for Shift Personnel
N-INS-08920-10002	Simulator-Based Initial Certification Examinations for Shift Personnel
N-INS-08920-10001	Requalification Testing of Certified Shift Personnel
N-MAN-08131-10000-CNSC-031	Responsible Health Physicist
N-MAN-08131-10000-CNSC-007	Shift Manager, Pickering Nuclear
N-MAN-08131-10000-CNSC-010	Authorized Nuclear Operator
N-MAN-08131-10000-CNSC-028	Control Room Shift Supervisor, Pickering Nuclear

2.3 Operating Performance

Pickering NGS has an effective Operations Program which meets or exceeds all applicable regulatory requirements and related objectives. The program ensures that plant operation is safe and secure, with adequate regard for health, safety, security, radiation and environmental protection, and international obligations.

For specific areas within this SCA, the following subsections describe the objectives, key results from the current licensing period, and planned improvements over the next licensing period. These discussions also support that:

- Nuclear safety will be assured such that plant personnel and the public are protected (e.g., Sections 2.3.2, 2.3.3, 2.3.5, and 2.3.9).
- The plant is reliable and programs will continue to improve reliability during the next licence period (e.g., Section 2.3.7).
- Transparency continues to be maintained through the internal corrective action program and external reporting to regulatory agencies (i.e., Sections 2.3.10 and 2.3.11 respectively).

2.3.1 Operations

The *Nuclear Operations* Program, N-PROG-OP-0001, implements a series of standards and procedures to ensure that the plant is operated safely and reliably. This program establishes safe, uniform, and efficient operating practices and processes within nuclear facilities that provide nuclear professionals the ability to ensure facilities are operated in such a manner that the reactor operating licence, Operating Policies and Principles (OP&P), and other applicable regulations and standards are followed. It also supports the alignment, prioritization and resolution of operational problems, keeping reactor safety as an overriding priority.

Plant Operational Focus is the behaviour of an organization that is necessary to achieve high levels of operational safety and reliability. Plant Operational Focus at Pickering is used to ensure Operations leaders are providing input and oversight to work management processes. This allows operations leadership to ensure risks to plant operation due to equipment deficiencies and degradation are appropriately mitigated.

Improvements in these areas have helped drive operator advocacy and are showing a reduction in operator challenges and equipment unavailability.

As well, plant operational focus has driven improvements in housekeeping, storage of transient material, the preservation of seismic routes and plant material condition.

2.3.2 Plant Status Control

Plant Status Control forms part of the managed process to operate the plant safely and within the approved design basis.

N-STD-OP-0024*, Nuclear Safety Configuration Management* defines expectations for the identification and control of systems and equipment to ensure the availability of systems needed for nuclear safety. It defines operational requirements that are used to ensure that controls are in effect when station equipment is placed or maintained in a specific position or state, for nuclear safety reasons.

As a performance metric of plant status control, a misposition is declared when a component is found in a position off its baseline position without documented approval, or a component is incorrectly operated, or the incorrect component is operated. There is an immediate follow-up to misposition events to gain an understanding of the organizational and individual drivers that contributed to the event and to establish compensatory actions to prevent reoccurrence. The human performance lessons learned process is then used to share the underlying contributors to the event to prevent other occurrences. The Plant Status Control Committee was established as an oversight body, to review and categorize all misposition occurrences, identify trends and review corrective action plans to ensure that adequate corrective actions are taken to prevent recurrences.

The results are a reduction in the number of department resets due to misposition events and fewer and less significant misposition events.

Figure 5 shows a reduction in significant misposition events which are categorized as Level 1 or 2. Level 3 misposition events are not significant themselves but are tracked for trending purposes, and as a leading indicator to help inform activities to improve plant status control.

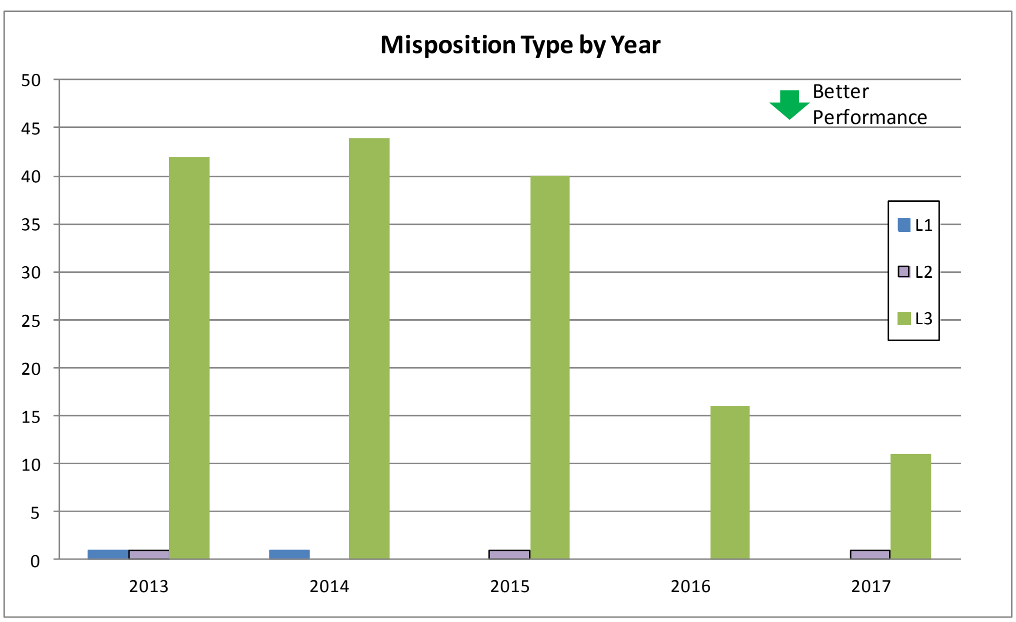


Figure 5 - Misposition Type by Year

2.3.3 Work Protection

The *Work Protection* program, N-PROG-MA-0015 describes the management processes, corporate governance, and roles and responsibilities to ensure worker safety where work on equipment requires isolation and de-energization. Worker safety is achieved through the effective application of work protection standards and procedures which ensure physical and administrative barriers are established between the energy source and the worker.

Operations provides oversight to the work protection program as follows:

- Nuclear Work Protection Review Board (NWPRB) - this group provides oversight of work protection performance at the nuclear or fleet level.
- Local Work Protection Review Board (LWPRB) – this group provides oversight of the Work Protection Performance at the site level.
- Site Work Protection Working Group (SWPWG) – this group is made up of individuals who execute work protection and provides oversight of work protection performance at the worker level.
- All 3 groups work to review events, identify trends, develop actions to improve performance and ensure that operating experience is used to inform improvement strategies.

Planned Improvements

Planned improvements include the development and use of model work protection permits and establishing an annual work protection oral review board to assess knowledge and identify gaps that require corrective actions.

2.3.4 Operating Procedures

Quality procedures are essential for maintaining safe and reliable operation. There is a dedicated group that ensures procedures are maintained current and technically correct.

A Technical Procedural Action Request (TPAR) is an approved request to change a technical procedure such as an operating procedure. High priority has been placed on completing these changes and reducing backlog.

Pickering has been successful in reducing both the number of temporary operating instructions and the backlog of operationally significant procedure change requests.

2.3.5 Reactivity Management

Reactivity Management practices are established through N-STD-OP-0009, such that reactivity of the reactor core is always respected and controlled. Reactivity management is the systematic control of activities that ensure core reactivity and stored nuclear fuel are monitored and controlled consistent with fuel design and operating limits. It is a key factor in maintaining barriers to fuel damage and fission product release.

Reactivity Management applies to all plant operations and maintenance activities with potential to impact on core reactivity and as such, must be performed in a safe, controlled, conservative manner, following approved procedures.

A reactivity management plan is produced weekly that integrates the timing of fuelling windows for adequate core reactivity with both unit and fuel handling maintenance. It is a forward-looking plan that ensures maintenance activities are scheduled appropriately for unit conditions and fuelling machine availability and staffing.

All reactivity management events and conditions are systematically reviewed, indexed and their significance quantified. The performance measure, Reactivity Management Index (RMI) is utilized in order to identify deficiencies and communicate overall program effectiveness. RMI is consistent with industry standards. Where deficiencies are identified, corrective actions are established and tracked for effectiveness. Pre-cursor, non-consequential events are evaluated as a leading indicator in order to prevent events. Additionally, significant reactivity management operating experience is reviewed and lessons learned implemented at the station.

2.3.6 Response to Transients

Unit transients are minimized by ensuring required corrective and preventive maintenance is performed, to ensure equipment reliability and redundancy is maintained, such that operation of the station is challenged as infrequently as possible by unanticipated equipment failures. In addition, station maintenance and operations activities are conducted in a manner such that the likelihood of unanticipated impact on station operation is minimized. In the event that a unit transient does occur, staff are trained and qualified to respond to transient conditions and ensure the equipment or the unit is placed in the appropriate safe state.

Response to Transients, N-STD-OP-0017, defines the response protocols for a unit transient. In addition, this standard requires, for all unit transients, that a robust multi-disciplinary post transient review is held shortly after unit conditions are stabilized.

The intent of the post transient review is to confirm the direct cause of the event is understood, verify major process system responses are as expected, ensure the unit is placed in the appropriate end state and document any corrective actions and lessons learned. The review also provides an opportunity to assess crew response for any improvements for personnel involved and adequacy of response procedures. Lessons learned from the review are shared with the entire operations team as well as the Training department to address any training requirements.

2.3.7 Outage Management Performance

Outage management is performed in accordance with OPG procedures for *Planned Outage Management*, N-PROC-MA-0013 and *Forced Outage Management*, N-PROC-MA-0049. The overall objective of outage management is to perform event free inspections, maintenance and modifications in a shutdown state, such that plant safety and reliability are maintained at the desired levels during normal operation. During the current licence term, Pickering NGS outages have been managed in a safe and effective manner.

Planned Improvements

Pickering has an outage performance improvement plan which includes a study for a 30-month outage scheduling cycle for Pickering to improve outage performance and maximize reliability, fitness for service and operational stability. The expected benefits of the potential 30-month outage cycle would include dose reduction, improved training windows, improved resource balancing because of reduced outage overlap, improved human performance, more outage preparation time and fewer outage days.

Additionally, the outage performance improvement plan includes a focus on risk mitigation and contingency planning to support execution of planned outage work. Accurately identifying and assessing risk ensures that business planning accounts for required contingencies, and key work required for plant reliability is completed within the outage window.

2.3.8 Heat Sink Management

Heat sinks are governed by a Heat Sink Management standard, N-STD-OP-0025 and define nuclear safety principles and requirements for the management of reactor heat sinks.

This standard is applicable to all planned reactor states and plant configurations in a low-power operating condition. The standard specifies requirements for the selection of heat sinks including the required diversity such that heat sinks are physically and electrically independent. It also specifies requirements for the monitoring of heat sinks and expectations following heat sink failures.

For planned outages, heat sinks are specified in advance to account for the planned equipment outages. The available equipment is reviewed against checklists as required by the operating manuals.

For forced outages, heat sinks are initially governed by abnormal operating procedures or emergency operating procedures. Once the unit is stable, a formal heat sink is declared using the same process as that for a planned outage.

In the event of a heat sink failure due to a Beyond Design Basis Event, heat sink restoration would be supported by Emergency Mitigating Equipment Guidelines (EMEG) and/or Severe Accident Management Guidelines (SAMG).

2.3.9 Safe Operating Envelope

OPG nuclear standard N-STD-MP-0016, *Safe Operating Envelope* (SOE) defines the processes, organizational responsibilities and key program elements to ensure that the SOE is defined and documented in a correct, complete and consistent manner and reflected in the station operating documentation.

The SOE specifies the information required to ensure plant operation is in conformance with the licensing basis. The safe operating limits, conditions and surveillance requirements as well as their bases as defined by the current safety analyses are documented in station and system specific documents, Operational Safety Requirements (OSRs).

The limits and conditions defined in the OSRs, including any surveillance requirements, are specified in the applicable operations and maintenance procedures and tests, to ensure the plant is operated within the SOE.

2.3.10 Corrective Action Program

The Corrective Action Program (CAP) objectives as described in N-PROG-RA-0003, *Corrective Action*, are to ensure deficiencies, non-conformances, and weaknesses that adversely impact, or may adversely impact plant operations, personnel, nuclear safety, the environment or equipment and component reliability, are promptly identified and corrected or dispositioned. The program has two elements: identification of adverse conditions and resolution of adverse conditions.

Pickering Nuclear has a healthy SCR reporting culture; over 13,000 SCRs are generated annually. These SCRs cover a variety of adverse conditions that are promptly reviewed by supervisors to assign dispositions based on resolution category and significance.

The site managerial team reviews all of the dispositions in order to ensure the appropriate disposition is assigned to each SCR. Approximately 95% of the SCRs generated at Pickering are by themselves not significant and are dispositioned for trend analysis or closed to a previous evaluation. This distribution of the SCR population is closely aligned with industry best practices based on benchmarking with nuclear utilities.

Root cause and apparent cause investigations are conducted for significant events to improve plant reliability and human performance at Pickering Nuclear.

Reporting and Trending analysis is conducted to identify trends in performance at a lower level before they become a more significant issue. The trending includes aspects from cognitive analysis, data analysis and industry experience.

Reporting is quarterly through SCR trending and performance improvement reports. Identified adverse trends are addressed by initiating an SCR and corrected as required through the corrective action program.

2.3.11 Regulatory Reporting

Procedure N-PROC-RA-0020, *Preliminary Event Notifications* identifies the notification requirements for reporting to facility and off-site organizations, management, and external officials and agencies, after a reportable event has occurred.

Procedure N-PROC-RA-0005, *Written Reporting to Regulatory Agencies* identifies the processes and requirements for written event reports to regulatory agencies and scheduled reporting to the CNSC.

Pickering NGS has been submitting routine scheduled reports in a timely fashion throughout the licence period that are required to assess plant performance and for compliance monitoring, in accordance with REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*.

2.3.12 Applicable OPG Documents

The following documents are the applicable OPG documents which support the licensing basis and are to be listed in the Licence Conditions Handbook.

Document	Title
N-PROG-OP-0001	Nuclear Operations
N-STD-OP-0012	Conservative Decision-Making
N-STD-OP-0036	Operational Decision Making
N-STD-OP-0024	Nuclear Safety Configuration Management
N-STD-OP-0011	Operations Performance Monitoring
N-STD-MP-0019	Beyond Design Basis Accident Management
N-STD-OP-0025	Heat Sink Management
N-STD-OP-0017	Response to Transients
N-STD-MP-0016	Safe Operating Envelope
N-STD-OP-0009	Reactivity Management
N-STD-OP-0021	Control of Fuelling Operations
NA44-OPP-03600	Pickering NGS-A Operating Policies and Principles
NA44-OSR-08131.02-00001	Pickering NGS A Shutdown Systems
NA44-OSR-08131.02-00002	Pickering A Operational Safety Requirements: Negative Pressure Containment
NA44-OSR-08131.02-00003	Pickering A Operational Safety Requirements: Fuel and Reactor Physics
NA44-OSR-08131.02-00004	Pickering A Operational Safety Requirements: Emergency Coolant Injection System
NA44-OSR-08131.02-00005	Pickering A Operational Safety Requirements: Boiler Emergency Cooling System
NA44-OSR-08131.02-00006	Pickering A Operational Safety Requirements: Emergency Boiler Water Supply System
NA44-OSR-08131.02-00007	Pickering A Operational Safety Requirements: Feedwater System
NA44-OSR-08131.02-00008	Pickering A Operational Safety Requirements: Service Water Systems
NA44-OSR-08131.02-00009	Pickering A Operational Safety Requirements: Powerhouse Emergency Venting System
NA44-OSR-08131.02-00010	Pickering A Operational Safety Requirements: Main

Document	Title
	Steam Supply System
NA44-OSR-08131.02-00011	Pickering A Operational Safety Requirements: Shutdown Cooling System
NA44-OSR-08131.02-00012	Pickering A Operational Safety Requirements: Moderator System
NA44-OSR-08131.02-00013	Pickering A Operational Safety Requirements: Heat Transport System
NA44-OSR-08131.02-00014	Pickering A Operational Safety Requirements: Reactor Regulating System
NA44-OSR-08131.02-00015	Pickering A Operational Safety Requirements: Electrical Power System
NA44-OSR-08131.02-00016	Pickering Nuclear 1-4: Annulus Gas System
NA44-OSR-08131.02-00017	Pickering NGS-A Operational Safety Requirements: Fuel Handling System and Irradiated Fuel Bays
NA44-OSR-08131.02-00018	Pickering NGS-A Critical Safety Parameter Monitoring Instrumentation
NA44-OSR-08131.02-00019	Pickering NGS- A Operational Safety Requirements: Shield Cooling System
NA44-OSR-08131.02-00021	Pickering NGS-A Operational Safety Requirements: Interstation Transfer Bus (ISTB)
NA44-OSR-08131.02-00022	Pickering Nuclear 1-4 Operational Safety Requirements: Powerhouse Environmental Protection System
NK30-OPP-03600	Pickering NGS-B Operating Policies and Principles
NK30-OSR-08131.02-00001	Pickering B Operational Safety Requirements: Emergency Coolant Injection System
NK30-OSR-08131.02-00002	Pickering B Operational Safety Requirements: Fuel and Reactor Physics
NK30-OSR-08131.02-00003	Pickering B Operational Safety Requirements: Negative Pressure Containment
NK30-OSR-08131.02-00004	Pickering B Operational Safety Requirements: Shutdown Systems
NK30-OSR-08131.02-00005	Pickering B Operational Safety Requirements: Boiler Emergency Cooling System
NK30-OSR-08131.02-00006	Pickering B Operational Safety Requirements: Feedwater System
NK30-OSR-08131.02-00007	Pickering B Operational Safety Requirements: Emergency Water Supply System
NK30-OSR-08131.02-00008	Pickering B Operational Safety Requirements: Service Water Systems
NK30-OSR-08131.02-00009	Pickering B Operational Safety Requirements: Main Steam Supply System
NK30-OSR-08131.02-00010	Pickering B Operational Safety Requirements: Moderator System
NK30-OSR-08131.02-00011	Pickering B Operational Safety Requirements: Powerhouse Emergency Venting System
NK30-OSR-08131.02-00012	Pickering B Operational Safety Requirements: Shutdown Cooling System
NK30-OSR-08131.02-00013	Pickering B Operational Safety Requirements: Heat Transport System
NK30-OSR-08131.02-00014	Pickering B Operational Safety Requirements: Emergency Power Supply
NK30-OSR-08131.02-00015	Pickering B Operational Safety Requirements: Reactor Regulating System
NK30-OSR-08131.02-00017	Pickering B Operational Safety Requirements: Group 1 Electrical Power System
NK30-OSR-08131.02-00018	Pickering B Operational Safety Requirements: Fuel

Document	Title
	Handling and Irradiated Fuel Bays
NK30-OSR-08131.02-00019	Pickering NGS Operational Safety Requirements: HPECI Power Supplies
NK30-OSR-08131.02-00020	Pickering B Operational Safety Requirements: Annulus Gas System
NK30-OSR-08131.02-00021	Pickering B Operational Safety Requirements: Critical Safety Parameter Monitoring Instrumentation
NK30-OSR-08131.02-00022	Pickering B Operational Safety Requirements: Shield Cooling System
N-PROG-MP-0014	Reactor Safety Program
N-PROC-RA-0035	Operating Experience Process
N-PROC-RA-0022	Processing Station Condition Records
N-PROG-RA-0003	Corrective Action
N-PROC-RA-0005	Written Reporting to Regulatory Agencies
N-PROC-RA-0020	Preliminary Event Notifications

2.4 Safety Analysis

Pickering NGS has a mature safety analysis program that meets or exceeds all applicable regulatory requirements and related objectives. Safety analysis is updated in an effective manner to maintain the overall safety case and demonstrate the fundamental safety functions to control power, cool the fuel, and contain or limit any accidental releases from the plant.

For specific areas within this SCA, the following subsections describe the objectives, key results from the current licensing period, and planned improvements over the next licensing period. These discussions also support that:

- Nuclear safety will be assured such that the public is protected (e.g., Sections 2.4.1 to 2.4.8)

2.4.1 Reactor Safety Program

The OPG *Reactor Safety Program*, N-PROG-MP-0014 defines the organizational responsibilities and key program elements for the management of issues related to nuclear safety analysis and operational safety requirements.

The program, standards, and implementing procedures govern the management of issues related to the safety analysis basis, which includes analyses and assessments which ensure that Pickering design and performance remain within the licensing basis.

2.4.2 Deterministic Safety Analysis

The deterministic safety analyses documented in the Pickering Safety Reports, demonstrate compliance with licensing limits and derived acceptance criteria.

NA44-SR-01320-00001	Pickering A Safety Report
NA44-SR-01320-00002	Pickering Nuclear 1-4 Safety Report Part 3: Accident Analysis
NA44-REP-00531.7-10001	Pickering A Analysis of Record
NK30-SR-01320-00002	Pickering B Safety Report - Part 2
NK30-SR-01320-00003	Pickering Nuclear 5-8 Safety Report Part 3: Accident Analysis
NK30-REP-00531.7-00001	Pickering B Analysis of Record

Table 5 - Document Numbers for Pickering Safety Analysis

The analyses listed in Table 5 are used to identify limits on process parameters and safety system requirements, and serve as a basis to establish the safe operating envelope for the station.

The Analysis of Record is the set of documents that establishes the current reactor safety licensing basis. It consists of the latest revision of the safety report and all analyses that update or supersede analyses contained in the latest revision of the safety report.

The safety reports are periodically updated and submitted to the CNSC in accordance with regulatory requirements.

The deterministic safety analysis will be updated in compliance to REGDOC-2.4.1, *Deterministic Safety Analysis* by including an appendix for common mode events into the safety reports by the end of 2017. For Pickering, the REGDOC-2.4.1 implementation plan is to be revised for 2018-2021 and will focus on aspects for which safety margins need to be confirmed. OPG will consider the Darlington experience during implementation of REGDOC-2.4.1 when determining the analysis upgrades for Pickering and include this in the revised implementation plan which OPG plans to submit to the CNSC before the end of 2017.

2.4.3 Heat Transport System Aging

The Heat Transport System (HTS) Aging Management activities were initiated in 2000 to evaluate the impact of HTS component aging on safety margins. The objective is to provide an integrated assessment on the cumulative effects of the identified aging mechanisms, and to develop effective safety margin management strategies based on the results of the assessments.

During the 2013-2015 period, OPG completed the deterministic safety analyses for the Slow Loss Of Regulation (SLOR), Loss of Flow (LOF), and Small Break Loss of Coolant Accident (SBLOCA) for future aged conditions for all Pickering units.

Progress reports on OPG Heat Transport System Aging Safety Analysis will continue to be submitted to the CNSC annually. The most recent progress report was submitted in February 2017. (Reference 19)

Pickering NGS has adequate provisions in place by which the effects of aging are managed to ensure that safety analysis margins are being maintained through to the end of commercial operation.

2.4.4 Risk and Reliability Program

The *Risk and Reliability Program,* N-PROG-RA-0016, establishes a framework for the development and use of Probabilistic Safety Assessment (PSA) as a means to manage radiological risks and to contribute to safe reactor operation. The PSA is used to assess the magnitude and frequency of radiological risks to the public, and operational reliability monitoring and reporting ensures that systems important to safety are monitored and managed.

Program elements have been developed to meet the intent of CNSC regulatory requirements in regulatory document RD/GD-98, *Reliability Programs for Nuclear Power Plants.*

Under the Risk and Reliability Program, actual station specific component failure data are collected and added to generic industry component failure data to obtain component failure rates. This component failure rate information is updated in models to derive an annual result for system Predicted Future Unavailability (PFU) of the Systems Important to Safety (SIS). This information is reported in the *Annual Risk and Reliability Report* which allows OPG to assess the performance of the SIS against their PFU targets, as well as to identify and take corrective actions in case the PFU results do not meet the targets.

The risk assessment models are also used operationally to assess the nuclear safety risk associated with taking station equipment out of service for maintenance during normal operation or during planned maintenance outages. This tool provides insight into the risk of plant configurations, enabling the application of alternate layers of defense, where required. Based on these assessments, changes to scheduled activities are made to reduce the risk level, if required.

2.4.5 Probabilistic Safety Assessment

Probabilistic Safety Assessment (PSA) is a tool used to help demonstrate that the design and operation of a nuclear power plant poses an acceptably low level of risk to the public. The main benefits of PSA include the identification of risk insights that can be used to improve the safety of plant design and operation. The results of the PSAs are compared with OPG's safety goals as documented in N-PROG-RA-0016, *Risk and Reliability Program*.

Hazard analysis is conducted as an initial step to probabilistic safety assessments. This involves the assessment and screening of various types of hazards: internal and external hazards, naturally occurring and human-induced.

Based on the hazard screening process, PSAs are developed for internal events, internal floods, internal fires, seismic events, and high winds. All other hazards identified were screened out and dispositioned to be of very low risk.

Pickering PSAs

The purpose of a PSA is to establish whether the design and operation of the plant poses an acceptable level of risk to the public and to identify the major sources of risk. The overall conclusion of the Pickering A and the Pickering B PSA is that the public risk from Pickering NGS operation is low.

In 2014 OPG updated selected elements of the Pickering A and B PSAs to include the Fukushima Action Plan (FAP) items, namely the Phase 1 Emergency Mitigating Equipment (EME) and other enhancements. These FAP updated PSAs were submitted to the CNSC in 2014 and showed that the EME reduces the Pickering NGS risk.

For each of the Pickering NGS PSAs (Pickering A and B, Level 1 and Level 2 PSAs for internal and external events, at power and outage), the OPG safety goals were met. Where the PSA results were found to be below the OPG safety goals but above the more stringent administrative safety goals, a risk improvement plan (or action plan) was prepared and submitted to CNSC detailing physical and analytical improvements to further reduce the plant risk where practicable. An annual update to this risk improvement plan has been provided to the CNSC since 2014.

As per regulatory requirements, the PSAs for Pickering are being updated on a periodic basis to reflect changes in the station. The updated PSA for Pickering NGS B will be completed and submitted to the CNSC by the end of 2017, and the PSA for Pickering NGS A will be updated and submitted by the end of 2018; these updates will be compliant with CNSC regulatory standard S-294. In accordance with the implementation plan for REGDOC-2.4.2, the additional new PSA requirements in this regulatory document will be addressed by the end of 2020.

Whole-Site Risk

During the previous Pickering relicensing hearing, the topic of “whole-site” risk was raised (given that the current PSAs and safety goals are per-unit based). Whole-site risk refers to the characterization of the overall risk of the site due to: multiple reactor units, other on-site sources of radioactivity (such as the irradiated fuel bays), internal and external hazards, and other reactor operating modes (besides full power and outage states).

The key issues associated with this topic include: a lack of international consensus on the methodology, the appropriateness of risk aggregation, and the acceptance criteria for a site-based risk assessment. For instance, a multi-unit PSA risk result is generally not equal to the per-unit risk value multiplied by the number of units on site.

In response to this issue at the time, OPG committed to perform a whole-site risk assessment for Pickering by the end of 2017 and submitted to the CNSC a concept-level report on whole-site PSA methodology, COG-13-9034 *Development of a Whole-Site PSA Methodology*, in collaboration with the CANDU Owners Group (COG). This COG report was made publically available on OPG’s external website.

In addition, OPG supported a COG-hosted international workshop (January 2014) and participated in a CNSC-hosted international workshop (November 2014) on topics related to whole-site PSA.

Since then, a COG joint project was launched to further develop the concepts in the COG paper and to complete a Pickering whole-site risk assessment. The work has progressed in collaboration with the industry and updates have been provided to the CNSC. In addition, OPG has actively participated in and monitored international developments in the area of whole-site risk. The Pickering whole-site risk assessment will be submitted to CNSC by the end of 2017, to further substantiate that the risk of the whole Pickering site is low.

2.4.6 Severe Accident Management

OPG's *Beyond Design Basis Accident Management program* has been implemented through N-STD-MP-0019. Severe accident management provides an additional layer of defence in depth to mitigate the consequences of accidents that fall beyond the scope of events considered in the plant design basis and is supported in its execution by the Emergency Response Organization.

Severe accident analysis has been conducted to support Level 2 PSA, as part of regulatory document, S-294 compliance, and in response to the Fukushima Action Items. Extensive analysis was carried out to identify beyond design basis events with the potential (albeit highly unlikely) to result in significant core damage and large offsite releases of radioactive material (severe accidents). This work included habitability studies to evaluate the impact of such events on the ability of station personnel to carry out actions as part of the emergency response.

The program ensures the safety of the public, environment, plant personnel and the station during a Beyond Design Basis Accident (BDBA) by identifying and implementing operational strategies to terminate the event progression and mitigate the consequences in order to ensure that fuel damage is precluded or limited. Operational strategies include maintaining the containment envelope to limit radiological release and achieving a stable plant configuration as soon as possible.

BDBA operational strategies are referred to as Emergency Mitigating Equipment Guidelines (EMEGs) and Severe Accident Management Guidelines (SAMGs).

EMEGs have a primary focus on fuel cooling, and are used to mitigate accident progression when design basis equipment is unable to provide adequate core cooling. The intent of EMEG use is to prevent a BDBA sequence from progressing to a severe accident.

SAMGs have a focus on both containment integrity and fuel cooling and their use is initiated if an event has progressed to the severe accident stage. The goals of SAMGs are to terminate progression of core damage by restoring cooling, and to maintain containment integrity and minimize radioactive releases.

2.4.7 Criticality Safety

The objective of criticality safety focuses on the prevention of the criticality of fuel outside the core, for either new or irradiated fuel.

The Pickering reactors use natural uranium fuel which cannot achieve a criticality event without a heavy water moderator. New fuel is stored in such a manner that the new fuel cannot be made critical.

Irradiated natural uranium fuel is stored under light water and cannot be made critical in any configuration; therefore no criticality risk exists in the irradiated fuel bays.

2.4.8 Management of Safety Issues

The Safety and Licensing (S&L) Research and Development (R&D) program addresses issues related to the safety design basis and safe operating envelope of existing nuclear plants, in collaboration with the CANDU Owner's Group (COG). There is a strong focus on supporting the resolution of outstanding generic S&L issues and safety margin improvement initiatives. The program takes into consideration both Canadian and international operating experiences in identifying and selecting R&D work to be performed. In part, this work also supports safety assessments for new plant designs and refurbishments and assists in maintaining the core capabilities, scientific expertise, and the infrastructure necessary for an ongoing nuclear safety R&D program.

Pickering-specific safety analysis issues are also addressed via the OPG Reactor Safety Program as well as the Risk and Reliability Program (for PSA issues).

The COG Industry Standard Toolset Program is a consolidation of the maintenance and support, development and qualification activities of the computer codes used for the design, safety analysis and operational support of CANDU reactors.

The COG R&D program overview report and operational plans are submitted to the CNSC as part of annual reporting requirements in accordance with REGDOC-3.1.1. This submission provides a summary of the work completed in the previous year and the on-going R&D activities that are being performed under the COG R&D and IST program. As well, COG-CNSC R&D seminars are held bi-annually.

2.4.9 Applicable OPG Documents

The following documents are the applicable OPG documents which support the licensing basis and are to be listed in the Licence Conditions Handbook.

Document Number	Document Title
N-PROG-MP-0014	Reactor Safety Program
N-PROG-RA-0016	Risk and Reliability Program
N-STD-MP-0019	Beyond Design Basis Accident Management
N-PROC-MP-0086	Safety Analysis Basis and Safety Report Updates
N-STD-RA-0034	Preparation, Maintenance and Application of Probabilistic Risk

Document Number	Document Title
	Assessment
NA44-SR-01320-00001	Pickering A Safety Report
NA44-SR-01320-00002	Pickering Nuclear 1-4 Safety Report Part 3: Accident Analysis
NA44-REP-00531.7-10001	Pickering A Analysis of Record
NK30-SR-01320-00002	Pickering B Safety Report - Part 2
NK30-SR-01320-00003	Pickering Nuclear 5-8 Safety Report Part 3: Accident Analysis
NK30-REP-00531.7-00001	Pickering B Analysis of Record
N-PROG-MP-0006	Software
NA44-GUID-03611-00010	Pickering NGS A Probabilistic Risk Assessment Guide – Level 1 At-Power
NA44-GUID-03611-00011	Pickering A Probabilistic Risk Assessment (PRA) Guide – Level 2 (At-Power)
NA44-GUID-03611-00012	Pickering 014 Probabilistic Risk Assessment Guide – Level 1 Outage for Internal Events
NA44-GUID-03611-00013	Pickering NGS A Probabilistic Risk Assessment Guide – Fire
NA44-GUID-03611-00014	Pickering NGS Probabilistic Risk Assessment (PRA) Guide – Internal Flood
NA44-GUID-03611-00015	Pickering NGS A Probabilistic Risk Assessment Guide – Seismic
N-CORR-00531-06350	Pickering NGS A - Outage Probabilistic Risk Assessment (PRA) for Seismic Events
N-CORR-00531-06351	Pickering NGS A - Outage Probabilistic Risk assessment (PRA) for High Winds
N-CORR-00531-06432	Pickering NGS A – Outage Probabilistic Risk Assessment (PRA) for Internal Floods
N-CORR-00531-06433	Pickering NGS A – Outage Probabilistic Risk Assessment (PRA) for Internal Fires
N-CORR-00531-06439	Pickering NGS A – Level 2 At-Power Probabilistic Risk assessment (PRA) for Internal Floods
NA44-REP-03611-00011	Hazards Screening Analysis- Pickering A
NA44-REP-03611-00012	Pickering NGS A Level 1 At-Power Internal Events Risk Assessment (PARA-L1P)
NA44-REP-03611-00013	Pickering NGS A Level 2 At-Power Internal Events Risk Assessment (PARA-L2P)
NA44-REP-03611-00014	Pickering NGS A Level – 1 Outage Internal Events Risk Assessment (PARA-L1O)
NA44-REP-03611-00021	Pickering NGS A Internal Flood Probabilistic Risk Assessment (PARA Flood)
NA44-REP-03611-00022	Pickering NGS A PRA – Based Seismic Margin Assessment (PARA Seismic)
NA44-REP-03611-00023	Pickering NGS A Level 1 High Wind Probabilistic Risk Assessment
NA44-REP-03611-00038	Pickering NGS A Probabilistic Risk Assessment (PRA) – Internal Fire Report
N-GUID-03611-10001 Volume 1	OPG Probabilistic Risk Assessment (PRA) Guide-Level 1 (At Power)
N-GUID-03611-10001 Volume 2	OPG Probabilistic Risk Assessment (PRA) Guide Volume 2 – Level 2 (At Power)
N-GUID-03611-10001 Volume 4	OPG Outage Probabilistic Risk Assessment (PRA) Guide-Level 1
N-GUID-03611-10001 Volume 5	OPG Probabilistic Risk Assessment (PRA) Guide-Fire
N-GUID-03611-10001 Volume 6	OPG Probabilistic Risk Assessment (PRA) Guide-Internal Flood
N-GUID-03611-10001 Volume 7	OPG Probabilistic Risk Assessment (PRA) Guide-Seismic

Document Number	Document Title
N-GUID-03611-10001 Volume 8	OPG Probabilistic Safety Assessment (PSA) Guide-External Hazard Screening
N-GUID-03611-10001 Volume 9	OPG Probabilistic Risk Assessment (PRA) Guide-Internal Hazards Screening
N-GUID-03611-10001 Volume. 10	OPG Probabilistic Risk Assessment Guide – High Wind Hazard
NK30-REP-03611-00006	Pickering NGS B Level 1 At-Power Internal Events Risk Assessment
NK30-REP-03611-00008	Hazards Screening Analysis – Pickering B
NK30-REP-03611-00009	Pickering NGS B Level 1 Outage Internal Events Risk Assessment
NK30-REP-03611-00010	Pickering NGS B At-Power Level 2 Probabilistic Risk Assessment (PRA) for Internal Initiating Events
NK30-REP-03611-00011	Probabilistic Risk Assessment Level 2 Outage Report – Pickering B
NK30-REP-03611-00012	Pickering NGS B Probabilistic Risk Assessment – Internal Fire Final Report
NK30-REP-03611-00013	Pickering NGS B (PNGS - B) PRA Based Seismic Margin Assessment (SMA)
NK30-REP-03611-00014	Pickering NGS B Internal Flood Probabilistic Risk Assessment (PBRA Flood)
NK30-REP-03611-00020	Pickering NGS B High Wind Probabilistic Risk Assessment
N-CORR-00531-04548	Submission of OPG Probabilistic Risk Assessment (PRA) Computer Codes
N-CORR-00531-04858	Submission of OPG Accident Sequence Quantification (ASQ) Tool
N-CORR-00531-05159	Submission of OPG Sensitivity and Uncertainty MAAP4-CANDU Post-Processing and Input Generation and Analysis Scripts
N-CORR-00531-05596	Submission of MAAP4-CANDU Version 4.0.7C for CNSC Acceptance in Accordance with S-294
N-CORR-00531-05492	Acceptance of Software Packages Used in OPG's Probabilistic Risk Assessments
N-CORR-00531-06093	Submission of MAAP4-CANDU Version 4.0.7D for CNSC Acceptance in Accordance with S-294
N-CORR-00531-05491	External Hazards Screening Methodology – Outage Unit
P-CORR-00531-03780	Pickering A and B – Internal and External Hazards Screening Analysis- Single and Coincidental Outage Unit
N-CORR-00531-05928	Pickering NGS B – Methodology for a Reduced Scope At-Power Level 2 Probabilistic Risk Assessment (PRA) for Seismic Events
N-CORR-00531-05961	Pickering NGS B – Outage Probabilistic Risk Assessment (PRA) for Internal Fires
N-CORR-00531-05962	Pickering NGS 'B' – Outage Probabilistic Risk Assessment (PRA) for High Winds
N-CORR-00531-05959	Pickering NGS 'B' – Methodology for a Reduced Scope Level 2 Outage Probabilistic Risk Assessment (PRA) for Internal Events
N-CORR-00531-05960	Pickering NGS 'B' – Outage Probabilistic Risk Assessments (PRA) for Internal Floods
N-CORR-00531-05927	Pickering NGS 'B' – Level 2 At-Power Probabilistic Risk Assessment (PRA) for Internal Floods
N-CORR-00531-05930	Pickering NGS 'B' – Outage Probabilistic Risk Assessment (PRA) for Seismic Events
N-CORR-00531-05997	Pickering NGS B – Level 2 At-Power Probabilistic Risk Assessment (PRA) for High Winds

2.5 Physical Design

Pickering NGS has an effective program to maintain its design basis that meets all applicable regulatory requirements and related objectives. The structures, systems, and components at Pickering remain available, reliable, effective, and consistent with design, analysis, and quality control measures.

For specific areas within this SCA, the following subsections describe the objectives, key results from the current licensing period, and ongoing activities over the next licensing period. These discussions also support that:

- Systems, structures and components at the plant are fit to continue commercial operation and programs will ensure fitness-for-service during the next licence period (e.g., Sections 2.5.4 to 2.5.6).

- OPG continues to invest in Pickering to support the assurance of fitness for service through procurement and fuel inspections (e.g., Sections 2.5.3 and 2.5.4).

- Nuclear safety is assured by maintaining the plant's pressure boundary and ensuring key mitigating equipment is qualified (e.g., Sections 2.5.5 and 2.5.6).

2.5.1 Conduct of Engineering and Design Management

The *Conduct of Engineering* program, as defined in N-PROG-MP-0007, defines the programs and processes to ensure that engineering is performed consistently across OPG Nuclear.

The *Design Management* program, as defined in N-PROG-MP-0009, sets the overall requirement for execution and control of activities that provide design support and documentation for the nuclear facility.

These programs provide assurance that all design activities and their resulting documentation are controlled in a manner consistent with the plant's licensing basis. The program defines the minimum set of documentation that identifies and describes the design basis, design outputs and design processes.

2.5.2 Engineering Change Control

Design changes are performed in accordance with OPG's program N-PROG-MP-0001, *Engineering Change Control*. The Engineering Change Control (ECC) program ensures design changes to each OPG Nuclear facility (including systems, structures, or components; software; and engineered tooling) are planned, designed, installed, commissioned and placed into or removed from service such that the facility configuration is managed in accordance with the design and licensing bases, and remains within the safe operating envelope.

The health of the design and ECC programs is monitored using the ECC site index. The index incorporates metrics associated with quality of design ECC packages, ECC process compliance, and the timely updating of records and closeout of modifications. Pickering performance in the ECC site index was generally strong during the current licence term.

Timeliness of Engineering Change (EC) close out activities has generally improved over the licensing period, including completion of significant efforts to eliminate the backlog of records that needed updating to reflect installation of past modifications, and to reduce the number of temporary modifications installed in the Pickering facility and bring that number in line with industry best practices. Reduction of the backlog of open EC's was completed in 2016 and remains low.

2.5.3 Procurement Engineering

The Procurement Engineering (PE) process involves a technical review of items and services in order to establish purchasing and acceptance requirements. The procurement process ensures that items and services meet the design intent and also supports plant operations in resolving technical issues related to purchases.

The process is applicable to individual items, generic classes, and services. The procurement requirements include technical and quality requirements, acceptance criteria and acceptance methods, and are established in order to assure that properties and attributes of importance are imparted to the item being purchased.

2.5.4 Fuel

The primary objectives of the *Fuel* program, N-PROG-MA-0016 are to establish a formal and systematic process for ensuring the safe use of fuel in OPG's nuclear reactors.

This program specifies the requirements for monitoring, integrating and assessing fuel-related information and details the documentation requirements for issues identified by this program. It requires regular cross-discipline reviews to ensure the safe operation of the plant and to facilitate efforts to operate with zero fuel defects.

The program also incorporates the reporting requirements associated with demonstrating fuel compliance within the fuel design basis.

Radioiodine levels have remained below station shutdown limits at Pickering NGS during the licensing period. In addition, improvements have been made to the fuel defect management process.

Post-discharge fuel inspections and post-irradiation hot cell examinations of samples of the fuel discharged in the last five years of operation indicate that the fuel condition remains within the design basis compliance envelope for wear and deformation.

Mitigation measures for eliminating the black deposits which were observed on the fuel in Unit 1 from 2011 - 2015 have been successful. As a result, the number and size of deposits recorded and the total coverage continue to decline. Pickering will continue to monitor the fuel for any changes and report as required.

2.5.5 Pressure Boundary Program

The objective of the *Pressure Boundary Program*, N-PROG-MP-0004 is to manage the processes that control the quality of pressure boundary activities at OPG. The program establishes the infrastructure and defines the activities necessary to maintain a sustainable managed process that allows OPGN to perform activities associated with repairs, replacements, modifications and alterations to pressure retaining items, components and systems, including installation of new systems.

The Pressure Boundary program is a mature program that is compliant with the mandated codes and standards. Pickering NGS has implemented CSA N285.0-2008 with Update No. 2 by revising the *Pressure Boundary Program Manual*, along with associated procedures to comply with the standard.

After a successful assessment in 2017 by TSSA (Technical Standards and Safety Authority) demonstrating pressure boundary processes to be in compliance with the applicable codes and standards, Certificates of Authorization (C of A) for pressure boundary activities were renewed for three years, until April 15, 2020.

2.5.6 Environmental Qualification

The *Environmental Qualification* (EQ) program is defined in document N-PROG-RA-0006, and is compliant with standard CSA N290.13-05.

The objective of the program is to ensure that all required systems, equipment, components, protective barriers, and structures are qualified to perform their safety functions under the environmental conditions defined by the Pickering design-basis accidents.

The program includes the procedures and processes to systematically identify the equipment to be environmentally qualified, the environmental conditions to be used for qualification and the required documentation.

EQ is an on-going program ensuring that aging is managed, obsolescence is taken into account and that qualification configurations are maintained.

2.5.7 Software

The objective of the *Software* program, N-PROG-MP-0006, is to identify the processes and overall requirements for software that supports safe and efficient plant operation. This program applies to software classified as Real-Time Process Computing (RTPC) and Scientific, Engineering and Safety Analysis (SESA) Software or Software Engineering Tools in OPGN. Software is classified in order to determine the set of applicable standards and procedures for its custom development, maintenance, acquisition, qualification, use and retirement. For each classification the detailed requirements are tailored to the significance of the software.

For the development of RTPC systems within OPGN, N-PROC-MP-0099, *Development of Real-Time Process Computing Systems* provides a systematic and uniform process for development. This procedure defines requirements on the development of RTPC systems.

The SESA portion of the software governance manages the analytical tools credited to support the design or maintenance of safety related systems with particular emphasis on the requirements of standard CSA N286.7. Software classified as SESA is extended to apply to all analytical software used within OPGN whose failure or misuse can lead to a safety (conventional, radiological or environmental), licensing or reliability impact on the facility.

2.5.8 Applicable OPG Documents

The following documents are the applicable OPG documents which support the licensing basis and are to be listed in the Licence Conditions Handbook.

Document	Title
N-PROG-MP-0007	Conduct of Engineering
N-PROG-MP-0001	Engineering Change Control
N-STD-MP-0027	Configuration Management
N-PROG-MP-0009	Design Management
N-PROG-MA-0016	Fuel
N-PROG-MP-0004	Pressure Boundary Program
N-PROC-MP-0040	System and Item Classification
N-PROC-MP-0082	Design Registration
N-PROG-MP-0006	Software
N-MAN-01913.11-10000	Pressure Boundary Program Manual
N-CORR-00531-06752	Authorized Inspection Agency service Agreement
N-INS-08173-10050	Procurement from Licensed Canadian Nuclear utilities
N-LIST-00531-10003	Index to OPG Pressure Boundary Program Elements
N-PROG-RA-0006	Environmental Qualification

2.6 Fitness for Service

Pickering NGS has an effective fitness for service program that meets or exceeds all applicable regulatory requirements and related objectives. The physical condition of structures, systems and components at Pickering remain available, reliable, effective and consistent with design, analysis and quality control measures.

For specific areas within this SCA, the following subsections describe the objectives, key results from the current licensing period, ongoing activities and planned improvements over the next licensing period. These discussions also support that:

- Equipment reliability is maintained and programs will continue to improve reliability during the next licence period (e.g. Sections 2.6.1, 2.6.3, 2.6.5, 2.6.7, and 2.6.8).

- Systems, structures and components at the plant are fit to continue commercial operation and inspection programs will ensure fitness-for-service during the next licence period (Sections 2.6.2 to 2.6.4).

- OPG continues to invest in Pickering to support the improvement of equipment reliability and assurance of fitness for service (e.g. Sections 2.6.4, 2.6.5, and 2.6.8).

- Nuclear safety is assured through periodic inspection, testing, and maintenance of plant systems, structures, and components (Sections 2.6.4, 2.6.5, and 2.6.7)

2.6.1 Equipment Reliability

The objective of the *Equipment Reliability Program*, N-PROG-MA-0026, is to improve station equipment reliability and reduce forced loss rate by ensuring high levels of reliable performance of components important to nuclear safety and production.

The equipment reliability process represents the integration and coordination of a broad range of equipment reliability activities into one program for plant personnel to evaluate important station equipment, develop and implement long-term equipment health plans, monitor equipment performance and condition, and make continuing adjustments to preventive maintenance tasks and frequencies based on equipment operating experience. This process includes surveillance and testing, Life Cycle Management (LCM) planning, and equipment performance and condition monitoring.

Pickering has performed benchmarking against other plants through participation in the Equipment Reliability Working Group (ERWG) of the CANDU Owners Group (COG). COG has established the Equipment Reliability Index (ERI) which the industry uses to assess the health of a plant's reliability program and performance and enables benchmarking against other plants. This index provides an aggregate assessment of equipment reliability and the supporting programs. See Figure 6 for the ERI data.

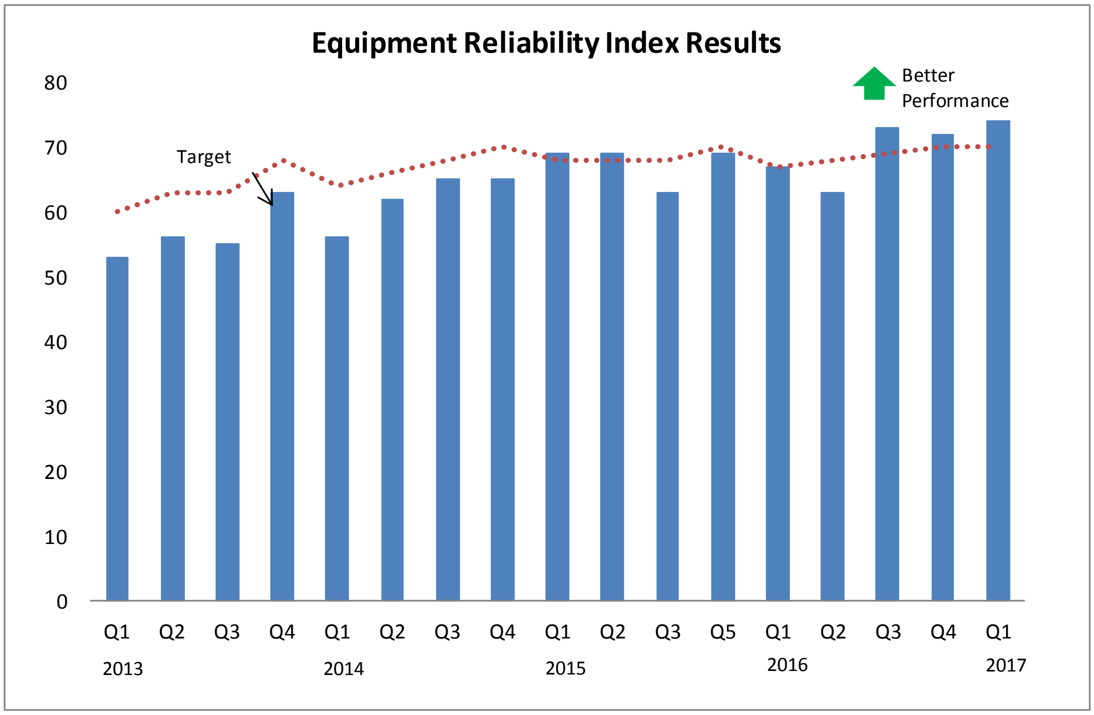


Figure 6 - Equipment Reliability Index (ERI)

The ERI score is derived from 17 key weighted sub-indicators which add up to a maximum score of 100. Pickering's ERI score has significantly improved over the course of the current licence period. This improvement is the result of various equipment reliability initiatives. At the end of 2016, the ERI was 72 versus a target of 70, and in June 2017 the ERI is 74 against a 2017 target of 72.

An increased ERI score is reflected in a reduction in Forced Loss Rate (FLR), a measure of the amount of gross unplanned production losses in a period of time. In 2015 and 2016, Pickering achieved its two best FLR values ever, 2.89% and 4.08% respectively.

2.6.2 Major Components

The *Major Components Program* is described in program document N-PROG-MA-0025. It establishes an integrated set of processes and activities to demonstrate fitness for service of Fuel Channels, Feeders, Steam Generators and Reactor Components and Structures, and develops long term life cycle management strategies for continued operation.

This program ensures that these four major components will perform safely and reliably until the end of commercial operations, maintaining design and licensing bases and operational safety requirements while optimizing production and cost-effectiveness.

Fuel Channels

The fuel channel life cycle management program facilitates the safe operation of the fuel channels to the Pickering specified targeted operating life, and is constructed based on many years of inspection, monitoring, and mitigation of known degradation mechanisms. With the implementation of the Fuel Channel Life Cycle Management Plan (LCMP), N-PLAN-01060-10002, OPG will continue to demonstrate that these degradation mechanisms are understood, and confirm that component condition remains acceptable via monitoring and inspection.

OPG's planned research and development activities continue to support demonstration of understanding of key degradation mechanisms, material properties and component fitness for service. Research and development findings, as well as inspection results and industry operating experience are incorporated into the fuel channel program to maintain adequate margins on fitness for service for the station operational life. Enhancements and improvements in engineering assessments have provided margin and incorporation of new models from the applicable standards.

Steam Generators

The goal of the steam generator life cycle management program is to maintain steam generator performance and reliability for operation until the end of commercial operation through the implementation of the LCMP, N-PLAN-33110-10009.

Steam Generators are closely monitored by an inspection program to manage active and plausible degradation mechanisms. The inspection results demonstrate that life-limiting degradation mechanisms are being monitored and mitigated. There were no boiler tube leaks detected in the current licensing period. This is due to sound inspection and maintenance strategies, which complies with standard CSA N285.4 Clause 14 requirements.

Through the inspection program, a new degradation mechanism was discovered in the steam generators on Pickering Unit 4. Based on strong technical rigor, detailed analysis, and conservative decision making, the degradation is under control and mitigating actions have been implemented.

Feeders

The goal of the feeder piping system life cycle management program is to maintain the integrity of the feeder piping system until the end of commercial operation through the implementation of LCMP, N-PLAN-01060-10001.

The Pickering feeder piping system's continuing fitness for service is demonstrated by inspection and assessment activities. Advanced stress analysis methodologies have been used to demonstrate that the required minimum wall thickness can be safely reduced in order to minimize or eliminate feeder replacement resulting from flow accelerated corrosion. Feeder fretting and contact with other components will continue to be closely monitored with visual inspections and with the incorporation of operating experience.

The COG Feeder Joint Integrity Project has produced feeder fitness for service guidelines, which are used in addition to ASME codes, as acceptance criteria for feeder degradation assessments. A feeder replacement schedule is developed from the most recent feeder thinning inspections and assessments of remaining life based on minimum required wall thickness, to demonstrate fitness for continued service. Feeder replacements will continue to be assessed for Pickering out to end of commercial operation.

Reactor Components and Structures

The Reactor Components and Structures LCMP, N-PLAN-01060-10003, is intended to establish the strategy or identify necessary actions to ensure that the effects of aging on reactor components and structures are appropriately managed for the plant operating life. The plan is updated annually and assessments are incorporated into the life cycle management strategies.

Reactor component and structures inspections and assessments continue to demonstrate fitness for service of these components. OPG expects that continued inspections and monitoring will effectively manage the degradation mechanisms to the end of commercial operation.

2.6.3 Aging Management

The *Integrated Aging Management* (IAM) Program, documented in N-PROG-MP-0008 ensures that the condition of Structures Systems and Components (SSC) and critical station equipment is understood and that required activities are in place to assure the health of the SSC's, through plant aging.

Integrated aging management is implemented with the following programs:

N-PROG-MA-0025, *Major Components* develops long-term life cycle management strategies that support continued fitness for service for major components.

The life cycle plans are established by a comprehensive Condition Assessment (CA) process. Condition assessments supplement the ongoing engineering surveillance activities in place to monitor and optimize system performance. These CA's focus on the aging mechanisms, current condition and recommended actions required to maintain the health of the component in order to reach Pickering NGS end of commercial operation.

N-PROG-MA-0026, *Equipment Reliability* establishes the process for Equipment Reliability (ER) for critical components. The ER Program and its implementing procedures ensure that critical components meet their defined or desired level of reliability for the lifespan of the station.

N-PROG-MA-0017, *Component and Equipment Surveillance* defines the requirements for the surveillance of a select set of components including inspection, maintenance, certification, and testing. Heat exchangers, check valves and power operated valves are examples of the defined component programs. Pipe wall thickness, pressure relief valves and buried piping are examples of equipment undergoing inspection and testing programs.

2.6.4 Periodic Inspection and Testing

The objective of the periodic inspection program and the in-service inspection program is to ensure pressure boundary integrity, fitness for service, and aging management of the nuclear plant systems and components in Pickering.

The program provides assurance that the likelihood of a failure that could endanger health and safety is being maintained low.

The programs are documented in specific periodic inspection program plans and associated inspection schedules and they are administered under nuclear and station governing documents.

The periodic inspection program for standard CSA N285.4, *Periodic Inspection of CANDU Nuclear Power Plant Components*, consists of approximately 300-600 inspection items for each of the six operating units. Each scheduled item is normally inspected once within each 10-year cycle. Inspected components include: piping and vessel welds, pumps, valves, pipe and component supports, heat exchangers, and mechanical couplings.

The periodic inspection program for standard CSA N285.5, *Periodic Inspection of CANDU Nuclear Power Plant Containment Components*, consists of approximately 100 inspection items for Unit 0 and 200-600 inspection items for each of the six operating units. Each item is normally inspected once within each 10-year cycle. Inspected components include: containment penetration seal welds, pipe supports, piping/ducting, valves, containment dampers and other components.

Baseline inaugural inspections are performed for newly installed equipment and components that are inspected under either the CSA N285.4 or CSA N285.5 program. These inspections are used to establish the condition of the SSC at the time it was placed into service. This ensures that when the standard inspections are performed on 10-year cycles there will be at least one previous result for each SSC, thus always allowing for comparative analysis between inspection results.

Inspections/testing of Vacuum Building (VB) and Pressure Relief Duct (PRD) containment structures were last performed during the 2010 Vacuum Building Outage under CSA N287.7, *In-Service Examination and Testing Requirement for Concrete Containment Structures for CANDU Nuclear Power Plants*. Inspection activities involved concrete components, vacuum building joint sealant, vacuum building roof seal and pressure relief duct joint seals. Pickering NGS will continue to meet regulatory requirements for VB and PRD inspections.

Structural Integrity

The station's principal structures consist of eight reactor buildings, two main control rooms (one for Pickering Units 1-4 and one for Pickering Units 5-8), two reactor auxiliary bays, two powerhouses (including the turbine hall and turbine auxiliary bay, the Vacuum Building (VB) with its associated Pressure Relief Duct (PRD), a service wing, an administration building, two irradiated fuel bays, an auxiliary irradiated fuel bay, a heavy water upgrading building, two screenhouses, a water treatment building, a high pressure Emergency Coolant Injection (ECI) pumphouse, and an ECI water storage tank. The administration and service buildings, heavy water upgrading building, VB and ECI structures serve the entire unit station.

Pickering NGS follows the CSA standard N285.5, *Periodic Inspection of CANDU Nuclear Power Plant Containment Components* and CSA standard N287.7, *In-service Examination and Testing Requirements for Concrete Containment Structures for CANDU Nuclear Power Plants*, for reactor building integrity.

The reactor building undergoes inspection for integrity during every planned unit outage. These inspections are covered under the Periodic Inspection Plan (PIP) which is overseen by the Components Engineering group. A reactor building pressure test is performed every 6 years to check for reactor building leak tightness.

The Units 1-4 underwater concrete structure and the Units 5-8 underwater concrete structure were inspected during the station vacuum building outage in 2010, to confirm their structural integrity and operational adequacy. The topic of the condition of the underwater concrete structures was discussed at the previous Pickering licence renewal hearings, and the matter continues to be managed as part of OPG's aging management program and is being considered via the PSR process in support of continued operations.

2.6.5 Non-destructive Examination

Non-destructive Examination (NDE) has a direct bearing on the safe and reliable operation of nuclear facilities and is performed in accordance with applicable codes and standards. NDE is governed by I-STD-AS-0003, *Non-Destructive Examination*, which ensures that NDE is conducted in a planned and controlled manner using approved procedures and qualified personnel.

Inspection and Maintenance Services (IMS), a division of Ontario Power Generation Nuclear (OPGN), provides inspection, specialized maintenance, project management, and technical services to nuclear and non-nuclear facilities in accordance with program document I-PROG-AS-0001, *Conduct of Inspection and Maintenance Services*.

2.6.6 Chemistry Control

The objective of the *Chemistry* program, N-PROG-OP-0004, is to specify processes, requirements, and staff accountabilities to ensure effective control of plant chemistry, including provision of analytical services. The chemistry program covers activities associated with overall objectives of controlling plant chemistry in order to ensure safe plant operation and to protect the long term life of SSC's.

The Chemistry Performance Index (CPI) compares the concentration of selected impurities and corrosion products to corresponding limiting values, with focus on secondary system chemistry. The limiting values are periodically reviewed against industry best practices to ensure they continue to represent challenging targets. The measure is reported as a twenty-four month rolling average.

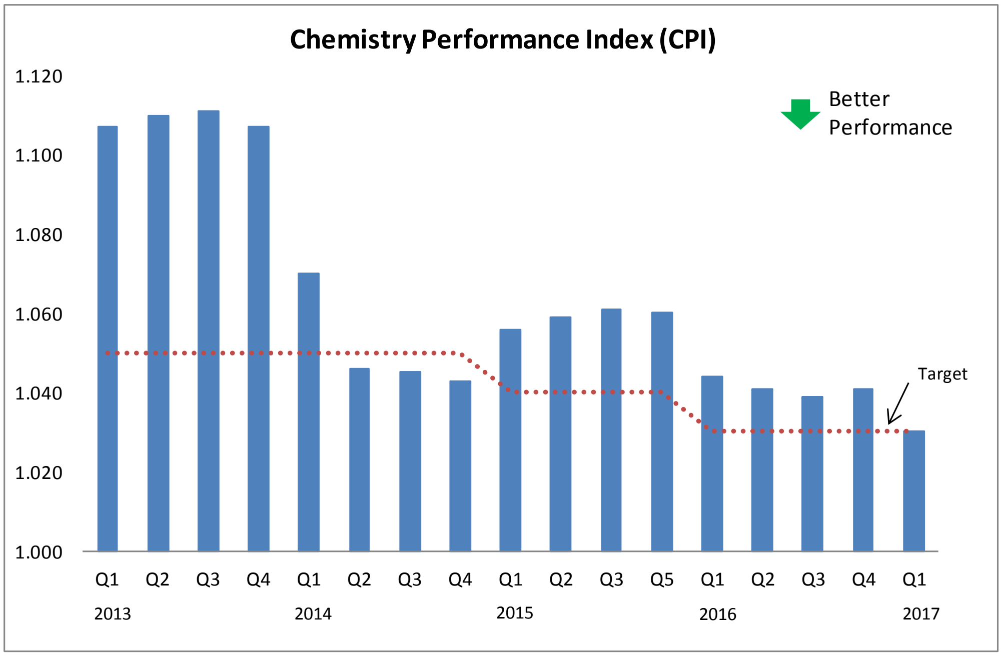


Figure 7 - Chemistry Performance Index (CPI)

As shown in Figure 7, the trend indicates improving performance. This is a reflection of combined efforts to improve the water treatment plant performance, as well as to improve start-up chemistry and outage practices, and to eliminate condenser cooling water ingress.

2.6.7 Maintenance

Program document N-PROG-MA-0004, *Conduct of Maintenance* is designed to ensure plant equipment is maintained to maximize safety and reliability through effective implementation and control of maintenance activities.

The Maintenance programs are organized to align closely with the Engineering, Work Management, Operations and Supply Chain organizations to support equipment fitness for service requirements.

The intent of the maintenance program is to ensure that safety systems remain available and that equipment failures are minimized. This is accomplished through corrective and preventive maintenance activities as well as routine inspections of system components to ensure they continue to operate as expected. N-PROG-MA-0019, *Production Work Management Program*, details the requirements for identifying, prioritizing, planning, scheduling and executing work in support of the operation, maintenance and modification of the plant.

Maintenance is a key component in equipment reliability. The Maintenance Department is focusing on improving maintenance technical skills, maintenance fundamentals and craftsmanship in order to assure the quality of the maintenance at Pickering.

2.6.8 FH Reliability

A primary focus of the Pickering NGS Fuel Handling (FH) group is to improve FH equipment reliability (ER). In 2014/2015 an Equipment Reliability Index (ERI) metric was developed specifically for FH in conjunction with the COG peer team to track ER improvement. Pickering NGS is taking the lead on various changes to the FH ERI metric indicators in order to improve its ability to accurately reflect ER condition in the station, and to aid as a predictor and tool for driving ER improvements. FH ERI has trended upwards since 2015.

Pickering NGS FH developed a reliability plan in 2012/2013 based on key performance indicators in specific equipment areas. From 2014 onwards, annual self assessments have been performed to analyze the overall effectiveness of the ER strategy. This plan has been modified over the years to best reflect the station's current needs.

The primary lagging indicator for FH ER is Forced Loss Rate due to FH equipment issues. FLR related to FH equipment was approximately 1.54% in 2016, with year to date for 2017 showing improvement from the 2016 value.

Some examples of recently completed reliability initiatives include the 014 Fuelling Machine (FM) 90 degree rotation modification, which eliminated obsolescence and reliability concerns; the D_2O and head oil supply filter element upgrades, and the FM cable catenary replacements. Progress continues on repairing the Irradiated Fuel Bay 'B' (IFB-B) liner leakage.

Planned Improvements

One of the major reliability focus areas for 2017/2018 is the upgrade to the FM ram seals, which is a joint project between OPG, COG and New Brunswick Power - Point Lepreau. This seal redesign is expected to mitigate the primary failure modes of the current seals, decrease failure rates, and extend the life of the ram seals.

2.6.9 Maintenance Backlog

Pickering Nuclear endeavours to ensure that work is prioritized, planned and executed in a manner that focuses on maintaining personnel and nuclear safety, increases plant equipment reliability and reduces the station Forced Loss Rate.

Part of the prioritization of this work is in identifying components important to safety and reliability and to ensure that where those components can no longer reliably perform their function, that the repair is executed with priority. These components receive coding per N-PROC-MA-0008 as either Corrective Critical (CC) or Corrective Non-Critical (CN), depending on component risk ranking.

It is a priority to ensure that CC and CN backlog is maintained low, which in turn allows important preventive maintenance programs to be executed and maintain system designed redundancy.

As shown in the Figure 8, the volume of corrective maintenance backlog work orders continues to steadily decrease since 2014.

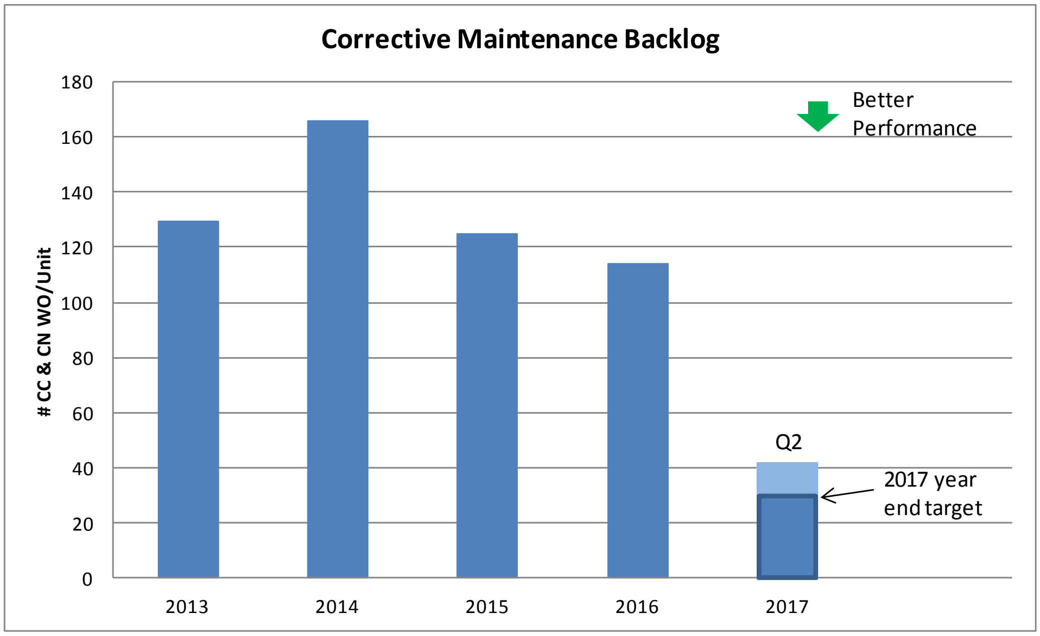


Figure 8 - Maintenance Backlog

2.6.10 Applicable OPG Documents

The following documents are the applicable OPG documents which support the licensing basis and are to be listed in the Licence Conditions Handbook.

Document	Title
N-PROG-MA-0004	Conduct of Maintenance
N-PROG-MA-0017	Component and Equipment Surveillance
N-PROG-MA-0019	Production Work Management
N-PROG-MP-0008	Integrated Aging management
N-PROC-MP-0060	Aging Management Process
N-PROC-MA-0013	Planned Outage Management
N-PROC-MA-0049	Forced Outage Management
N-PROG-MA-0026	Equipment Reliability
N-PROG-RA-0016	Risk and Reliability Program
N-STD-RA-0033	Reliability and Monitoring of Systems Important to Safety
NA44-REP-03611-00004	Pickering A Systems Important to Safety
NK30-REP-03611-00024	Pickering B Systems Important to Safety
P-INS-03611-00001	Pickering Reliability Instruction
P-LIST-06937-00001	Pickering A and B List of Safety Related Systems
N-PROG-OP-0004	Chemistry
N-PROG-MA-0025	Major Components
N-PLAN-01060-10001	Feeders Life Cycle Management Plan
N-PLAN-01060-10007	Feeders Life Cycle management Plan: Technical Basis Document
NA44-PIP-33126-00002	Pickering Nuclear Unit 1 Fuel Channel Feeder Pipes Periodic Inspection Program Plan
NA44-PIP-33126-00001	Pickering Nuclear Unit 4 Fuel channel Feeder Pipes Periodic Inspection Program Plan
NK30-PIP-33126-00001	Pickering Nuclear Unit 5 Fuel channel Feeder Pipes

Document	Title
	Periodic Inspection Program Plan
NK30-PIP-33126-00002	Pickering Nuclear Unit 6 Fuel channel Feeder Pipes Periodic Inspection Program Plan
NK30-PIP-33126-00003	Pickering Nuclear Unit 7 Fuel channel Feeder Pipes Periodic Inspection Program Plan
NK30-PIP-33126-00004	Pickering Nuclear Unit 8 Fuel channel Feeder Pipes Periodic Inspection Program Plan
COG-JP-4107-V06	Fitness-for-Service Guidelines for Feeders in CANDU Reactors
N-PLAN-33110-10009	Steam Generators Life Cycle Management Plan
NA44-PLAN-33110-10003	Picketing Units 1 and 4 Steam Generator life Cycle Management Plan (Excluding Sheet Sections 001 to 007)
NA44-PLAN-33110-10003 Sheet Sections 001 to 007	Pickering Units 1 and 4 Steam Generator Life Cycle Management Plan- Pickering Units 1 and 4 Steam Generators In-Service Inspection Plan
NK30-PLAN-33110-10008	Pickering Units 5 – 8 Steam Generator Life Cycle Management Plan (excluding Sheet Sections 001 to 007)
NK30-PLAN-33110-10008 Sheet Section 006	Pickering Units 5-8-In-Service Inspection Plan
COG Report 07-4089	Fitness-For-Service Guidelines for Steam Generator and Pre-heater Tubes
N-PLAN-01060-10002	Fuel Channels Life Cycle Management Plan
N-REP-31100-10041	Acceptance Criteria and Evaluation Procedures for Material Surveillance Pressure Tube
N-REP-31100-10055	Report on technical basis for Fuel Channel Aging and Life Cycle Management Strategy and Plan
NA44-PIP-31100-00001	Pickering Nuclear 1-4, Unit 1 Fuel Channel Pressure Tubes Periodic Inspection Program Plan
NA44-PIP-31100-00004	Pickering Nuclear 1-4, Unit 4 Fuel Channel Pressure Tubes Periodic Inspection Program Plan
NK30-PIP-31100-00001	Pickering Nuclear 5-8, Unit 5 Fuel Channel Pressure Tubes Periodic Inspection Program Plan
NK30-PIP-31100-00002	Pickering Nuclear 5-8. Unit 6 Fuel Channel Pressure Tubes Periodic Inspection Program Plan
NK30-PIP-31100-00003	Pickering Nuclear 5-8, Unit 7 Fuel Channel Pressure Tubes Periodic Inspection Program Plan
NK30-PIP-31100-00004	Pickering Nuclear 5-8, Unit 8 Fuel Channel Pressure Tubes Periodic Inspection Program Plan
NA44-CORR-00531-06621	Letter, G Jager to T.E. Schaubel, “Notification of Correction of Pickering ”A” Fuel Channel Periodic Inspection Program Plans, Attachment 1” December 23, 2010
N-REP-31100-10055	Report on Technical Basis for Fuel Channels Life Cycle Management Plan
N-PLAN-01060-10003	Reactor Components and Structures Life Cycle Management Plan
N-PLAN-01060-10008	Reactor Components and Structures Life Cycle Management Plan: Technical Basis Document
NA44-PIP-03641.2-00001	Pickering Nuclear Generating Station A Periodic Inspection Plan for Unit 1
NA44-PIP-03641.2-00007	Pickering Nuclear Generating Station A Periodic Inspection Plan for Unit 4
NK30-PIP-03641.2-00001	Pickering Nuclear Generating Station B Periodic Inspection Plan for Unit 5
NK30-PIP-03641.2-00002	Pickering Nuclear Generating Station B Periodic Inspection Plan for Unit 6
NK30-PIP-03641.2-00003	Pickering Nuclear Generating Station B Periodic Inspection Plan for Unit 7

Document	Title
NK30-PIP-03641.2-00004	Pickering Nuclear Generating Station B Periodic Inspection Plan for Unit 8
N-PLAN-01060-10004	Aging Management Plan for Containment Structures
NA44-PLAN-34220-00002	Life Cycle and Aging Management Program Plan for Fibreglass-Reinforced Plastic Components in the Pickering NGS Vacuum Building
NA44-PIP-03642.2-00001	Pickering Nuclear Generating Station A Periodic Inspection Program for Containment Components
P-PIP-03642.2-00001	Pickering Nuclear Generating Station A Periodic Inspection Program For Unit 0 Containment Components
NK30-PIP-03642.2-00001	Pickering Nuclear Generating Station B Periodic Inspection Program for Containment Components
NA44-PIP-03643.2-00001	Pickering Nuclear GSA – Reactor Building Periodic Inspection Program
NK30-PIP-03643.2-00001	Pickering Nuclear GSB – Reactor Building Periodic Inspection Program
NA44-PIP-03643.2-00002	Pickering Nuclear GS – PRD & VB Periodic Inspection Program
NA44-PIP-03643.2-00003	Pickering Nuclear GS – Vacuum Building Post Tensioning Rods Periodic Inspection Program
NA44-REP-34200-00017	Pickering NGS "A" Reactor Building and Pressure Relief Duct In-Service Leakage Rate Test Requirements in Accordance with CSA N287.7-08
NA44-REP-25100-00009	Pickering NGS Vacuum Building In-Service Leakage Rate Test Requirements in accordance with CSA N287.7-08
N-PROC-MA-0066	Administrative Requirements for In-Service Examination and testing for Concrete Containment Structures

2.7 Radiation Protection

Pickering NGS has an effective radiation protection program that meets or exceeds all applicable regulatory requirements and related objectives. The health and safety of persons is protected through the implementation of this program, which ensures that radiation doses are kept below regulatory dose limits and are optimized and maintained as low as reasonably achievable (ALARA).

For specific areas within this SCA, the following subsections describe the objectives, key results from the current licensing period, and planned improvements. These discussions also support that:

- Radiological impacts of plant operation to workers and the public will continue to be of acceptably low risk and adequately mitigated (e.g., Sections 2.7.1 to 2.7.3)

2.7.1 Radiation Protection Program

The Radiation Protection (RP) program is described in program document N-PROG-RA-0013, *Radiation Protection*. The objective of the RP Program at Pickering is to control occupational and public exposure to radiation.

For the purposes of controlling doses to workers, this program has four implementing objectives:

- Keeping individual doses below regulatory limits.
- Avoiding unplanned exposures.
- Keeping individual risk from lifetime radiation exposure to an acceptable level.
- Keeping collective doses As Low As Reasonably Achievable (ALARA), social and economic factors taken into account.

In terms of protecting the public, the RP program prevents the uncontrolled release of contamination or radioactive materials from the site by controls and monitoring of people and materials. The RP program includes a set of action levels to provide an alert before a regulatory dose limit is reached.

2.7.2 Application of ALARA

The *Radiation Protection* program, N-PROG-RA-0013, implements a series of standards and procedures for the conduct of activities within the nuclear station and with radioactive materials intended to keep radiation exposure to workers - As Low as Reasonably Achievable (ALARA).

The Pickering ALARA strategy identifies initiatives, actions and programs that support achieving these objectives. The strategy applies to all units at Pickering, whether operating, in outage or in safe storage. Equally, the strategy applies to all staff, contractors and visitors at Pickering. The strategy is updated annually to reflect the results of benchmarking, corrective action plans and industry best practices. Management of collective dose is implemented in N-STD-RA-0018, *Controlling Exposure as Low as Reasonably Achievable*.

Collective dose performance targets for Pickering are established annually by OPG. Annual targets take into account planned maintenance outage scope, past performance, and anticipated dose savings from planned initiatives and application of ALARA techniques. As work is planned in more detail, collective dose projections are reviewed and actions taken to ensure dose is ALARA. Actual performance against targets is reviewed and corrective actions taken where expectations are not met. Refer to Figure 9 for a historical summary of results over the current licence term.

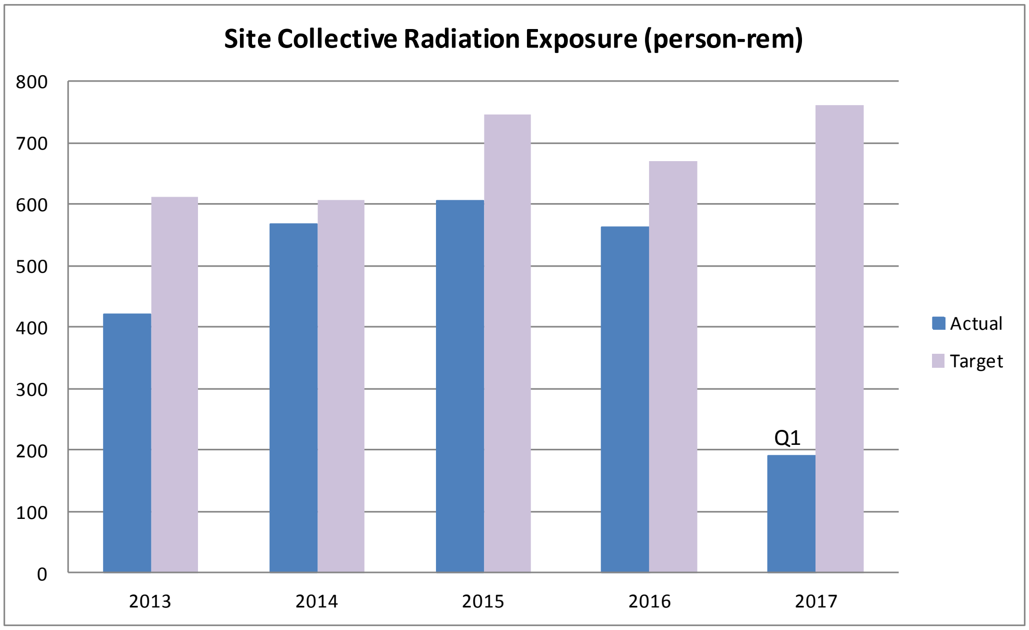


Figure 9 - Site Collective Radiation Exposure

Pickering has been successful with actual Collective Radiation Exposure (CRE) better than the targets, which was achieved through the implementation of increased line accountability for dose and improvements driven through lessons learned and OPEX. This is evidenced by continued dose performance improvement during major outage evolutions such as feeder inspections, fuel channel reconfigure, single fuel channel replacement, jigsaw installation and removal, and boiler primary side inspections.

Pickering ALARA strategy initiatives that contributed to improved dose performance include improved shielding and fine mesh heat transport filters to reduce dose rates from system equipment.

2.7.3 Worker Dose Control

Worker exposures are planned and managed to ensure doses are kept well below regulatory limits and to ensure unplanned exposures are avoided. Individual worker doses, including those for contractors and visitors, are managed to exposure control levels that are below administrative dose limits, which are in turn below the regulatory limits. This ensures individual risk from lifetime radiation exposure is kept to an acceptable level.

The worker dose control program at Pickering is managed through the assessment of hazards and maintaining knowledge of conditions in order to plan radioactive work using best practices.

During the current licence period from 2013 to date, there were no worker doses at Pickering which exceeded regulatory or OPG administrative dose limits.

Since 2013, there has been continued strong performance in the precursor indicators related to worker dose control such as the number of Electronic Personal Dosimeter (EPD) dose alarms and precursor-level tritium uptakes (see Figure 10 and Figure 11). These precursor indicators are the tracking of low level events used to identify and correct behaviours, or improve radiation work plans, thus preventing more significant events from occurring.

This level of performance is attributed to improved line accountability, planning tritium exposure, and focus on preventing alarms.

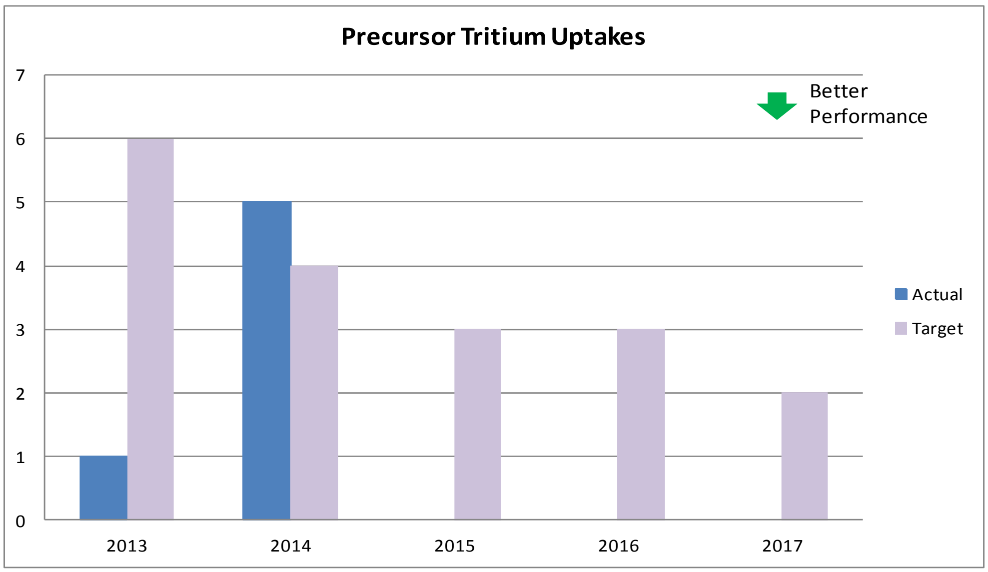


Figure 10 - Precursor Tritium Uptakes

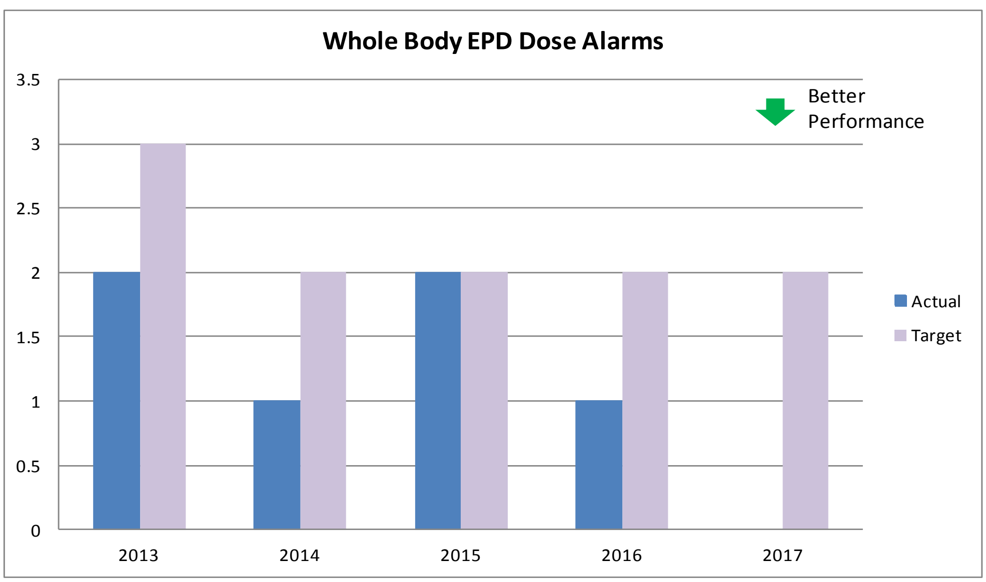


Figure 11 - Whole Body EPD Dose Alarms

A recent enhancement has been the implementation of individual dose goals for work executed in the field. These dose goals provide a platform for workers and supervisors to set challenging targets for their work each day (that are below the limits of their radiation exposure permit) and use comparison of their actual dose vs. target as an opportunity to identify and implement dose improvement initiatives.

Pickering's effective use of technology has been recognized as industry leading. Significant improvements have been made in the use of teledosimetry, remote on-line hazard monitoring and digital hazard display boards. Continuous monitoring of hazard levels and remote monitoring of worker dose reduce the risk of workers working in changing hazard conditions and ensure dose is kept ALARA.

2.7.4 Radiological Hazard Control

Radiological hazard surveys are performed using approved instruments on both a routine basis and prior to performance of radioactive work. Remote instrumentation is used to provide real-time hazard information to staff. Robotic equipment is used by Operations staff to reduce exposure during on-power entries, and allow for searches in areas previously inaccessible. In one case, robotic equipment was used to remove and contain active debris from a steam generator drain line with a high dose rate. The work was executed event free and within the dose target established for the job. This remote instrumentation and use of robotics has reduced exposure to staff.

Contamination control ensures that contamination is prevented from leaving the radiological controlled area, and the spread of contamination within this area is minimized.

The protected area (inside the inner security fence) of the station is divided into zones to facilitate contamination control. Boundaries of the zones are well marked and changes to the boundaries are approved by the Responsible Health Physicist. Workers moving through the radiological zones monitor themselves and material as required when crossing zone boundaries (depending on the direction of travel) and at other designated monitoring points. Loose surface contamination is not tolerated within the radiological zones except within established contamination control areas. Whole Body Contamination Monitor alarm setpoints have been reduced on exit and interzonal personnel contamination monitors. The lowered detection limit allows for continued improvements in detecting and monitoring for contamination.

Certain areas of the station are subject to high radiation fields as a result of normal reactor operation, irradiated fuel transfer, equipment operation or exposure of calibration sources. Accidental entry to these areas is prevented through the use of locked access points. When work is required in these areas, workers use procedures and physical controls to ensure the access hazards are not present or, if present, are strictly controlled.

2.7.5 Occupational Radiation Protection Action Levels

Section 6 of the *Radiation Protection Regulations* specifies requirements related to action levels and the timeline for notification when an action level has been reached. These action levels are precautionary levels, below the actual regulatory limits.

As required by the *General Nuclear Safety and Control Regulations,* the action levels for Pickering NGS are documented in N-REP-03420-10001, *Occupational Radiation Protection Action Levels for Power Reactor Operating Licences.*

2.7.6 Applicable OPG Documents

The following documents are the applicable OPG documents which support the licensing basis and are to be listed in the Licence Conditions Handbook.

Document	Title
N-PROG-RA-0013	Radiation Protection
N-STD-RA-0018	Controlling Exposure As Low As Reasonable Achievable
OPG-PROC-0132	Respiratory Protection
N-REP-03420-10001	Occupational Radiation Protection Action Levels for Power Reactor Operating Licences
N-PROC-RA-0019	Dose Limits and Exposure Control

2.8 Conventional Health and Safety

Pickering NGS has an effective Conventional health and safety program that meets or exceeds all applicable regulatory requirements and related objectives. Conventional health and safety work practices and conditions at the station result in a high degree of personnel safety.

The following describes the objectives, key results from the current licensing period, and planned improvements in this area. These discussions also support that:

- Worker safety is taken seriously at Pickering NGS and plant personnel are protected from conventional hazards such that the associated risk is low.

2.8.1 Conventional Health and Safety Program

The foundation of OPG's Health and Safety Management System is the *Employee Health and Safety Policy,* OPG-POL-0001, which describes the approach and commitments to conventional health and safety for the organization, and the requirements and accountabilities of all employees. OPG is committed to preventing workplace injuries and to continuously improve employee health and safety performance.

OPG's *Health and Safety Management System Program*, OPG-PROG-0010 puts the Health and Safety Policy into action. The Health and Safety Management System program and supporting governing documents establish process requirements that protect employees by ensuring they are working safely in a healthy and injury-free workplace. It also outlines the responsibilities of various levels in the organization to ensure activities are performed to meet the requirements of OPG's Health and Safety Policy.

During the current licensing period, Pickering NGS has demonstrated strong safety performance throughout its operations.

In 2014, Pickering NGS reached 11 million hours without a lost time accident with an All Injury Rate of 0.22 which represented the best performance achieved for the station.

In November 2016, OPG received the Canadian Electricity Association President's Gold Award of Excellence for Employee Safety in recognition of the company-wide All Injury Rate and Accident Severity Rate performance for 2013, 2014 and 2015.

All Injury Rate

As shown in Figure 12, Pickering NGS All Injury Rate performance was better than target from 2013 through 2015. For 2016, an executive leadership decision was made to challenge the organization's All Injury Rate targets and accelerate the drive towards zero injuries. While the new target has been challenging to the organization, it has driven a sharper focus on low level safety events and injury prevention. The current rate for 2017 is zero.

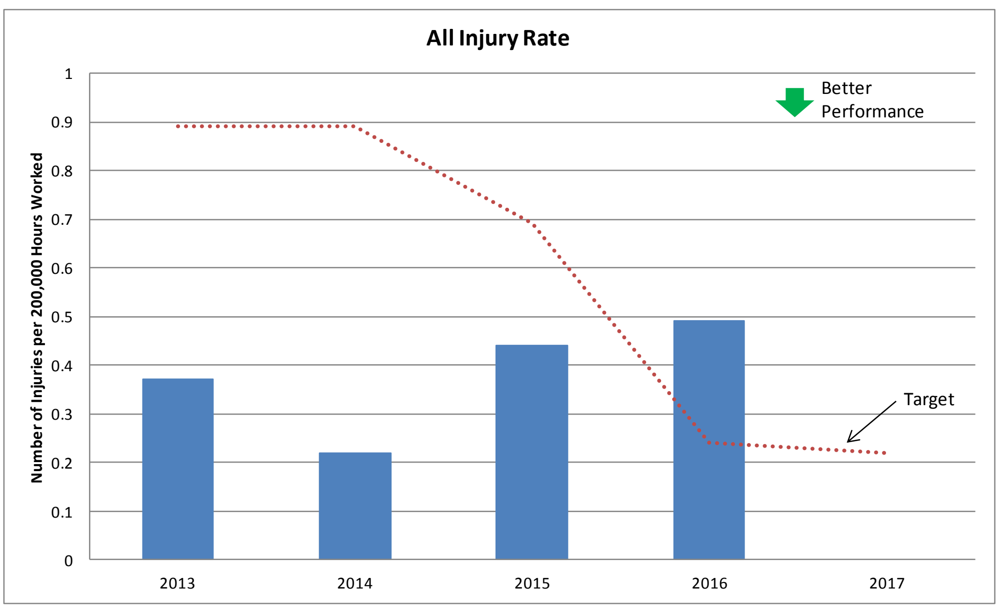


Figure 12 - Pickering All Injury Rate vs. Target

Accident Severity Rate

Pickering's Accident Severity Rate performance over the current licensing period was very good overall. However, in 2016, a slip and fall injury in a change room resulted in 120 days of lost time, which dramatically impacted Pickering's Accident Severity Rate. The incident was reviewed and lessons learned were reinforced.

Safety Enhancements

A number of health and safety enhancements have been made to the program, equipment and systems at Pickering NGS, during the current licensing period.

OPG has implemented an "iCare" safety culture initiative aimed at elevating worker safety culture where employees are self-motivated to work safely. Following established rules and procedures forms the foundation for the OPG health and safety programs, however, following rules is not enough to achieve the goal of zero injuries. OPG introduced the concept of "iCare Enough to Act for Safety" because all employees must care enough to act to protect themselves and each other. OPG cares that all employees get home safely to their families at the end of each day.

Some further safety enhancement initiatives include:

- Implementation of a Total Health initiative aimed at fostering a stronger employee health culture with a focus on enhanced support and mental health training. This initiative supports employees and their families in their efforts to achieve an optimal level of health and functioning, primarily through health education, health promotion, disease and injury prevention, and crisis intervention. Some examples include implementation of a mental health training program for people leaders, mental health stigma awareness campaign, access to confidential personal health assessments, and Employee Family Assistance Program resource awareness.
- Focused campaigns aimed at heightening and improving situational awareness in order to improve employee ability to recognize hazards by anticipating them, looking out for changing conditions in the work environment and taking action. This includes injury prevention for non-routine activities and even routine activities such as walking.

2.8.2 Applicable OPG Documents

The following documents are the applicable OPG documents which support the licensing basis and are to be listed in the Licence Conditions Handbook.

Document	Title
OPG-POL-0001	Employee Health and Safety Policy
OPG-PROG-0010	Health and Safety Management system Program
N-PROG-MA-0015	Work Protection

Document	Title
OPG-PROC-0132	Respiratory Protection
N-PROG-RA-0012	Fire Protection
P-LIST-71400-00001	Application of CSA N293-07 to Structures, and Components for Pickering Nuclear

2.9 Environmental Protection

Pickering NGS has an effective environmental protection program that meets or exceeds all applicable regulatory requirements and related objectives. All reasonable precautions are taken to ensure that adequate provisions for the protection of the environment are maintained.

For specific areas within this SCA, the following subsections describe the objectives, key results from the current licensing period, and planned improvements over the next licensing period. These discussions also support that:

- Impacts of plant operation to the environment and the public will continue to be of low risk and adequately mitigated (e.g., Sections 2.9.1, 2.9.3, and 2.9.7).

- Transparency and appropriate public consultations have been upheld and will continue (e.g., Section 2.9.1 regarding community engagement and Section 2.9.3 regarding external posting of effluent monitoring results).

- OPG continues to invest in Pickering to support environmental protection (e.g., Sections 2.9.4 and 2.9.7).

2.9.1 Environmental Policy

OPG's *Environmental Policy*, OPG-POL-0021, provides direction related to environmental performance and environmental management. This policy is approved by the OPG Board of Directors. It ensures that:

- OPG establishes an environmental management system registered to the ISO 14001 Environmental Management System standard;
- Adverse effects on the environment are prevented and mitigated with a long-term objective of continuous improvement in OPG's environmental management system and its environmental performance; and
- The Pickering site is managed in a manner that strives to maintain, or enhance where it makes business sense, significant natural areas and associated species of concern. This is achieved through the work with community partners to support regional ecosystems and biodiversity through science-based habitat

stewardship and by taking reasonable steps to manage any residual impact to these areas and species.

2.9.2 Environmental Management System (ISO 14001)

The OPG *Environmental Management* program, as documented in N-PROG-OP-0006, maintains an environmental management program consistent with the International Organization for Standardization (ISO) 14001 *Environmental Management System*.

OPG's environmental management program requires assessment of environmental risks associated with station activities, and to ensure that these activities are conducted such that any adverse impact on the natural environment is As Low as Reasonably Achievable (ALARA). This program includes OPG's approach to ensure compliance with applicable statutory and regulatory requirements.

The Environmental Management System (EMS) provides the structure and processes to ensure implementation and follow-up on management programs needed to deliver the environmental policy are achieved. As part of OPG's EMS, environmental performance targets and environmental compliance are reviewed annually to ensure that opportunities for continuous improvement are identified and implemented.

Annual internal environmental compliance audits are conducted, including components of the ISO 14001 EMS. Adverse conditions or opportunities for improvements are addressed following OPG's corrective action program.

2.9.3 Protecting the Public

Assessment and Monitoring

The monitoring program at Pickering is designed in accordance with CSA N288.5-11, *Effluent Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills*. This monitoring program ensures that releases are ALARA and are within regulatory limits.

OPG provides the results of the Effluent Monitoring Program to the CNSC annually, and these results are also available to the public on the OPG website at www.opg.com.

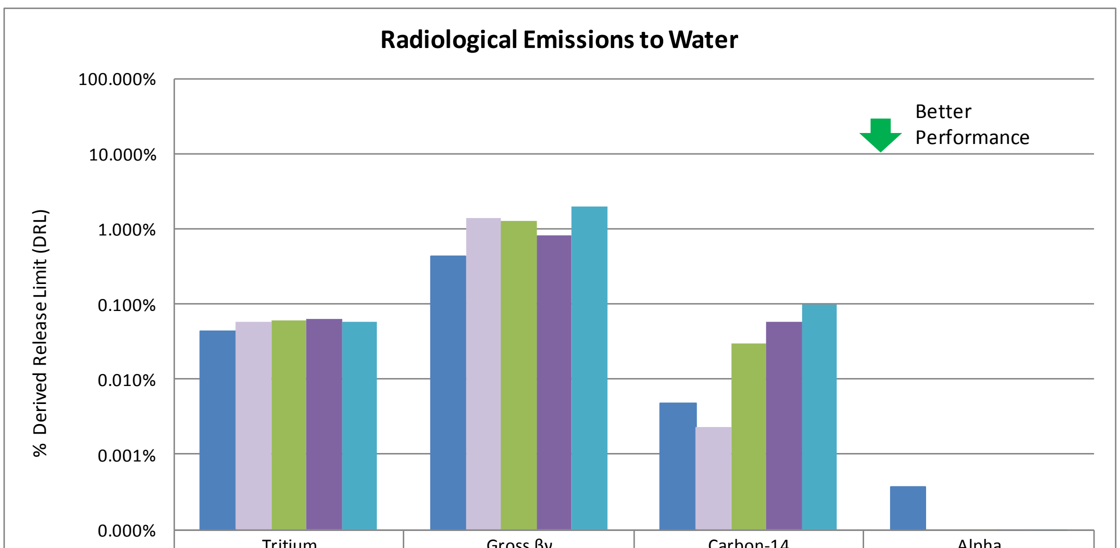
OPG began publishing quarterly environmental emissions data reports on OPG's external web-site in 2014, in response to questions asked in the 2013 Pickering licence renewal hearings. The reports include data related to radiological emissions to air and water, waste management facility monitoring results, and spills to the environment that are reportable to a regulatory authority.

Radiological Emissions to Water

During the current licence period, there were no Derived Release Limit (DRL) or action level exceedances for Tritium, Beta/Gamma, Carbon-14 or Alpha emissions to water on an annual basis. See Figure 13 for a historical summary. The DRL's were revised in 2013 which changed the historical values; therefore data are included as a percentage of the DRL before and after the revision.

Also from Figure 13, elevated waterborne Carbon-14 is a reflection of a larger amount of Spent Resin Storage Tank (SRST) water being sent and processed by Common Services (CS). This varies from year to year. CS received SRST water in January 2015 and in January/February 2016 for discharge via active liquid waste, which accounts for the higher Carbon-14 concentrations and corresponding loadings. Waterborne Carbon-14 still remains well below 1% of the DRL.

There was one reported monthly action level exceedance on Pickering 5-8 for Beta/Gamma to water in February 2016 from a routine sample. The elevated beta activity was detected in the reactor building service water from entrained lake sediment.



	Tritium	Gross βγ	Carbon-14	Alpha
Pre-Apr 2013	0.04%	0.43%	0.0047%	0.00037%
Post-Apr 2013	0.06%	1.38%	0.0023%	0.00005%
2014	0.06%	1.27%	0.0305%	0.00001%
2015	0.06%	0.82%	0.0581%	0.00002%
2016	0.06%	2.04%	0.0985%	0.00001%

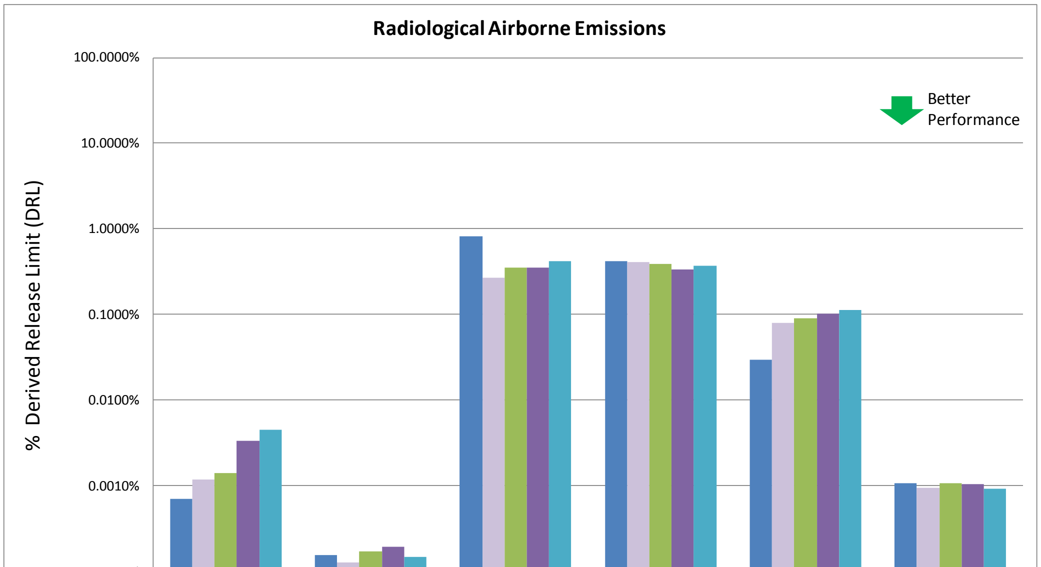
Figure 13 - Radiological Emissions to Water

Radiological Emissions to Air

During the current licensing period, Pickering Nuclear has not exceeded the Derived Release Limit (DRL) or the Action Level for any radiological emission to air on an annual basis. Details of the emissions can be found in Figure 14 - Radiological Airborne Emissions; as shown, emissions have been well below the licence limit.

Increased 2016 tritium emission values can be attributed mainly to an increase in airborne tritium releases which were as a result of tritiated water in the 056 fuel transfer conveyor tunnel, and overall dryer reliability. Actions were completed to reduce tritium emissions back to baseline values through the installation of portable dryers. A dedicated investigation team has determined the root cause of the tritiated water in the 056 fuel transfer conveyor tunnel was the construction joint seals in the floor of the Unit 5 moderator room. All of the identified degradations at the construction joints were repaired and additional sealant was applied. Post-maintenance testing confirmed the successful completion of the repairs.

A dryer reliability team is in place to improve vapour recovery equipment reliability and operating performance, to help further reduce tritium emissions.



	Particulate	Iodine	Tritium	Noble Gases	Carbon-14	Gross Alpha
Pre-April 2013	0.0007%	0.00016%	0.82%	0.42%	0.03%	0.0011%
Post-April 2013	0.0012%	0.00013%	0.27%	0.41%	0.08%	0.0010%
2014	0.0014%	0.00017%	0.35%	0.39%	0.09%	0.0011%
2015	0.0034%	0.00019%	0.35%	0.34%	0.10%	0.0010%
2016	0.0045%	0.00015%	0.43%	0.37%	0.11%	0.0009%

Figure 14 - Radiological Airborne Emissions

Conventional Emissions

Standby Generators and Emergency Power Generators are standby safety support systems designed to provide electrical power to critical nuclear systems in the event of a loss of normal supplies. As with any standby safety support system, routine testing is a regulatory requirement to confirm availability. Routine and non-routine testing of these generators results in the release of small quantities of carbon dioxide (CO_2), nitrogen oxides (NO_X), and sulphur dioxide (SO_2).

Pickering Nuclear uses some Ozone Depleting Substances (ODS) such as HydroChloroFluoroCarbons (HCFCs) and ChloroFluoroCarbons (CFCs), in water coolers, air conditioning systems and refrigerators. In accordance with continuous improvement efforts ODS emissions have been decreasing due to the installation of high efficiency purge units on the larger chillers in conjunction with post maintenance helium leak checks. In addition, Pickering 5-8 has installed and now operates R-123 containing chillers, replacing older R-11 (CFC) units. ODS emissions remain low, but variable.

The National Pollutant Release Inventory (NPRI) is an Environment Canada initiative, which provides public access to information regarding releases of specific chemicals from industrial sources. Pickering Nuclear's NPRI report includes hydrazine, nitrogen oxides (NO_X), particulate matter, and sulphuric acid.

The Ministry of the Environment and Climate Change (MOECC) regulates the use of the following chemicals which are used at Pickering NGS:

- Sodium hypochlorite is used to control zebra/quagga mussel infestation in piping systems at the station. Sodium hypochlorite is neutralized before release to the environment.
- Sodium hydroxide is used at the Water Treatment Plant (WTP). Sodium hydroxide is neutralized before release to the environment.
- Sodium metabisulphite is used to neutralize residual chlorine generated from sodium hypochlorite used to control zebra/quagga mussel infestation in piping systems at the station. Sodium metabisulphite is neutralized before release to the environment.
- Sulphuric acid is used at the WTP for regeneration of resin and neutralization. Sulphuric acid is neutralized before release to the environment.
- Ammonia and Morpholine are used as pH control.
- Hydrazine is used as an oxygen scavenger.

Pickering Nuclear controls and monitors certain waterborne discharge streams under the Municipal Industrial Strategy for Abatement (MISA) regulations, O. Reg. 215/95. The monitored discharge streams are the water treatment plant, radioactive liquid waste management system, and the inactive drainage system. Pickering Nuclear issues MISA quarterly reports to the Ministry of the Environment and Climate Change (MOECC).

All effluent streams that are monitored under O. Reg. 215/95 were discharged to the environment via approved pathways and were in compliance during the current licence period.

Groundwater Monitoring Program

The Pickering Nuclear groundwater monitoring program was established to confirm the predominant on-site groundwater flow characteristics of the Pickering Nuclear site. Monitoring is designed to detect changes to on-site groundwater quality to ensure timely detection of any inadvertent releases of nuclear and hazardous substances to groundwater. The overall objective of the program is to ensure no adverse off-site impacts from contaminants in groundwater.

In 2016, groundwater samples from 140 sampling points were collected. Collected samples were mainly analyzed for tritium, but several locations were also analyzed for petroleum hydrocarbons (PHCs), benzene, toluene, ethylbenzene, xylenes (collectively referred to as "BTEX"), and volatile organic compounds (VOCs).

Sampling points included monitoring wells, foundation drains, sumps, catch basins, and ground tubes. Based on the collected data, tritium concentrations at site-perimeter locations of Pickering Nuclear remain low and indicate that there were no adverse off-site trends. Tritium concentrations in groundwater at the Unit 1 Reactor Building area have declined substantially since 2012 as a result of corrective actions completed to mitigate the source of tritium from the foundation drainage sump.

As part of Pickering's annual groundwater monitoring program, data are collected from the site-perimeter monitoring wells and analysed statistically to identify any trends. The term "low" is descriptive and used in a qualitative fashion because there is no tritium in groundwater limits. In addition, a previous study indicated that the upper limit of expected tritium concentrations from atmospheric deposition for areas within the immediate influence of the station is 3.7×10^4 Bq/L. The concentrations at the site-perimeter locations are significantly lower than this value, as would be expected.

A source of tritium in the Unit 5 to 8 Reactor Building (RB) areas was attributed to historic releases from the RB foundation drainage sumps due to the failure of non-return valves. Pickering NGS has preventive maintenance scheduled to clean or replace the Unit 5 to 8 non-return valves.

In 2016, elevated tritium concentrations in the groundwater were identified in the vicinity of the Unit 5 and 6 RBs and a comprehensive investigation was initiated which determined the source to be the Unit 5 moderator room floor slab construction joint seals, as discussed previously. The increase in tritium concentration is due to leakage from the Unit 5 moderator sump through the floor slab joints and repairs have been completed.

Based on the groundwater migration pathway, tritium in groundwater identified in the vicinity of U5 and U6 reactor building is migrating northwards to the Inactive Drain (IAD) sumps. The combined discharge from the IAD sumps is sampled each shift and sample results are within the normal range. The monitoring of Unit 5 to 8 RB foundation drains and the RB foundation drainage sumps will continue in this area.

In this licence period (2013 - 2016) elevated tritium concentrations in groundwater were observed at the Pickering 5-8 Irradiated Fuel Bay area, with a maximum tritium concentration of 3.96×10^6 Bq/L in 2013 with a downward trend at the end of 2016. In 2013, OPG had initiated a project to repair the Pickering 5-8 Irradiated Fuel Bay liner and its collection sumps, which is expected to reduce the potential for the bay water to negatively impact site groundwater quality. The liner repair tooling has been fabricated, tested and delivered and field repair as well as sump repair is expected to be completed by the end of 2017. Surveillance will continue to track the movement of tritium in groundwater in this area. It should be noted that this level of tritium in groundwater has no adverse environmental impact.

2.9.4 Spill Management Program

Pickering NGS has extensive programs to ensure the risk of spills to the environment is effectively assessed and managed.

Any spill that causes or is likely to cause an adverse effect must be reported to the Ontario Ministry of the Environment and Climate Change (MOECC). Within OPG, reportable spills to the MOECC have been classified as Category A (major), Category B (moderate) and Category C (minor) depending on criteria such as environmental impact and quantity of substance released.

From 2013-2017, there were no Category A or Category B spills and 12 Category C spills at Pickering Nuclear. The Category C spills are listed below. The number of Category C spills has been declining at Pickering Nuclear since 2004; this improvement is attributed to improved environmental awareness and to more stringent spill control practices.

2013 1) 4 L of ethylene glycol from an air conditioning unit

2) 50 L of sodium hypochlorite solution from an underground pipe

3) 536 L of generator seal oil from a heat exchanger

2014 4) 30 L of hydraulic fluid from a pump

5) 200 L of sewage – overflow

6) 19 L of FRF (fire resistant fluid) from the turbine govenor system

7) 10 L of oil from a transformer temporary dike

8) 100 L of sewage from a leak in a line

2015 9) 100 L of sewage – overflow

10) 50 L of sewage – overflow

2016 11) 8 L of oil from a compressor

2017 12) 50 L of lube oil – spilled on the floor

The following spill mitigation initiatives have been completed driven by OPG's adherence to continuous improvement:

- Replaced all 4 sodium bisulphite solution storage tanks with one double walled stainless steel tank on Pickering 058. (Completed November 2016)
- All of the Pickering 058 seal oil drain lines to the local water tundish have been cut and capped in order to remove any flow path from the seal oil heat exchangers to the environment. (Completed December 2014)
- Installation of underflow weir system to the existing spill containment surrounding the Main Output Transformers located on all 4 units of Pickering Units 058. (Completed December 2016).
- Upgraded spill containment in the new Water Treatment Plant Chemical Addition Area. (Completed April 2014)

Planned Improvements

- A permanent concrete dike will be installed around the overflow tank associated with the Emergency Coolant Injection system, which will reduce the risk of spills to the environment. The scheduled project completion date is December 2017.
- The 012 sewage sump pumps are being replaced with more robust grinder style pumps for improved availability. An additional level switch will also be installed to prevent sump overflows. The scheduled project completion date is September 2017.

2.9.5 Environmental Monitoring Program

OPG maintains an Environmental Monitoring Program (EMP) in the vicinity of Pickering Nuclear in accordance with operating licence requirements. The EMP complies with the standard CSA N288.4-10, *Environmental Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills*. The program scope encompasses protection of both the public and the environment from nuclear substances, hazardous substances, and physical stressors resulting from the operation of Pickering Nuclear, including on-site waste management facilities.

Results of the Pickering Nuclear EMP are reported annually and made available on www.opg.com.

Additionally, environmental sampling and analyses for the EMPs support the calculation of annual dose to the public resulting from operation of Pickering Nuclear. The EMP routinely measures radionuclides in environmental media such as air, water, and food products. Radioactivity in the environment is measured near Pickering as well as at provincial background locations. Measured data are used together with station emissions data to determine the dose received by members of the public, known as potential critical groups. The highest estimated potential critical group dose establishes the official public dose for the site.

During the current licensing period the dose to the public has always been less than 0.2 % of the annual legal limit of 1000 μSv. The public dose for 2016 was 1.5 μSv and was assigned to the "Urban Resident (Adult)" group, as shown in Figure 15.

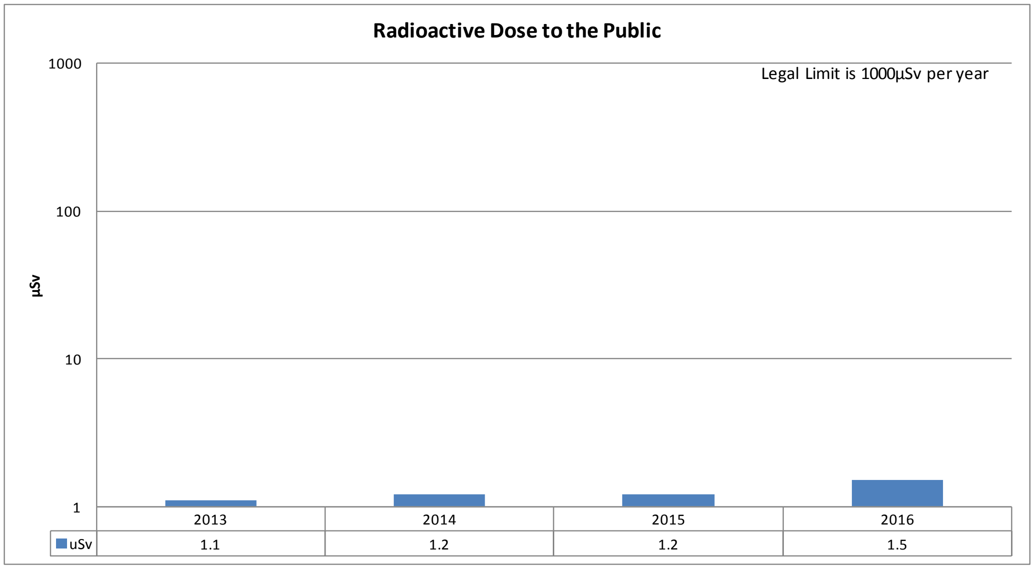


Figure 15 - Radioactive Dose to the Public

As shown in Figure 16, the radiation dose to the public resulting from the operation of the Pickering Nuclear Generating Station is a very small fraction of the estimated annual average natural background radiation dose around the station.

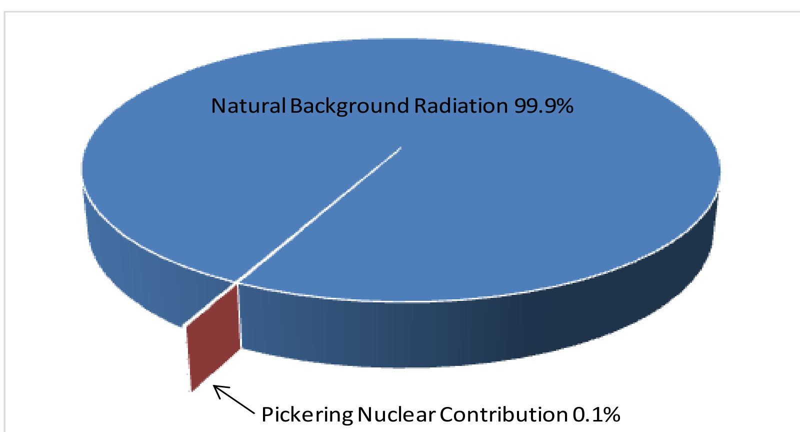


Figure 16 - Radioactive Dose Relative to Natural Background Radiation

2.9.6 Regulatory Compliance

Pickering operates under numerous environmental regulations governing plant operations. The primary regulators from an environmental perspective are the CNSC and the Ontario Ministry of Environment and Climate Change (MOECC).

During the period 2013 to 2017 there were no major infractions of environmental regulations.

Pickering Nuclear had a total of 23 other infractions over the period of 2013 – 2017 year to date (~5 year period), decreasing to only 1 infraction in 2016 and none to-date in 2017. Table 6 contains the details of these infractions.

During the period of 2013 to 2017 Pickering Nuclear had ten occurrences of exceeding the Environmental Compliance Approval (ECA) delta temperature limit. The number of events has declined each year starting in 2015, this improvement is attributed to equipment improvements and improved awareness.

	Infraction
2013	Station discharge ΔT exceeded C of A Limits (four infractions)
	Unapproved discharge to Pickering Sewer per the Durham Sewage By-Law
	Waste storage timeline exceeded
2014	Unapproved discharge to Pickering Sewer per the Durham Sewage By-Law
	Station discharge ΔT exceeded C of A Limit (five infractions)
	Upgrades to Water Treatment Plant without ECA amendment
	Exceeded allowable annual un-monitoring limit for C14 (2 infractions)
2015	Station discharge ΔT exceeded C of A Limit
	MISA Report data missing
	Contravention of both Ontario Endangered Species Act and Migratory Bird Convention Act
	Fish impingement event
	ECA Semi-Annual sample missed
	Public complaint of Noise or Odour
	Waste non-compliance due to refrigerant storage timeline
2016	CNSC Monthly Action Limit exceeded for beta gamma activity
2017	No infractions to date

Table 6 - Environmental Infractions for the Period 2013-2017

2.9.7 Fish Impingement and Entrainment

Impingement and entrainment of fish within the Pickering Nuclear Generating Station occurs from the use of lake water for condenser cooling water. A Fish Diversion System (FDS) as shown in Figure 17, is used to mitigate impingement and has been demonstrated to reduce fish losses by more than 80%.

Typically the FDS is installed in the spring, around April, and removed at the end of November each year before significant lake ice build up. During the deployment of the FDS, there is ongoing maintenance to remove algae and zebra mussels as well as complete minor repairs to the net.

A new net was installed in the FDS for the 2017 season. OPG continues to ensure fish impingement is maintained at levels consistent with CNSC targets.

Figure 17 - Fish Diversion System

During the off season, the net is inspected and repaired as necessary at its storage facility and made ready for the following year's deployment.

Monitoring of fish impinged is conducted weekly throughout the year. Fish from the screen house are collected in bins and specially trained staff identify the fish species, count them and measure representative samples of fish. The estimated biomass of impinged fish is reported annually to the CNSC. The annual reports demonstrate that the CNSC impingement target reduction has been achieved.

The FDS is not designed to prevent entrainment. Entrainment occurs when very small fish eggs and early life stages (less than 4.7mm) pass through the travelling screens and are subsequently carried through the condenser cooling water system.

OPG has proposed three offsetting measures to counterbalance losses such that a net benefit in fisheries productivity is achieved. Two of the offsetting measures are habitat creation projects; the first is in the Big Island Wetland located in the Bay of Quinte and has already been created, and the second is to be constructed in the Simcoe Point Wetland near the outlet of Duffins Creek. The third offset is associated with OPG's stocking contribution for the Lake Ontario Atlantic Salmon Program. OPG is the lead sponsor from 2016 to 2020.

The reduction of impingement and entrainment continues to be verified through a monitoring program.

2.9.8 Thermal Plume

In 2017, OPG evaluated the lake water temperature from the thermal plume at Pickering NGS and reference sites from 2009-2010, 2010-2011 and 2011-2012 using a revised impact assessment model to predict hatch date and survival of Round Whitefish embryos. The estimated survival loss at the plume stations compared to the reference stations, were all below the survival loss of 10%, the threshold for no-effect level for round whitefish embryo survival. The average water temperature during the spawning and egg incubation period for all plume stations and each individual station in 2009-2010, 2010-2011 and 2011-2012 were below the threshold effect level of 6^0C in each year. Therefore, the thermal plume from Pickering NGS is not having an adverse effect on Round Whitefish embryo survival.

2.9.9 Environmental Risk Assessment

OPG has completed an updated Environmental Risk Assessment (ERA) for Pickering Nuclear (PN), focused on the years 2011 to 2015. The assessment meets the requirements of Canadian Standards Association (CSA) N288.6-12, *Environmental Risk Assessments at Class I Nuclear Facilities and Uranium Mines and Mills*. The ERA includes a Human Health Risk Assessment (HHRA), and an Ecological Risk Assessment (EcoRA), for radiological and non-radiological contaminants and physical stressors. The ERA evaluated the risk to relevant human and ecological receptors from exposure to contaminants and physical stressors related to Pickering and its activities; and as warranted, recommended further monitoring or assessment based on the results of the ERA. The ERA report P-REP-07701-00001, *Environmental Risk Assessment for Pickering Nuclear* was submitted to the CNSC (Reference 15).

Human Health Risk Assessment (HHRA)

Predicted exposures to PN emission sources were evaluated on the basis of potential toxicological effects from non-carcinogenic Contaminants of Potential Concern (COPCs), cancer risk from carcinogens, and radiation exposure from radionuclides. Human receptors evaluated include off-site members of the public, specifically those critical groups used for dose calculations in the annual OPG EMP reports within approximately 20 km of the PN site. Measured and modeled concentrations of COPCs were evaluated against screening benchmarks that are protective of human health. Radiological stressors were carried forward to Tier 2 because of the public interest in these emissions.

Non-radiological HHRA**:** The complete exposure pathways assessed in the non-radiological HHRA included inhalation (hydrazine) for all six human receptor groups; water ingestion (hydrazine and morpholine) for the Urban Resident, Correctional Institution, and Industrial/Commercial Worker; and game fish ingestion (hydrazine and morpholine) for the Sport Fisher.

- No increased risk to human receptors is expected from exposure to morpholine.
- No risks to the urban resident, correctional institution resident and industrial/commercial worker are expected due to exposure to modeled hydrazine in drinking water at the Ajax Water Supply Plant.
- No risks to the sport fisher are expected from fish ingestion based on mean modeled hydrazine in fish tissue.
- The estimated risks to all human receptors from inhalation of hydrazine are below the cancer risk target.

Radiological HHRA: The annual dose to the critical group (the urban resident adult) during this five-year period ranged from 0.9 to 1.2 µSv, approximately 0.1% of the regulatory public dose limit of 1 mSv/a. The sport fisher may receive a maximum dose up to 0.14 µSv/a from exposure to the Pickering Waste Management Facility (PWMF) (Phase I and Phase II) at full capacity; a small fraction of the regulatory public dose limit. Since the critical groups that receive the highest dose from Pickering are protected, other receptor groups near Pickering NGS are also protected.

Ecological Risk Assessment (EcoRA)

The assessment for the EcoRA focused on the near shore Lake Ontario (generally in the area surrounding the Pickering NGS outfalls), the Pickering site, and Frenchman's Bay. Valued Ecosystem Components (VECs) were selected for dose and risk analysis because they are known to exist on-site, and/or are representative of major taxonomic/ecological groups, major pathways of exposure, or have a special importance or value. Protection of VECs implies that other species in the same VEC category are also protected. Threatened and endangered species identified within the PN Terrestrial Site Study Area during the 2011 to 2015 time period, including the Barn Swallow, Least Bittern, Butternut, and American Eel, were assigned a representative species already selected for the EcoRA.

Non-radiological EcoRA: The potential for ecological effects was assessed by comparing exposure levels to toxicological benchmarks, and characterized quantitatively in terms of Hazard Quotients (HQ). A HQ greater than 1 indicates a need to more closely assess the risk to the concerned VEC whereas a HQ less than 1 indicates little likelihood of an adverse effect.

Maximum measured concentrations of COPCs did not exceed their respective benchmarks for the ecological receptors evaluated near the PN outfall, with the exception of measured maximum copper surface water concentrations near the PN outfall that exceeded fish and benthic invertebrate benchmarks. However, mean copper concentrations in water were acceptable. Since fish are mobile, exposure to the mean concentration is more likely. Overall, the risk to fish at the outfall is low, and fish are not expected to experience any significant adverse effects due to non-radiological releases from PN operations.

Regarding the results of the ecological risk assessment to ecological receptors at Frenchman's Bay, the EcoRA evaluated the contribution from PN to the overall risk, and concluded that PN operations contribute a small proportion of the overall risk to aquatic receptors at Frenchman's Bay. The percent contribution from PN ranges from 0.3% to 22% of the total risk for all contaminants of potential concern.

The soil sampling program focused on areas of previously identified contamination and emphasized areas identified as potential habitat. Soils that exceed benchmark concentrations are associated with past industrial activities on site, rather than deposition from ongoing sources. HQs were not exceeded for mammals or birds exposed to average concentrations in soil, therefore, adverse effects are not expected. Although HQs were exceeded for earthworms and terrestrial plants in areas of past industrial activity, the earthworm community and terrestrial plant populations on the site as a whole, would not be significantly affected. Species at risk were also assessed and confirmed to not be at risk from PN operations.

Radiological EcoRA

At the outfall there were no exceedances of the radiation dose benchmarks for aquatic biota including fish, benthic invertebrates, and Ring-billed Gull. There were no exceedances of the radiation dose benchmarks for any aquatic receptors at Frenchman's Bay, and no exceedances of the radiation dose benchmark for terrestrial biota on the PN site. Similarly there were no radiation dose levels that approached the radiation benchmark for terrestrial biota associated with the Pickering Waste Management Facility.

Overall, these studies confirm the PN site is continuing to operate in a manner that is protective of human and ecological receptors residing in the surrounding area.

2.9.10 Predictive Effects Assessment

OPG undertook a Predictive Effects Assessment (PEA) to evaluate the potential for adverse effects to human health and the environment from the activities associated with transitioning the station from end of commercial operation to a Safe Storage with Surveillance state. The PEA encompasses both the Stabilization Phase and the Safe Storage with Surveillance Phase. The PEA report, P-REP-07701-00002, *Predictive Effects Assessment for Pickering Nuclear Safe Storage* was submitted to the CNSC (Reference 15).

Overall, the change from power generation to the Stabilization and Safe Storage with Surveillance Phases will result in reductions in emissions from the Pickering NGS. Noise, atmospheric emission, waterborne emissions and thermal discharges will all be reduced as Pickering moves from the current operational condition to a safe storage state.

Human Health Risk Assessment (HHRA)

The human health risk assessment evaluated potential radiological impacts to receptors that include: farm and dairy farm use; urban residents; area industrial/commercial occupants; a potential future industrial/commercial worker at the current Engineering Services Buildings (i.e., a new tenant); and a sport fisher (i.e., a person assumed to be fishing south of the Pickering Nuclear Generating Station). The exposure duration, exposure factors and calculations are the same as those used in the Pickering Nuclear Environmental Risk Assessment. The dose was updated based on conservative assumptions and the modelled surface water and airborne concentrations. All other exposures were considered to be bounded by the Pickering Nuclear Environmental Risk Assessment. The maximum predicted dose was estimated to be 0.002 mSv/a to a future industrial/commercial worker (i.e., a new tenant of the Engineering Services Buildings).

The public dose estimates for the human receptors for the Safe Storage with Surveillance Phase are approximately 0.2% of the regulatory public dose limit of 1 mSv/a and approximately 0.15% of the dose from Canadian background radiation. Since the dose estimates are a small fraction of the public dose limit and natural background exposure, no discernible health effects are anticipated due to exposure of potential groups to radioactive releases from Pickering Nuclear during the Safe Storage with Surveillance Phase.

Ecological Risk Assessment (EcoRA)

For the EcoRA, exposure points at receptor locations were estimated based on the Tier 1 assessment. The receptor locations of interest were the Pickering Nuclear outfall (nearshore Lake Ontario), forebay, and Frenchman's Bay. Receptors, exposure, dose and risk estimation calculations were based on the work completed in the Pickering Nuclear Environmental Risk Assessment.

Given the reduced flows into the station and assumed removal of the Fish Diversion System, the potential forebay habitat was evaluated based on the Safe Storage with Surveillance Phase assumptions. Potential impacts within the forebay were assessed for exposure to tritium, carbon-14 and cobalt-60 for radionuclides. There were no potential adverse effects identified.

Thermal effects were also evaluated as part of the Predictive Effects Assessment. In general, the lake near the discharge will be returned to a thermal condition that is more normal for the nearshore zone of Lake Ontario.

Entrainment and impingement effects were evaluated as part of the Predictive Effects Assessment. Impingement and Entrainment cease to be a concern at the low flow rates anticipated during the Safe Storage with Surveillance Phase, once the condenser cooling water pumps are not required.

No interactions were identified that are predicted to pose an unacceptable risk to humans or the environment during the Stabilization and Safe Storage with Surveillance activities proposed. Therefore, no new mitigation is required based on the conclusions of the Predictive Effects Assessment. During both the Stabilization and Safe Storage with Surveillance Phases, OPG's environmental programs will be maintained, and updated as needed. Emission control measures and discharge limits are specified within specific permits. These permits and in-design mitigation measures will remain in place until such a time that it can be demonstrated, in discussion with the regulator as applicable, that they are no longer required.

Planning the work to define the safe storage end states of the station systems is ongoing, and waterborne emissions and cooling water flows in the Safe Storage with Surveillance Phase will be reviewed as final configurations are determined. If the surface water assumptions and the environmental interactions are substantially different than those indicated in the PEA, a reassessment of the environmental risk would be carried out and mitigation identified as required. The outcome of the review will be documented in a future Environmental Risk Assessment.

The PEA concludes that there are no predicted potential adverse effects from the Stabilization and Safe Storage with Surveillance activities proposed.

2.9.11 Biodiversity and Wildlife Habitat Council

Pickering Nuclear has a Biodiversity and Natural Areas Management Program to protect, maintain and enhance the natural environment, species and wildlife habitat on, and in the vicinity of, the Pickering Nuclear site.

On-site biodiversity initiatives include enhancement of wildlife corridors across the site, protection of species of concern like peregrine falcons (see Figure 18) and enhancement and protection of the ecological value of the Frenchman’s Bay and Duffins Creek watersheds, and associated natural areas on and adjacent to the site.

Pickering’s resident Peregrine Falcons have returned. This is the fifth year the falcons have joined us at Pickering and we once again have a strategy in place to help protect this species of concern while ensuring personnel safety on site

Figure 18 - Biodiversity

Program activities have focused on habitat enhancement. In the past three years, approximately 2000 trees and shrubs have been planted on Pickering OPG property by volunteers from the community and OPG staff.

Pickering Nuclear continues to enhance habitat off site through the ongoing partnership with Environmental Stewardship Pickering (ESP). Projects have included the creation of a wildflower garden at a local school, tree planting events and the creation of habitat structures for birds and pollinators. ESP also hosts educational workshops for community members on gardening, habitat creation and environmental stewardship.

OPG submits applications for Wildlife Habitat Council certification of select sites. The Wildlife Habitat Council is an international non-profit, non-lobby group that promotes and independently certifies habitat conservation and management on corporate lands through partnerships and education.

In January 2017, Wildlife Habitat Council advised OPG that the 2014-2016 Nuclear Biodiversity Program at Pickering and Darlington Nuclear Generating Stations application successfully received Wildlife Habitat Council's new "Conservation Certification" for 2017-2019.

2.9.12 Fisheries Act Authorization

Pickering Nuclear has submitted an application for authorization from the Department of Fisheries and Oceans (DFO) under section 35 (2)(b) of the *Fisheries Act*.

Key activities to complete the application for an authorization included a quantitative assessment of residual impact from fish loss, offsets for the residual impacts, and Aboriginal engagement. The *Fisheries Act* allows offset to include habitat improvements, stocking of fish and limited funding for research.

It is expected that the authorization will be in effect prior to the 2018 Pickering NGS licensing hearings.

2.9.13 Applicable OPG Documents

The following documents are the applicable OPG documents which support the licensing basis and are to be listed in the Licence Conditions Handbook.

Document Number	Document Title
OPG-POL-0021	Environmental Policy
N-PROG-OP-0006	Environmental Management
OPG-PROC-0126	Hazardous Material Management
N-PROC-OP-0044	Contaminated Lands and Groundwater Management
N-PROC-OP-0025	Management of the Environmental Monitoring Programs
N-STD-OP-0031	Monitoring of Nuclear and Hazardous Substances in Effluents
N-PROC-OP-0037	Environmental Approvals
P-REP-08965-0633695	Pickering NGS Hazardous Substances
NA44-REP-03482-00001	Derived Release Limits and Environmental Action Levels for Pickering Nuclear Generating Station A
NK30-REP-03482-00001	Derived Release Limits and Environmental Action Levels for Pickering Nuclear Generating Station B
P-REP-03482-00001	Derived Release Limits and Environmental Action Levels for Pickering Nuclear Sewage Effluent
4922-5S7NFH	Dual Phase Extraction System Operation
4881- 5MHQ9F	Comprehensive Certificate of Approval (Industrial Sewage)
4881- 5MHQ9F	Station Temperature Limits Notice 5 (Industrial Sewage)

Document Number	Document Title
2460-A2NHF2	PNGS-A-Permit to Take Water
2731-8ULK95	PNGS-B Permit to Take Water
A390407	Closure of West Landfill Site (Waste Disposal)
0947-A7NM85	New Water Treatment Plant Operation
4766-A3YMB9	Pickering Site Operation Comprehensive certificated of Approval (AIR)
5683-6XAMAB	Auxiliary Power System (Industrial Sewage)
7719-5TXL94	Dual Phase Extraction System Operation
8-3056-94-006	Performance Testing of Air Filtering and Monitoring Equipment

2.10 Emergency Management and Fire Protection

Pickering NGS has an effective emergency preparedness and fire protection program that meets or exceeds all applicable regulatory requirements and related objectives. Emergency preparedness measures and fire protection response capabilities are in place at Pickering NGS to prevent and mitigate the effects of nuclear and hazardous substances releases, both onsite and offsite, and fire hazards in order to protect workers, the public and the environment.

For specific areas within this SCA, the following subsections describe the objectives, key results from the current licensing period, and planned improvements over the next licensing period. These discussions also support that:

- Nuclear safety will be assured such that plant personnel, the public and the environment are protected (Sections 2.10.1 and 2.10.2)
- Staff are qualified and competent to respond to nuclear and fire events at the plant, and this will be maintained though the next licence period, including staffing numbers (e.g., see Section 2.10.1 regarding Staffing, Training and Resources).
- OPG continues to invest in Pickering to support nuclear safety (e.g., via drills and exercises as described in Section 2.10.2)
- Transparency and appropriate public consultations have been upheld and will continue (e.g., via public alerting provisions and public awareness campaigns for KI pill distribution, as described in Section 2.10.2)

2.10.1 Fire Protection and Conventional Emergency Preparedness and Response

The OPG *Fire Protection* program, N-PROG-RA-0012, describes the fire protection organization and interfacing organization and processes, and their accountabilities within the fire program. The objective is to ensure that all reasonable measures are taken to prevent fires, and to promptly detect and suppress any fires that may occur at the nuclear plant.

The overall program is based on CSA N293, *Fire Protection for CANDU Nuclear Power Plants* and industry best practices.

Staffing, Training and Resources:

The Pickering Fire Protection section at Pickering NGS incorporates positions for Shift Emergency Response Managers (SERM) and Emergency Response Maintainers (ERM), who are trained to respond to emergencies that may occur on-site.

The Pickering Fire Protection section is supported by the Fire Protection Programs department. Fire Protection Program staff play a key role in standardizing emergency response procedures, equipment, and training.

Fire Protection Training has made substantial enhancements to field training simulators at Wesleyville Fire and Rescue Academy owned and operated by OPG.

Fire Protection Training has also implemented the first delivery of 2016 International Fire Service Training Association Standards in 2017. In addition, training has implemented the *Blue Card Incident Command Certification* which is an industry standard for incident command, as well as implementing the NFPA1407 Rapid Intervention/Fire Fighter Survival program.

The continuing training program at OPG requires ERMs to participate in annual continuing training and practice sessions where response skills are demonstrated and assessed. These skills require the ability to respond safely and effectively to physically demanding scenarios. ERT drills documenting team and individual performance are also evaluated annually and have demonstrated the capability of the ERT to respond effectively to realistic scenarios at the station and at the Wesleyville live fire training facility.

Integrated Response Capability:

On an annual basis, OPG reviews its Memorandum of Understanding with the City of Pickering. The memorandum defines the mutual responsibilities, provides for a high level of mutual aid between the parties, and provides a strong foundation for continued productive and integrated working relationships between Pickering Fire Services (PFS) and OPG. Equally important, it provides the local community with access to additional resources from OPG to deal with major incidents and improved training for emergency response staff.

Fire protection staff periodically meets with PFS firefighters to discuss fire safety and response at the Pickering site. PFS continues to participate in fire drills, exercises and training evolutions and site orientations with OPG staff to maintain an effective integrated response capability.

PFS officers and Pickering Nuclear Fire Protection staff participate annually in the Incident Command training at Wesleyville. Also, joint live fire training takes place at Wesleyville on an annual basis with PFS and the Emergency Response teams to maintain an effective integrated response.

Planned Improvements

OPG is partnering in the Durham Regional NextGen public safety radio system and is installing radio system infrastructure at the site. This will allow seamless integration and interoperable communications with Pickering Fire Service responders using their own radios in the plant, and is expected to be completed by the end of 2017.

Fire Safety Assessments

In 2017 an updated Pickering NGS A Fire Safe Shutdown Analysis (NA44-REP-71400-00023) and Pickering NGS A Fire Hazards Assessment (NA44-REP-71400-10003) were completed and submitted to the CNSC as per Reference 20.

An updated Pickering NGS B Fire Safe Shutdown Analysis (NK30-REP-71400-00001) and Pickering NGS B Fire Hazards Assessment (NK30-REP-71400-10002) were completed and submitted to the CNSC as per Reference 21 .

2.10.2 Nuclear Emergency Preparedness Program

The Nuclear Emergency Preparedness program is documented in OPG's *Consolidated Nuclear Emergency Plan* (CNEP), N-PROG-RA-0001. This plan describes concepts, structures, roles and processes to implement and maintain an effective OPG response in the unlikely event of a nuclear emergency that could endanger onsite staff, the public, or the environment. The CNEP provides a framework for interaction with external authorities and defines OPG commitments under the *Provincial Nuclear Emergency Response Plan* (PNERP).

The objective of the OPG Nuclear Emergency Preparedness program is to ensure OPG has adequate provisions for the preparedness and response capability that would mitigate the effects of accidental releases of radioactive material.

In order to respond effectively to an emergency, Pickering NGS practices the response capability of staff through simulated emergencies, and maintains plans and procedures to ensure that this capability is sustained.

A summary of performance is provided in Table 7 - Emergency Response Performance Indicators.

The Radiological Emergencies Performance index is an indication of the accuracy and timeliness of the station's initial notification under the PNERP.

The ERO Drill participation index provides information on how many of the ERO staff scheduled to participate in a drill complete this during the year.

The Emergency Response Resources Completion index considers the ratio of completed to scheduled work and presents an indication of the operational readiness of emergency facilities.

Performance Indicator	2013	2014	2015	2016
Radiological Emergencies Performance Index (% - 100 max)	99.2%	96.9%	92.6%	100%
ERO Drill Participation Index (% - 100 max)	100%	100%	100%	100%
Emergency Response Resources Completion Index (% - 100 max)	100%	100%	100%	100%

Table 7 - Emergency Response Performance Indicators

A new emergency accounting system was installed within Pickering's protected area, which includes emergency accounting readers at each assembly area. When assembling during a station emergency, employees account by scanning their entry card at an emergency accounting reader in their designated assembly area. This change aligns with industry best practices, and more importantly, by providing a more accurate and timely accounting process, it also enhances the safety of staff.

Formalized self-assessments are conducted to identify additional program improvement opportunities. A systematic review and assessment process has been implemented to ensure operational readiness of the emergency preparedness program to support safe and reliable operation of Pickering units.

Drills and Exercises

In order to demonstrate OPG's emergency response capability, Pickering maintains an extensive drill and exercise program. This program validates emergency plans and procedures, and provides the emergency response organization with the opportunity to improve and sustain their emergency response capability.

In the unlikely event of an emergency at the station, OPG would perform the appropriate notifications to the Province, CNSC, and local municipalities in accordance with established procedures. Pickering NGS takes actions to control and mitigate the emergency on-site and minimize off-site effects. The Province under the PNERP takes actions to notify and protect the public, including recommending protective actions such as sheltering, potassium iodide ingestion, or evacuation. The local municipalities support provincial directions, which may include such activities as guiding members of the public should an evacuation be required. OPG and a range of other organizations are integrated to ensure effective emergency measures are in place.

In May 2014 OPG executed the "Exercise Unified Response" in order to test and demonstrate the effective integration of emergency response; see Figure 19. This exercise assessed the preparedness of OPG and government agencies at federal, provincial, and municipal levels to respond to a simulated severe nuclear event with off-site releases at the Darlington station. This exercise involved over 2000 participants and 54 agencies over three days. The exercise was very successful and demonstrated the integration of nuclear response plans at all levels of government. Although the incident station in Exercise Unified Response was Darlington, a majority of the participants would fulfil a similar role in the unlikely event of a Pickering emergency.

In November 2015, Pickering conducted a station emergency exercise involving a multi-unit severe accident. The initiating events for this exercise were conducted from the Pickering Simulators, with field actions performed as permitted by exercise design. The scope of this exercise was developed to demonstrate OPG's response capability to an event which progressed into a multi-unit severe accident requiring deployment of the Emergency Mitigating Equipment; see Figure 20.

OPG has scheduled a multi-agency interoperability exercise 'Exercise Unified Control' for December 6-7, 2017, focused on Pickering NGS. This full-scale integrated exercise is designed to test the capacity of onsite and off-site agencies to respond to a significant emergency at the Pickering site. The exercise is being planned to include participation of emergency response agencies of the Province of Ontario, Durham Region, the City of Toronto, the CNSC and other federal agencies. Lessons learned from this unified exercise will be available early in 2018 and will help participating agencies to continue to improve respective emergency plans.

Figure 19 - Exercise Unified Response Montage

Figure 20 - Pickering Emergency Mitigation Equipment

Public Alerting

In the unlikely event of an emergency where the Province initiates protective actions under the PNERP, the need to shelter, evacuate or take other actions is communicated to the public as follows:

- *Sirens*: Mounted on poles, sirens emit a single tone alarm that can be heard outdoors. These sirens are located within 3 kilometres of the Pickering site.
- *Radio, Television, Social Media*: Local radio and television stations, and social media, will broadcast information on public health, safety, and welfare. Instructions on what to do in the event of a nuclear emergency will be provided.
- *Telephone Dialing System*: An automated telephone dialing system will deliver a recorded emergency message through landline home phones to a large population in a short time.

In addition, OPG has partnered with Durham Region, the Office of the Fire Marshall and Emergency Management (OFMEM), Bell Canada and the Weather Network to pilot a Wireless Public Alerting System (WPAS) project in Durham Region. Wireless Public Alerting is a system that broadcasts messages through wireless (cell phone) technology; see Figure 21, for example. This technology is used successfully in other jurisdictions outside of Canada, such as the United States, and significantly helps to make the receiving of public alerts more accessible. As part of the pilot project, approximately 80 people in Durham Region, including OPG employees, were equipped with WPAS-enabled phones. Over the course of several months, they received test messages to validate the functionality and effectiveness of the program.

This is an important step for Canada in its emergency preparedness and response, and OPG is proud to be a partner in the pilot program. The Canadian Radio-television and Telecommunications Commission (CRTC) has issued a regulatory policy (CRTC 2017-91) to direct wireless service providers to implement wireless public alerting capability on their networks by April 6, 2018.

Figure 21 - Sample Wireless Public Alerting Service

Evacuation Time Estimate

An updated Evacuation Time Estimate (ETE) was completed for Pickering and issued in 2016. This update is based on current census data, and future population growth projections on a per-decade estimation. Industry-accepted methodology was used for this study. The ETE study takes into consideration the time required to evacuate schools, hospitals and other residential institutions, and was completed with support from the Province, local municipalities, police and transit organizations.

The estimate provides off-site emergency planners with projections on how long it may take for sectors and the primary zone to evacuate if required. Variables such as time of day, day of week, road restrictions, special event assemblies and weather were assessed as to how those factors may impact the evacuation duration.

The study determined that the conservative value for the evacuation time estimate was 8 hours. This value is expected to be used by off-site emergency planners and response organizations, in alignment with the provincial strategy, when considering the need to implement access control or to commence an evacuation.

Off-Site Support

OPG provides Monitoring and Decontamination Unit capability and readiness at Emergency Worker and Reception Centres.

OPG participated in the Reception Centre Exercises in 2012 (Durham College) and 2013 (Fleming College), as well as Emergency Worker Centre Exercises in 2014 at the Orono Arena in Clarington and in 2016 at Iroquois Park in Whitby. This effort is in addition to the routine work of OPG's Emergency Response and Fire Protection staff to work with key members of the Ajax-Pickering hospital staff to review and familiarize each other with procedures and training relevant to radiological emergency situations.

To ensure emergency plans continue to support a timely and safe evacuation in the event of a nuclear emergency, OPG monitors and engages with the Province, Region of Durham, and the City of Pickering regarding land use policies and activities in associated emergency planning zones to ensure no adverse impact on implementation of nuclear emergency plans.

Equipment Important to Emergency Response

A program to manage Equipment Important to Emergency Response (EITER) has been implemented to align with industry best practices. This program identifies equipment that is required in an emergency response and its back-up equipment, and ensures contingency actions if equipment is out of service if no acceptable back-up is available.

The EITER program is ensured through N-PROC-RA-0133 *Management of Equipment Important to Emergency Response*. EITER includes systems, structures, and components, as well as essential tools and equipment, necessary to implement the emergency *Consolidated Nuclear Emergency Plan.*

The Pickering station-specific EITER equipment and facilities and necessary actions are identified in a Pickering instruction. Corporate and OPG off-site facilities and equipment which may be required to support Pickering are identified in a corporate instruction.

The EITER program ensures that OPG has the capability to implement the emergency plan through the readiness and availability of the EITER equipment, facilities, or through enacting compensatory measures or use of designated alternate facilities where the primary means may be unavailable. The EITER requirements are integrated into the work management for planned maintenance activities.

Potassium Iodide (KI) Pills

In response to requirements in CNSC regulatory document REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response*, the pre-distribution of an iodine thyroid blocking agent or potassium iodide pills was expanded to the population residing in the primary zone.

Ingestion of Potassium Iodide (KI) is one protective action that may be directed by authorities in the unlikely event of a nuclear emergency. Historically, the off-site response plan protocol for KI pill pre-distribution has been to provide them free of charge through local pharmacies. In addition, KI pills have been available in schools, child care centres, health care facilities, municipal services, and reception centers designated in nuclear emergency plans.

OPG developed a communication campaign that began in January 2015 with focus groups established in the primary zone. The campaign included a two-part communications strategy for pre-distribution and distribution, based on the results obtained from the focus groups. The pre-distribution campaign was a focused education campaign that raised public awareness of KI distribution. The distribution campaign utilized product packaging to improve the public’s understanding of when and how to use the KI pills, and to reinforce the safety of OPG’s nuclear facilities. KI pills were distributed in October 2015.

Branding for the distribution campaign was specifically designed; helping to ensure the packages would be easily recognized and not discarded. The KI packages included user instructions and information printed on the front. As part of the overall campaign, a website was created to provide an online site for people within 50 km of Pickering NGS to order KI pills and provide information.

KI pill fact sheets were distributed to operators at local and provincial health help lines and local physicians in order to assist in answering questions from the public. The public within 50 km can continue to order KI pills through the website.

Website FAQs are translated into the 9 most common languages spoken within 10 km (based on census data). New households and businesses are identified three times a year by Canada Post and sent information packages including KI pills. On-going public awareness campaigns by the local health department and OPG remind residents of pill availability and other preparedness information.

Planned Improvements

The provincial Office of the Fire Marshall and Emergency Management (OFMEM) are working to update the PNERP which was last revised in 2009. The review and update of the PNERP began in 2015 and is being revised to incorporate lessons learned from past nuclear exercises and adopt aspects of International Atomic Energy Agency (IAEA) guidance. The Province is conducting a public consultation process with the objective of obtaining a Cabinet approved PNERP by year end 2017 and an approved OFMEM Pickering implementing plan by March 2018. OPG has reviewed and provided comments during the public review period, and will enhance its emergency plans to align with any PNERP requirements once issued.

A new public education campaign is planned for 2017 building on the successful previous campaign designed to provide guidance on what to expect in the unlikely event of a nuclear emergency and how to prepare prior to an emergency.

2.10.3 Applicable OPG Documents

The following documents are the applicable OPG documents which support the licensing basis and are to be listed in the Licence Conditions Handbook.

Document	Title
N-PROG-RA-0001	Consolidated Nuclear Emergency Plan
N-STD-AS-0010	Nuclear Crisis Communications Standard
N-PROC-RA-0045	Emergency Preparedness Drills and Exercises
N-PROG-RA-0012	Fire Protection

2.11 Waste management

Pickering NGS has an effective waste management program that meets or exceeds all applicable regulatory requirements and related objectives. Pickering's facility and waste stream-specific waste management program is fully developed, implemented and audited to control and minimize the volume of nuclear waste generated by the licensed activity.

For specific areas within this SCA, the following subsections describe the objectives, key results from the current licensing period, and planned improvements over the next licensing period. These discussions also support that:

- Nuclear safety will be assured such that plant personnel, the public and the environment are protected during the various phases of activities in the next licensing period
- Impacts of plant operation to the public, workers, and the environment during these different phases will be of low risk and adequately mitigated

2.11.1 Waste Minimization, Segregation and Characterization

Procedure, *Waste Management*, N-PROC-OP-0043, provides an overview of waste processes and responsibilities and ensures that all waste at Pickering NGS is processed in accordance with federal, provincial and municipal regulations.

The objective of the procedure, *Segregation and Handling of Radioactive Waste*, N-PROC-RA-0017, is to ensure that radiological waste is properly handled, segregated and characterized.

Waste is generated at Pickering as a result of daily operations and maintenance activities and during planned and unplanned outages. Waste is characterized as either radiological or conventional depending on the radiological zone of its origin and from radiological surveys and analysis, in order to ensure that waste is safely disposed.

Low Level Radioactive Waste (LLRW)

Radioactive waste is collected from designated areas throughout the station. Waste handlers separate the solid waste into conventional and radiological and hazardous waste streams. Designated waste handlers process the waste to prepare and stage for shipment and final disposal.

In order to reduce radioactive waste generated in the Pickering NGS, OPG has reduced the amount of plastic, wood and cardboard by de-packaging materials and equipment before entering the station, thus reducing the risk of contaminating items that eventually become low level radioactive waste.

Monthly tracking of performance allows the operations and maintenance organization to assess where waste reduction strategies can be focused.

Site wide communications on waste reduction expectations will continue to improve behaviours and performance in waste reduction initiatives. Work groups are held accountable for waste reduction strategies and implement them in daily activities as well as for outage planning activities.

Conventional Solid Waste

Conventional waste is generated through maintenance activities in the Zone 2, unzoned and the public domain areas. This waste is confirmed to be free of contamination and is either processed to a waste transfer station and then onto a landfill or to a recycler for processing.

Conventional solid waste is also minimized to reduce the impact that it can have on the environment. This reduction includes implementation of the 3R's (Reuse, Reduce and Recycle). Recyclable material collected and processed at Pickering includes wood, cans, cardboard, paper, paper towels, newspaper, plastic, asphalt, concrete, compost, metal and glass.

The proportion of recycling diversion is dependent on the specific annual work as different activities generate varying forms of waste, not all of which are recyclable. Consequently the changing relative proportion between recyclable and non recyclable waste results in varying recycling diversion percentages each year.

Nevertheless, Pickering has improved in recycling methods over the years with introduction of organic waste segregation and blue box recycling, including single stream recycling, allowing all of general office recyclables to go into a single bin, simplifying the process for the users. Waste that cannot be recycled is sent to landfill.

Hazardous/Chemical Waste

Pickering NGS continues to meet federal and provincial requirements in processing and disposing of hazardous and chemical wastes.

Typical hazardous waste generated at Pickering includes chemicals and liquids such as cleaning agents, grease, oil, waste fuels, acids as well as batteries and PCBs. The liquid and chemical wastes are collected as a result of operations activities from equipment /system use or maintenance.

The volume of chemical drums on site is tracked and reported monthly with associated targets to ensure that the backlog is maintained at a low manageable level and that the waste is disposed as required by Ontario Regulation 347 requirements. These tracked drum volumes also support and impact the Environmental Index performance measure.

Environment Canada completed a site inspection of Pickering's PCB Waste Management Program in August 2015. The enforcement officers found no non-compliances and were satisfied with the program.

2.11.2 Waste Storage and Processing

There are various waste disposal paths depending on the characterization of the waste.

The waste disposal paths include:

- Solid radioactive waste shipped to Western Waste Management Facility for incineration or long term storage (compactable and non-processible);
- Radioactive oil shipped to Western Waste Management Facility for incineration;
- Radioactive liquid chemicals incinerated or solidified and stored at Western Waste Management Facility;
- Non radiological solid conventional waste shipped to public landfill or recycled;
- Non radiological chemicals/liquid industrial waste shipped to hazardous waste receiving company for incineration or disposal in hazardous landfill; and,
- PCBs shipped to Swan Hills Alberta Hazardous Waste Facility and incinerated.

All such waste will continue to be disposed safely.

2.11.3 Interim Dry Storage of Irradiated Fuel

The objective of interim dry storage of irradiated fuel is to provide safe, passive dry storage of irradiated fuel onsite until a permanent storage facility is in operation.

Fuel is moved from wet storage to dry storage in order to ensure sufficient irradiated fuel bay storage area for sustainable operation and eventual shutdown of the Pickering station.

Pickering NGS has been removing fuel from the wet irradiated fuel bays and transferring it as dry fuel to the Pickering Waste Management Facility (PWMF) since 1996. As of December 2016, a total of approximately 855 Dry Storage Containers (DSCs) containing 330,000 bundles of spent fuel have been safely processed and stored in 3 storage buildings onsite. The PWMF is licensed separately by the CNSC and considers the future needs of the Pickering station.

2.11.4 Decommissioning Plans

The objective of the Pickering Preliminary Decommissioning Plan (PDP) is to demonstrate the technical and financial feasibility of decommissioning Pickering NGS. The scope of the PDP includes all of the associated buildings and structures located inside the Pickering Protected Area, not including decommissioning of the Pickering Waste Management Facility. There is a separate PDP for the decommissioning of the Pickering Waste Management Facility, which is licensed separately.

In support of the above objective, the PDP accounts for the removal of all structures on site and of all radioactive and other (conventional) hazardous materials, their disposal at licensed facilities, and eventual restoration of the site to an end state agreed with the Regulators. As per the PDP, upon completion of the decommissioning program, the site will be in a condition that will support an application for a Licence to Abandon.

The decommissioning activities outlined in the PDP are planned in accordance with the requirements of the Canadian Standards Association (CSA) standard N294-09 “Decommissioning of Facilities Containing Nuclear Substances”, CNSC guides G-206 “Financial Guarantees for the Decommissioning of Licensed Activities”, and CNSC G-219 “ Decommissioning Planning for Licensed Activities”.

OPG’s management system for decommissioning is defined under its Decommissioning Program, W-PROG-WM-0003. Lower tier supporting governing documents (W-PROC-WM-0093 Planning for Decommissioning, W-STD-WM-0003 Nuclear Liability Management – Update of Cost Estimates for the Ontario Nuclear Funds Agreement and Financial Guarantee Processes, and W-STD-WM-0005 Conduct of Decommissioning) have been prepared and issued.

Pickering’s PDP demonstrates that, through the process of decommissioning, the licensed facilities can be permanently retired from service and the site restored to a predetermined end state in a manner that will ensure that the health, safety and security of workers, the public and the environment are protected. The Pickering PDP was updated and submitted to the CNSC in January 2017 (Reference 6).

2.11.5 Preparation for Management of Waste from Transition to Safe Storage State

The eventual shutdown of Pickering is expected to increase the volume and variety of waste generated in a short time period. In order to protect workers and the environment during the Safe Storage Phase, all transient hazardous substances in non-operational systems and storage will be removed, packaged and disposed through appropriate disposal channels during the Stabilization Activities Phase. Planning ahead for the influx of waste will ensure OPG has sufficient capability for the treatment of these wastes, their storage, transport and disposal.

As part of the planning for wastes in the transition to the safe storage state, a waste forecast was prepared to estimate the type, volume and schedule of wastes expected to be produced. The waste forecast identified most wastes as typical operational wastes that have established processes for removal and transport from the station.

Two forms of waste require further planning:

Intermediate Level Resin Waste: Current resin generation rates and maximum shipping capacity indicates waste resin will remain in the station for an extended period after shutdown. Further information will be required to accelerate the transport of waste resin.

Polychlorinated Biphenyl (PCB) Waste: PCB regulation SOR/2008-273 requires removal of PCBs on site by December 31, 2025. OPG is developing a phase-out plan on PCB management (including radioactive PCB), after the end of commercial operations at Pickering and is in discussions.

2.11.6 Applicable OPG Documents

The following documents are the applicable OPG documents which support the licensing basis and are to be listed in the Licence Conditions Handbook.

Document	Title
N-PROG-OP-0006	Environmental Management
N-PROC-OP-0043	Waste Management
N-PROC-RA-0017	Segregation and Handling of Radioactive Wastes
W-PROG-WM-0003	Decommissioning Program
P-PLAN-00960-00001	Preliminary Decommissioning Plan-Pickering Nuclear Generating Stations A and B

2.12 Security

Pickering NGS has an effective security program that meets or exceeds all applicable regulatory requirements and related objectives. It effectively prevents the loss, theft or sabotage of nuclear material and the sabotage of the licensed facility.

For specific areas within this SCA, the following subsections describe the objectives, key results from the current licensing period, and planned improvements over the next licensing period. These discussions also support that:

- Nuclear safety will be assured such that the public is protected (e.g., Sections 2.12.1 and 2.12.4).
- OPG continues to invest in additional security measures at Pickering (e.g., planned improvements mentioned in Sections 2.12.1 and 2.12.4).

2.12.1 Nuclear Security Program

The *Nuclear Security Program*, N-PROG-RA-0011 ensures the safe and secure operation of the station and compliance with the legislative requirements by maximizing protection through use of equipment, personnel, and procedures.

OPG documents the specific regulatory security requirements for the security program in the OPG report, 8690-REP-61400-10003, *Pickering Site Security Report*. This security protected report will be updated in 2017.

Pickering Security personnel consist of two roles, Nuclear Security Officers (NSO) and Armed Nuclear Security Officers (ANSO). NSO’s perform all security functions for Pickering NGS, while ANSO’s provide on-site armed support capable of dealing with situations as outlined in the Design Basis Threat.

OPG Nuclear Security continues to participate in the inter-utility working group that includes security representatives from all commercial nuclear reactor operators in Canada. The group ensures nuclear security programs in Canada continue to evolve to meet future requirements, through the sharing of OPEX, and the promotion of best security practices.

Planned Improvement

OPG is in the process of developing an implementation plan in 2017 to comply with new mandatory credit checks and digital fingerprinting requirements as a result of changes to the Treasury Board Secretariat Security Screening Standard and the Royal Canadian Mounted Police (RCMP) Law Enforcement Records Check.

Facilities and Equipment

The objective for Facilities and Equipment is to ensure that Pickering Security and Emergency Services possess and operate the required equipment needed to comply with the Nuclear Security Regulations.

The Pickering search facilities are equipped with dedicated equipment for conducting personnel and vehicle security searches in order to enter the protected area of the Pickering plant. Personnel are also required to perform identity checks using both a proximity card and biometric hand geometry.

All exterior doors of the Pickering powerhouse are hardened against explosive or forced entry, and the doors are equipped with a robust lock system to prevent unauthorized access. The doors are alarmed and monitored.

Exits are also monitored with portal monitors for the detection of Category I, II or III nuclear material to prevent theft of material.

Searches are conducted on all packages and equipment entering the protected area for weapons and explosive substances.

The Pickering NGS protected area is surrounded by a security fence equipped with devices intended to detect any attempt at unauthorized intrusion into the protected area, and to detect any tampering or component failures that could cause the system to malfunction. The system is monitored at all times by Nuclear Security officers in the Security Monitoring Room. Alarms within the protected area are responded to by armed Nuclear Security officers. Pickering NGS also has physical protection measures against forced land vehicle penetration of the protected area.

Planned Improvements

There are initiatives underway that will enhance the Security Monitoring Room in order to improve the overall response capability and are expected to be completed in 2019.

2.12.2 Drills and Exercises

Security Drills are regularly conducted at the Pickering site with the objectives of validating security practices, ensuring regulatory compliance, and to identify security improvements. Security Training has been recognized by the American Society for Industrial Security (ASIS) International for providing industry leading training

OPG conducts a CNSC audited security exercise at the Pickering facility every two years. Also, a security drill that tests the operation of one or more of Pickering's physical protection measures and readiness of security personnel is conducted at least once every 30 days.

In 2014 and 2016, major security CNSC exercises were conducted. These exercises involved the integrated response of the Nuclear Security personnel as well as offsite police personnel and members of the Emergency Response Team. All of the exercises were conducted in a safe manner and the lessons learned improved security efficiency.

Currently, Security Training is conducting Incident Command Training based on the systematic approach to training process developed by all of the Nuclear Security groups in Canada. This training involves the active participation of the Durham Regional Police Service and ensures a smooth incident command transfer if it is necessary, during a security event.

OPG is partnering in the Durham Regional NextGen public safety radio system and is installing radio system infrastructure at the site. This will allow an improved communication link to offsite services in Durham Region and is expected to be completed by the end of 2017.

2.12.3 Response Arrangements

OPG has a Memorandum of Understanding (MOU) with the Durham Regional Police Service (DRPS) to provide off-site armed response force support to the Pickering Nuclear Generating Station pursuant to the Nuclear Security Regulations.

An update to the Memorandum of Understanding with DRPS is currently being agreed upon between Security and Emergency Services and DRPS. An updated copy of this MOU will be included in the 2017 Site Security Report.

2.12.4 Cyber Security

OPG's cyber security program is designed to implement OPG's corporate cyber security policy OPG-POL-0035, *Cyber Security Policy.* Information technology and industrial control systems are managed in a secure, vigilant and resilient manner that minimizes cyber risks to information assets and generation facilities.

The objective of nuclear cyber security is to provide for the secure operations of computer systems governed by the nuclear software program. Cyber security is applied to plant systems including those used to ensure safe operations and those which provide for physical security of the facility. Since 2013, there have been cyber security related updates to Engineering Change Control (ECC), employee training, and various maintenance and engineering instructions, guides, procedures and standards in addition to OPG's corporate cyber security policy.

ECC ensures all modifications to OPG nuclear systems, structures, and components (SSCs), including software and engineered tooling, are planned, designed, installed, commissioned, placed into service, or removed from service within the licensing basis. Within the ECC program, the modification process is followed for all changes to the OPG Nuclear design basis. Cyber Security is initially addressed during the design scoping phase of the modification process and issues are tracked through to the in-service declaration.

Employee training has included new qualifications for the Cyber Security Subject Matter Experts and the Cyber Security Single Point of Contact to support cyber security under the nuclear software program during design scoping and cyber essential asset identification and classification. Supplementing the internal training, a number of staff participated in a National Training Course on cyber security assessments sponsored by the CNSC and delivered by the International Atomic Energy Agency. For individuals performing maintenance related work, a training course was created to reinforce expectations with regard to portable computing devices (e.g., laptops), removable media (e.g., USB keys), and virus detection. Supporting the training, new instructions and guides have been issued to improve cyber security for portable and mobile computing, removable media devices and vendor digital assets.

OPG is improving the cyber security program by continuing to address the identified gaps communicated to the CNSC in order to comply with CSA N290.7-14, *Cyber Security*. These gaps are associated with the new identification and classification scheme for cyber assets and require a different selection and implementation of risk-based controls for the expanded inventory of cyber assets. As a consequence, a new engineering standard has been produced to provide direction for the identification and classification of *Cyber Essential Assets* (*CEAs*) in alignment with CSA N290.7-14. Subsequently, all station systems were systematically reviewed to identify and classify the CEAs. In some instances, modifications to newly identified cyber assets will be required to achieve compliance with CSA N290.7-14. The need to proceed with such modifications will be evaluated using the normal engineering change request process.

2.12.5 Applicable OPG Documents

The following documents are the applicable OPG documents which support the licensing basis and are to be listed in the Licence Conditions Handbook.

Document	Title
N-PROG-RA-0011	Nuclear Security
8690-D0H-14100-1003	Pickering GS Site Security Taut Wire Fence Layout and Survey
8690-REP-61400-10003	Pickering Nuclear Generating Station Security Report
N-CORR-00531-04980	Attachment 1: Primary Firearm Course of Fire and Qualification
N-CORR-00531-06348	Secondary Firearms Qualification
8690-CORR-00531-00483	Addendum to Pickering NGS Security Report R008
8690-CORR-00531-00459	Addendum to Pickering NGS Security Report R008
8690-CORR-00531-00544	Addendum to Pickering NGS Security Report R008
N-PROC-MP-0103	Security for Real-Time Process Computing System
N-STI-69000-10015	Cyber Asset Identification for Real-Time Process Computer Systems
N-STI-69000-10016	Cyber Security for Real Time Process Computing System
P-LIST-69000-00001	Significant Cyber Assets
TRAN-PLAN-03450-10000	Transport Security Plan

2.13 Safeguards and Non-Proliferation

Pickering NGS has an effective safeguards and non-proliferation program that meets or exceeds all applicable regulatory requirements and related objectives. Pickering NGS takes adequate measures to meet Canada's international safeguards obligations arising from the Canada/International Atomic Energy Agency (IAEA) safeguards agreements as well as other measures arising from the Treaty on the Non-Proliferation of Nuclear Weapons.

For specific areas within this SCA, the following subsections describe the main objectives and OPG activities at Pickering NGS. These discussions also support that:

- Pickering continues to provide the required level of transparency and co-operation with IAEA and CNSC staff for this area.

2.13.1 Nuclear Safeguards Program

OPG's *Safeguards Program* N-PROG-RA-0015 is designed to establish, maintain, and verify compliance with nuclear safeguards requirements for nuclear operations and to ensure that all necessary measures are taken to facilitate Canada's compliance with safeguards agreements as well as all other measures arising from the Treaty on the Non-Proliferation of Nuclear Weapons.

The safeguards implementing document, N-STD-RA-0024, provides direction to ensure OPG complies with its licence conditions, the Nuclear Safety and Control Act, the General Nuclear Safety and Control Regulations, and any other related regulations in support of Canada's safeguards agreements.

During the current licence period, Pickering has met all Safeguards conditions in its operating licences and the terms of the agreement between Canada and the IAEA pursuant to the Treaty on Non-Proliferation of Nuclear Weapons. Pickering staff has fully cooperated with the IAEA and facilitated achievement of IAEA Safeguards goals

Pickering's compliance with the IAEA's Fuel Verification Program is met through the following activities:

- Complying with the Safeguards Agreement and the Additional Protocol,
- Providing services and assistance for IAEA staff tasks and equipment operation,
- Disclosing any records to the IAEA upon request,
- Installing, servicing and operating safeguards equipment,
- Not interfering in any way with safeguards equipment, samples or seals,
- Making no changes to operations, equipment or procedures that would affect safeguards implementation without prior written CNSC approval, and
- Preparing and submitting nuclear material accountancy reports per CNSC regulatory document RD-336, *Accounting and Reporting of Nuclear Material*, and as required under Regulatory Document REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*.

2.13.2 Operational and Design Information

The Design Information Questionnaire (DIQ) provides the IAEA/CNSC with information pertaining to PNGS' design to ensure safeguards responsibilities are met as per the facility attachment. The DIQ is provided upon request from the IAEA/CNSC. The DIQ ensures that general information describing the Pickering NGS facility, design and operation, nuclear material descriptions, processing and flow of nuclear materials, safeguard measures, and accounting and reporting of nuclear materials are accurate and available to support a Design Information Verification (DIV) inspection.

2.13.3 Safeguards Equipment and Surveillance

Safeguards equipment is labelled and secured to prevent interference or tampering. The IAEA conducts annual inspections to ensure functionality and that no tampering of remote monitoring equipment has occurred. Surveillance systems (e.g., digital multi-camera surveillance systems, bundle counters and core discharge monitors) are installed at Pickering to provide the IAEA with continuous detailed data of safeguards-related functions. The information is compared against Pickering's monthly declarations.

After an IAEA inspection, an accessibility issue was raised for a portion of the spent fuel bays due to the stacking of the fuel frames. This issue will be addressed to the satisfaction of IAEA and CNSC staff.

2.13.4 Import and Export

The scope of the non-proliferation program at Pickering is limited to the tracking and reporting of foreign obligations and origins of nuclear material. Import and export of controlled nuclear substances, equipment and information as identified in the *Nuclear Non-proliferation Import and Export Control Regulations,* is not currently permitted under the Pickering site licence and any application is made in accordance with applicable regulations.

2.13.5 Applicable OPG Documents

The following documents are the applicable OPG documents which support the licensing basis and are to be listed in the Licence Conditions Handbook.

Document Number	Document Title
N-PROG-RA-0015	Nuclear Safeguards
N-STD-RA-0024	Nuclear Safeguards Implementation

2.14 Packaging and Transport

Pickering NGS has an effective packaging and transport program that meets or exceeds all applicable regulatory requirements and related objectives. Packaging and transport of nuclear substances are conducted safely.

For specific areas within this SCA, the following subsections describe the objectives, key activities performed, and some planned improvements. These discussions also support that:

- Packaging and transport activities associated with the continued operation of the Pickering NGS will be conducted in a manner such that the risk to the public, workers, and the environment will be low.

2.14.1 Package Design and Maintenance

OPG controls the design of its radioactive materials packages and performs maintenance on the packages to ensure compliance with the Packaging and Transport of Nuclear Substances Regulations (PTNSR).

OPG owns and operates a fleet of radioactive materials packages of various types and capabilities. Some of the packages were designed by OPG and some were designed by external agencies. The engineering of new package designs (internally or externally produced) and modifications to existing packages are conducted in accordance with OPG's Engineering Change Control program and associated governance.

Each OPG radioactive materials transportation package (with the exception of one-time use packages) is subject to an annual maintenance outage. Package maintenance is performed in a dedicated facility located at the Western Waste Management Facility.

Each package is maintained in accordance with a package-specific procedure. Maintenance tasks include disassembly of major components, visual inspections of critical package features and components such as fasteners, and replacement or refurbishment of worn parts. The containment system of each package is tested to ensure its effectiveness.

Modifications to OPG's existing radioactive materials transportation packages are a rare occurrence due to the maturity of the designs.

All packages are maintained in proper condition to ensure there is no reduction in safety or operability.

Planned Improvements

OPG Nuclear Waste Management (NWM) is in the process of replacing its older transportation packages. The designs of the new packages incorporate improvements based on NWM's operating and maintenance experience, and utilize industry best practices.

2.14.2 Radioactive Material Transportation

The objective of the Radioactive Material Transportation (RMT) program is to ensure that shipments of radioactive material for which OPG is the consignor are prepared and offered for transport in a manner that is compliant with the Transportation of Dangerous Goods Regulations (TDG) and the Packaging and Transport of Nuclear Substances Regulations (PTNSR). This is done to ensure the safety of workers, the public, and the environment.

The *Radioactive Material Transportation* Program is owned by the Low and Intermediate Level Waste Operations and Radioactive Material Transportation (RMT) Department within the Nuclear Waste Management (NWM) division of OPG. The overall structure of the program is provided in W-PROG-WM-0002. OPG ensures that radioactive shipments are characterized, classified, packed, shipped, and received in accordance with approved procedures and applicable regulations. To ensure regulatory compliance, NWM issues and maintains a set of procedures and instructions that provide information on the correct means of handling, loading, and offering of radioactive material for shipment.

Table 8 below describes the various types of radioactive waste commonly shipped by Pickering Nuclear, and the packaging in which they are typically shipped.

Material	Packaging
Active Zone 2, and Zone 3 Waste	ISO-40 Trailer (IP-2 or Type A) & other Less than Type A Packaging
Filters, IX columns, hot particles	Radioactive Filter Transportation Package (Type B) & Multi-Purpose Transportation Package (Type B)
Spent Resin (in stainless steel liner)	Trillium Transportation Package (Type B)
High Active Waste (in drums)	Trillium Transportation Package (Type B)
Tritiated Heavy Water	TDO Package (Type B) Multi-Purpose Transportation Package (Type B)

Table 8 - Radioactive Material and Packaging

TDG regulations require that anyone who handles (i.e. loads, unloads, receives, classifies or ships) radioactive material in preparation for transport must be adequately trained or under the direct supervision of someone who is qualified. Within OPG, evidence that an employee is adequately trained for their function is demonstrated by holding a valid Class 7 Certificate of Training issued by RMT. To meet their responsibilities to the RMT Program, each work group maintains an adequate complement of trained Class 7 Handler/Receivers and Shippers. Each work group receives sufficient oversight from their line management to ensure compliance with RMT procedures. In addition, all Type A or Type B radioactive shipments are approved by an RMT Transportation Officer prior to leaving site.

Pickering has safely shipped hundreds of radioactive material packages, without any incident resulting in a radioactive release or serious personal injury.

2.14.3 Registration for Use

The objective of the user registration process is to ensure that OPG applies for and obtains confirmation from the CNSC that OPG's intended use of a radioactive materials transportation package of certified design has been registered. OPG has procedures in place for the registration for use of certified design packages.

OPG is currently a registered user for 12 different package designs. These packages include OPG's intermediate level waste and tritiated heavy water transportation packages, and shipping packages from external agencies and companies for used fuel, Cobalt-60, and radiation devices such as radiography cameras.

2.14.4 Transport Security Plan

The purpose of the transportation security plan is to govern security arrangements for shipments of Category III nuclear material by OPG. Specifically, it provides a description of the threat assessment of actions to be taken during the planning and execution of a Category III shipment.

There is a licensing requirement (Licence Condition 4) in the Licence to Transport (TL-S-12861-06.00/2018) to have a security plan, to ensure it is in effect during the licensing period and to review and update it annually.

The *Transport Security Plan* is documented in OPG document, TRAN-PLAN-03450-10000.

2.14.5 Applicable OPG Documents

The following documents are the applicable OPG documents which support the licensing basis and are to be listed in the Licence Conditions Handbook.

Document Number	Document Title
W-PROG-WM-0002	Radioactive Material Transportation
N-STD-RA-0036	Radioactive Materials Transportation Emergency Response Plan

3.0 Licensee Public Information Program

3.1 Public Information Program

OPG believes in open and transparent communication in a timely manner to maintain positive and supportive relationships and confidence of key stakeholders. OPG's Corporate Relations and Communications organization adheres to the principles and process for external communications as governed by the nuclear standard N-STD-AS -0013, *Nuclear Public Information and Disclosure*.

This document guides OPG's external community stakeholder activities, public response requirements of issues or significant events and OPG's standards to respond to concerns expressed by the public.

OPG's community relations and public information program has been recognized as a strength by national and international utility peers. OPG benchmarks current practices amongst other industries to ensure continuous performance improvement.

Each year a community engagement and consultation plan is developed to support OPG's business strategy to build community awareness and support of OPG and site operations that will result in sustained company reputation and positive community relations. The community relations program proactively provides information to stakeholders on Pickering operations and any effects on the community or environment that may result. The community information program ensures OPG continues to operate within an environment of limited public concern or intervention.

Pickering's community relations and public information program manages communications and relationships between Pickering and host communities by fostering healthy, open relationships and sustainable partnerships with community stakeholders, including government, media, business leaders, educational institutions, interest groups, and community organizations. In addition, Pickering strives to ensure transparent disclosure of operations and potential impacts, both positive and negative that may occur as a result of those operations.

OPG provides a quick response to issues and questions raised by stakeholders and the public, and tracks issues and questions to identify trends in order to further refine proactive communications. Two-way dialogue with community stakeholders and residents is facilitated through personal contact, community newsletters, speaking engagements, paid advertising and educational outreach.

3.1.1 Key Yearly Activities

OPG relies heavily on websites to provide up-to-date information that is easily accessible by the public and offers opportunities for further contact. The OPG website provides online access to information on environmental assessments and projects. It also carries regulatory information, such as relicensing hearings and event reports. Information brochures and fact sheets are also posted. OPG Nuclear and Pickering Nuclear Performance Reports are produced quarterly and published to the OPG website. The website provides an opportunity for users to email questions, comments and concerns.

Social media continues to increase in popularity and use. OPG actively monitors and responds to activity through Tweets, Facebook, and other social media platforms. OPG maintains a Twitter account, an Instagram account, and Tweets on relevant nuclear activities and information.

3.1.2 Station reporting

OPG regularly and proactively provides information to the public on its facility activities. For operational status changes or unscheduled operations that may cause public concern or media interest, OPG follows a protocol to notify key community stakeholders in a timely manner. OPG maintains a duty on-call position 24 hours a day, seven days a week.

In conjunction with the Durham Emergency Management Organization, OPG maintains a protocol to notify key community stakeholders via faxes, e-mails and telephone (as warranted) when there are activities or events that have the potential to garner public or media interest. The purpose of the protocol is to ensure contacts in the emergency agencies (fire, police, and emergency management) and political offices are kept aware and are able to respond accurately if they receive questions from constituents.

On a quarterly basis, OPG publicly posts performance reports on station operations at www.opg.com and shares this document electronically with key stakeholders. Additionally, starting in 2014 OPG developed and began issuing a quarterly Environment report in an easy to read and understandable format. Annually, OPG posts the Environmental Monitoring Program report on www.opg.com for both Pickering and Darlington.

3.1.3 Welcoming Visitors

Pickering NGS maintains an Information Centre to host public and school visitors. Visitors receive information on current operations and issues and are provided an opportunity to have questions addressed. Students are offered curriculum-based educational presentations and self-directed use of the centre.

OPG encourages community groups to use the Information Centre for events unrelated to the industry. Its meeting room and event space were built to help build greater ties to the community. By creating a meeting space, organizations otherwise unrelated to the industry gain a comfort and familiarity with the technology.

Information about station operations and public waterfront trails is distributed to new residents in the Pickering and Ajax community via the Welcome Wagon.

3.1.4 Community Outreach

OPG hosts an annual community information session. The sessions are widely advertised in the community and in nearby Toronto. At many of the sessions, staff from OPG, the Canadian Nuclear Safety Commission (CNSC), the Region of Durham, the City of Toronto Emergency Management Office, and the Office of the Fire Marshal and Emergency Management were on hand to answer questions and provide information about safety and station operations.

Figure 22 - 2015 Pickering Nuclear Community Information Session

Figure 23 - Information Sharing Session and Station Tour

As well, Pickering Nuclear provides presentations and tours to community groups, key stakeholders, industry partners and the general public as shown in Figure 22 and Figure 23.

Quarterly ads on station performance are placed in local newspapers. Ads on station activities and community events are also run in newspapers and aired on local television stations.

120,000 copies of *Pickering Neighbours* newsletter are distributed quarterly to all residents and businesses in the City of Pickering, Town of Ajax and Toronto East.

Since 2006, Pickering Nuclear's Corporate Relations and Communications has provided a community-based program known as "Tuesdays on the Trail", reaching over 16,000 community members on Tuesdays throughout the summer months of July and August at Alex Robertson Park, which is adjacent to the Pickering Nuclear site (Figure 24). The long standing community based program has been recognized as a good practice by external reviews. This program provides a forum for the OPG staff to educate the public on plant operations while also promoting environmental awareness.

Figure 24 - Tuesdays on the Trail – Summer 2016

3.1.5 Community Committees

Pickering Nuclear manages the Pickering Community Advisory Council (CAC) which meets monthly to exchange information and provide advice to senior plant management on environmental, economic and public concern. Media attends and reports on the meetings. Figure 25 shows a CAC meeting in progress.

Figure 25 - Joint DNGS and PNGS CAC meeting June 2015

Pickering Nuclear has a representative on the Durham Nuclear Health Committee (DNHC) and OPG Nuclear staff makes regular presentations to the DNHC on a variety of environmental, community outreach and operational issues. The committee is chaired by the Durham Region Medical Officer of Health.

3.1.6 Environmental Partnerships and Programs

Pickering Nuclear is committed to biodiversity work on public lands, on OPG property and within the host community. Pickering Nuclear's biodiversity program continues to provide planting, butterfly gardens, and numerous other initiatives. More than 15,000 native trees and shrubs have been planted in the vicinity of Pickering Nuclear since 2000 by OPG staff and community volunteers.

Since 2011, OPG has been a lead partner in the Bring Back the Salmon program with the Ontario Ministry of Natural Resources, and the Ontario Federation of Anglers and Hunters. The program is designed to help restore the Atlantic salmon population in Lake Ontario by 2020 as shown in Figure 26. The success of this partnership led to a recent nomination for Wildlife Habitat Council – Partnership of the Year award.

In January 2017, OPG's Nuclear Operations successfully received "Conservation Certification" for 2017-2019 from the international Wildlife Habitat Council and Pickering Nuclear has twice been recognized as Wildlife Habitat of the Year.

Figure 26 - Students helping to raise salmon eggs in the Pickering Information Centre.

3.1.7 Employee Communications

The Corporate Relations and Communications (CRC) Department's Employee Communication division at Pickering Nuclear works to keep employees informed on station, fleet-wide company and industry issues in a timely, accurate and consistent manner by working collaboratively with station leadership and staff to develop and implement strategic station-wide communications programs. These comprehensive programs support Pickering's vision of working together, as well as overall business objectives, work programs and goals to effectively drive improvements and support the safe and reliable operations of the plant. Additionally, the messages used within these communication programs help to foster alignment, engagement and teamwork amongst the intended audiences.

The internal CRC team develops annual communications strategies to support Pickering's business plans and vision, major on-site projects, initiatives and events. They include selected services and materials designed to achieve the communications goals. This ensures consistent communications have a positive, long-term impact on workforce alignment and engagement using a reliable two-way information exchange by way of the supervisory chain and meaningful face-to-face communication with direct reports, as well as more informal and formal online information channels. Pickering site communications anchor and reinforce key messages through multiple channels, including but not limited to face-to-face meetings, intranet websites, site-wide emails, posters and banners, in-station TV screens, and videos.

The CRC leads a number of initiatives throughout the year to measure and gauge the effectiveness of the strategies to promote a process of continual learning and improvement.

External evaluators and review teams continue to recognize the positive contributions of internal communications on the culture at Pickering.

3.1.8 Applicable OPG Documents

The following documents are the applicable OPG documents which support the licensing basis and are to be listed in the Licence Conditions Handbook.

Document Number	Document Title
N-STD-AS-0013	Nuclear Public Information and Disclosure

3.2 Aboriginal Consultation

Pickering NGS has an Indigenous Relations program in compliance with *REGDOC-3.2.2 Aboriginal Engagement.*

Under its Indigenous Relation Policy, OPG acknowledges the Aboriginal and Treaty rights of Indigenous communities as recognized in the *Constitution Act, 1982* and regularly undertakes engagement with Indigenous communities with asserted or established Aboriginal and treaty rights and/or interests proximate to Pickering NGS. These communities include:

- Members of the Williams Treaties First Nations:
  - Scugog First Nation;
  - Hiawatha First Nation;
  - Curve Lake First Nation, and
  - Alderville First Nation.
- Mississaugas of the New Credit First Nation
- Mohawks of the Bay of Quinte
- Métis Nation of Ontario, Region 8

OPG meets with these Indigenous communities on an ongoing basis to provide details of nuclear operations, reports and to discuss interests and identify concerns over current and future operations. OPG also maintains a listing of all relevant documents and notices on a designated external website for such events as the Pickering NGS licence renewal, and provides notification of site updates to communities when they occur.

Beginning in 2015, OPG began a renewed series of conversations on how communities proximate to Pickering NGS wished to be engaged; what information should be provided and discussed; frequency of meetings; and capacity support for communities to assist them in understanding potential impacts or concerns. The scope of the engagement was discussed and agreed upon; consultation protocols were reviewed; representatives were identified, and work objectives outlined.

OPG also provided community information sessions to Curve Lake and Hiawatha at their request in August 2016 (both members of the Williams Treaties First Nations), which covered the Pickering Waste Management Facility (PWMF) and Pickering site licensing processes among other topics.

As a part of OPG's overall engagement with the Indigenous community as a whole, tours have been undertaken by Indigenous communities that have rights or interests in current and planned OPG Nuclear and related operations. There were two Indigenous community specific tours in 2016 of the PWMF, with twenty-two participants. There was also a tour for Williams Treaties First Nations representatives on January 19, 2017.

Further, engagement meetings were undertaken with representatives of the Williams Treaties First Nations, Mississaugas of New Credit, Mohawks of the Bay of Quinte and the Métis Nation of Ontario Region 8 between January and March 2017 regarding OPG's fish impingement and entrainment mitigation and off-set measures. Engagement on this topic and others, with an emphasis on Pickering re-licensing, will be undertaken between September 2017 and February 2018.

Additionally, OPG participated in the second annual Aboriginal Apprenticeship Board of Ontario (AABO) *Day in the Trades* event, hosted by LiUNA Local 183 at their facility in Cobourg. Representatives from various building trades, suppliers and contractors interacted with Indigenous high school students from the communities as diverse as the Mohawks of the Bay Quinte, Curve Lake First Nation, Pikwakanagan First Nation and Durham Region Métis.

The OPG Native Circle, made up of Indigenous employees, organizes and hosts the annual National Aboriginal Day celebrations every June and oversees the John Wesley Beaver Memorial Awards for Indigenous post-secondary students. The Native Circle serves, in part, as a connection to the wider Indigenous community and participates in various Indigenous events, e.g., the annual *Indspire* career fair, where OPG is one of the sponsors.

Indigenous community representatives have expressed the following concerns and OPG has initiated or will implement the following communication sessions:

- Transportation and storage of nuclear waste - OPG continues to inform and educate communities, additional information sessions are being planned on OPG's Transportation Emergency Response Plan.

- Emergency preparedness and the ability for community members to be notified - OPG has provided information on notification protocols by OPG and appropriate authorities.

- Environment and fish impact as a result of operations - Numerous presentations on OPG's efforts to reduce fish impingement and entrainment have been provided.

- Potential outcome of an event that could impact their traditional territories given the close relationship First Nations and Métis have with the land - OPG continues to provide information on actual risks of operations and response and lessons learned that have been applied as a result of the Fukushima event in Japan.

- Desire to remain involved in future environmental monitoring opportunities - OPG commits to ongoing, participatory engagement and involvement of communities in the results and efforts to appropriately confirm environmental impacts of operations.

- An expressed interest in economic opportunities through procurement and employment through OPG's nuclear operations – as part of its Silver designation from the Canadian Council for Aboriginal Business' Progressive Aboriginal Relations (PAR) program, OPG is working to improve its business procurement and employee recruitment with local Indigenous communities.

4.0 Program for Cobalt-60

4.1 Cobalt-60

OPG produces Cobalt-60 as a commercial by-product at Pickering 5-8. Cobalt-60 is an important radioisotope with a wide range of industrial, medical, and food processing applications, and is a product that provides broad societal benefits. Cobalt production has been an important part of the Canadian nuclear industry since its inception, and Pickering NGS is a major supplier of Co-60. Pickering Units 6, 7 and 8 are fitted with adjuster elements consisting of a number of bundles strung end to end (similar in configuration to that of a fuel bundle). Each bundle is comprised of a number of pencils containing cobalt slugs. The Cobalt adjuster elements are then harvested during planned unit outages. Cobalt-60 rods are then packaged and shipped off-site.

Cobalt-60 is shipped off-site in accordance with the Transportation of Dangerous Goods Regulations and Packaging and Transport of Nuclear Substances Regulations. No spent Cobalt-60 has been received at Pickering from any off-site commercial facility.

The procedures which are used for Cobalt-60 processing and transfer are listed below. Pickering has not received any cobalt from MDS Nordion with an activity greater than 0.3 TBq in this licence period to-date, and will continue to submit the appropriate reports should any Cobalt-60 be received.

4.2 Applicable OPG Documents

Document Number	Document Title
P-OP-31985-0001	Cobalt Processing Procedure
P-OM-018-31985-01	Cobalt Processing – Table of Contents / Revision History
P-OM-018-31985-04.04.12	Cobalt Processing – Cobalt Handling

5.0 References

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3 Letter, B. McGee to H. Overton, "Submission of Pickering NGS Periodic Safety Review 2 (PSR2) Basis Document Revision 001", June 3, 2016, P-CORR-00531-04752.

4 Letter, R. Lockwood to G. Frappier, "End Date of Commercial Operations for Pickering NGS", June 28, 2017, P-CORR-00531-04930.

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8 Letter, B. McGee to A. Vikorov, "Pickering NGS – CNSC Action Item 2016-48-7470 Status Update on Emergency Mitigation Equipment and Telecommunications Projects", February 16, 2017, P-CORR-00531-04945.

9 Letter, B. McGee to A. Vikorov, "Pickering NGS – Risk Improvement Plan Update", February 27, 2017, P-CORR-00531-04946.

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13 Protocol, "OPG-CNSC Protocol for the Conduct of a Periodic Safety Review in Support of Pickering NGS Licence Renewal", January 17, 2017, e-Doc 5143721, P-CORR-00531-04725 R001.

14 Email, P. Herrera to A. Viktorov, "Pickering NGS Sustainable Operations Plan (SOP) - Revision to 2016 Update", January 9, 2017, P-CORR-00531-04943.

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16 Letter, K. Dehdashtian to A. Viktorov, “Pickering Quarterly Report on Nuclear Power Plant Personnel - Fourth Quarter 2016”, March 30, 2017, P-CORR-00531-04986.

17 Letter, K. Dehdashtian to A. Viktorov, “Pickering Quarterly Report on Nuclear Power Plant Personnel - First Quarter 2017”, June 30, 2017, P-CORR-00531-05066.

18 Email, L. Mitchell to M. Santini and A. Viktorov, “CNSC Staff’s Written Notification of Document Change: N-PROG-RA-0018, Nuclear Pandemic Plan, R003 Superseded”, June 27, 2017, N-CORR-00531-18652.

19 Letter, W.S. Woods to A. Viktorov and M. Santini, “Progress Report on OPG Heat Transport System Aging Safety Analysis”, February 24, 2017, N-CORR-00531-18427.

20 Letter, R. Lockwood to A. Viktorov, Pickering Units 1 to 4: Updated Fire Hazard Assessment (FHA) and Fire Safe Shutdown Analysis (FSSA) Reports - CNSC Action Item 2015-48-6623 - Request for Closure”, June 30, 2017, P-CORR-00531-05062.

21 Letter, B. McGee to A. Viktorov, “Pickering Units 5 to 8: Updated Fire Hazard Assessment (FHA) and Fire Safe Shutdown Analysis (FSSA) Reports - CNSC Action Item 2015-48-6303 - Request for Closure”, March 31, 2017, NK30-CORR-00531-07407.

Appendix A – Activities and Nuclear Substances to be Encompassed by the Licence

The information below is provided to satisfy the requirements of Section 3(1)(b) of the General Nuclear Safety and Control Regulations.

Activities to be Licensed:

The application for renewal of Power Reactor Operating Licence (PROL) 48.03/2018 contains information for the activities to be licensed. These activities include those currently licensed in PROL 48.03/2018:

(i) Operate the Pickering Nuclear Generating Station units 1, 4, 5, 6, 7 and 8, for power production, and operate units 2 and 3 in the safe storage phase at a site located in the City of Pickering, in the Regional Municipality of Durham, in the Province of Ontario.

(ii) Possess, transfer, use, package, manage and store the nuclear substances that are required for, associated with, or arise from the activities described in [i].

(iii) Possess and use prescribed equipment and prescribed information that are required for, associated with, or arise from the activities described in [i].

(iv) Possess, use, manage and store enriched uranium as required for fission chambers for the Pickering Nuclear Generating Station units 1 and 4 Shutdown System Enhancement, including spares.

(v) Possess, produce, manage, transfer and store Cobalt-60.

(vi) Possess, manage and store Cobalt-60 sealed sources.

(vii) Possess, transfer, manage and store heavy water from other nuclear facilities.

Additional activities requested to be licensed include the activities associated with the Stabilization and Safe Storage with Surveillance phases described in this application, including to:

Operate the Pickering Nuclear Generating Station units 1, 4, 5, 6, 7 and 8 in the safe storage phase at a site located in the City of Pickering, in the Regional Municipality of Durham, in the Province of Ontario, following the end of commercial operation of these units.

The table below is provided to satisfy the requirements of Section 3(1)(c) of the General Nuclear Safety and Control Regulations. The data provided are current as of June 2017.

Nuclear Substance	Form	Location	Maximum Quantity
Natural Uranium	Solid Fuel Bundles[1]	New Fuel Inventory	11177 bundles
Depleted Uranium	Solid Fuel Bundles[1]	New Fuel Inventory	508 bundles
	Solid	Tooling and Shielding	~26000 kg
	Solid Spent Fuel Bundles[1]	IFB-A, AIFB & IFB-B	399703 bundles
Irradiated Uranium	Solid[1,2] Fuel Bundles	Pick A Reactor Cores - Units 1 & 4	9360 bundles
	Solid[1] Fuel Bundles	Pick B Reactor Cores - Units 5, 6, 7 & 8	18240 bundles
Heavy Water	Liquid (D_2O)	Units 1,4,5,6,7 & 8	3000 Mg
	Liquid (D_2O)[3]	Storage	2100 Mg (Note 3)
Cobalt-60	Solid	Units 6, 7 & 8	6.3 MCi
	Solid	AIFB	0 MCi
Enriched Uranium	Solid	Painted layer on the tubes of Fission Chambers[4]	24 Fission chambers

Notes:

1. A fuel bundle contains on average 20.142 kg U.
2. Pickering Unit 2 and 3 have been defueled and are in the Safe Storage State.
3. Heavy water storage is the maximum capacity of heavy water that can be stored at Pickering; the current inventory of heavy water (in the units and stored) is 3556 Mg.
4. A fission chamber contains on average 3.56 g U-235 (93% enriched). This includes Fission chamber detectors used in SDSE in PNGS 014 and in Core Discharge Monitoring System in PNGS 014 and 058.

Appendix B - Financial Guarantee, Nuclear Liability Insurance and Cost Recovery

Financial Guarantee

The objective of OPG's financial guarantee is to ensure that sufficient funds are estimated, collected and administered for the management of liabilities associated with operating and decommissioning of all its nuclear facilities. The financial guarantee is prepared for all OPG owned or leased facilities and makes specific financial provisions for the decommissioning of the Pickering Nuclear Generating Station. The Pickering *Preliminary Decommissioning Plan* (Reference B-1) forms the basis for establishing and maintaining an acceptable Financial Guarantee.

In addition to the decommissioning program, OPG's Financial Guarantee also covers financial provisions for the long-term management (storage and eventual disposal) of all operational and decommissioning wastes (Used Fuel, Low Level and Intermediate Level Wastes).

OPG's financial guarantee is prepared and maintained on a five-year cycle in accordance with the requirements set out in CSA Standard N294-09 and CNSC regulatory documents G-219 and G-206. OPG also provides an annual financial guarantee report to the CNSC detailing the status of the guarantee including the amounts accumulated in segregated funds and the value of the Provincial guarantee required. The report compares the amount of the liabilities and the financial resources available to discharge the obligations.

The financial guarantee provisions for Pickering demonstrate that the current level of funding is adequate for decommissioning the station and returning the site to an end state agreed with the Regulators. The 2013 - 2017 CNSC financial guarantee was approved by the CNSC in December 2012.

The 2018 - 2022 CNSC financial guarantee is based on the decommissioning and operational waste management cost estimates completed by OPG in 2016 as part of the five-year Ontario Nuclear Funds Agreement (ONFA) reference plan update cycle and was submitted to the CNSC in the spring of 2017 for Commission approval by Hearing, to be held before the end of 2017. The update has been previously submitted for approval to the Ontario Finance Authority (OFA) and approved in December 2016 [Reference B-2].

OPG will continue to provide annual Financial Guarantee reports to the CNSC detailing the status of the guarantee including the amounts accumulated in segregated funds and the value of the Provincial Guarantee (if required).

Nuclear Liability

OPG is required, under the Nuclear Liability and Compensation Act (NLCA), to maintain $650 million of nuclear liability insurance for its Pickering nuclear generating station in 2017. The NLCA increases OPG's nuclear liability limit from $650M to $750M, $850M and $1B in 2018, 2019 and 2020 respectively. OPG will purchase nuclear liability insurance in accordance with the requirements of the NLCA. The following certificate of insurance verifies that the insurance required by the NLCA for 2017 is in place. Insurance inspections are conducted at Pickering every 18 months by nuclear property insurers. These inspections are also attended by conventional insurers who inspect the non-nuclear side of the station.

MARSH

Certificate of Insurance

No.: **2017-2** Dated: **January 03, 2017**

This document supersedes any certificate previously issued under this number

This is to certify that the Policy(ies) of insurance listed below ("Policy" or "Policies") have been issued to the Named Insured identified below for the policy period(s) indicated. This certificate is issued as a matter of information only and confers no rights upon the Certificate Holder named below other than those provided by the Policy(ies).

Notwithstanding any requirement, term, or condition of any contract or any other document with respect to which this certificate may be issued or may pertain, the insurance afforded by the Policy(ies) is subject to all the terms, conditions, and exclusions of such Policy(ies). This certificate does not amend, extend, or alter the coverage afforded by the Policy(ies). Limits shown are intended to address contractual obligations of the Named Insured.

Limits may have been reduced since Policy effective date(s) as a result of a claim or claims.

Certificate Holder:	Named Insured and Address:
Canadian Nuclear Safety Commission **Headquarters** **280 Slater Street P.O. Box 1046** **Station B** **Ottawa, ON K1P 5S9**	**Ontario Power Generation Inc.** **700 University Avenue, H18-J18** **Toronto, ON M5G 1X6**

This certificate is issued regarding:
Pickering NGS

Type(s) of Insurance	Insurer(s)	Policy Number(s)	Effective/ Expiry Dates	Sums Insured Or Limits of Liability	
NUCLEAR LIABILITY • Pickering	Nuclear Insurance Association of Canada	OF104	Jan 01, 2017 to Jan 01, 2018	Limit of Liability	$ 403,000,000 out of $650,000,000
NUCLEAR LIABILITY • Pickering	Lloyd's Underwriters	NCNTPL56	Jan 01, 2017 to Jan 01, 2018	Limit of Liability	$ 47,000,000 out of $650,000,000
NUCLEAR LIABILITY • Pickering	Euro Liab. Ins for the Nuc. Ind. (ELINI)	EL031CA17	Jan 01, 2017 to Jan 01, 2018	Limit of Liability	$ 25,000,000 out of $650,000,000

Additional Information:
In accordance with their rights under the Nuclear Liability and Compensation Act, Ontario Power Generation Inc. has retained $175,000,000 out of the total policy limit of $650,000,000.

Notice of cancellation:
The insurer(s) affording coverage under the policies described herein will not notify the certificate holder named herein of the cancellation of such coverage.

Marsh Canada Limited
120 Bremner Boulevard
Suite 800
Toronto, ON M5J 0A8
Telephone: 1-844-990-2378
Fax: 416-868-2526
certificaterequestscanada@marsh.com

Marsh Canada Limited

[redacted]

By: [redacted]

Cost Recovery

Pursuant to the *Canadian Nuclear Safety Commission Cost Recovery Fees Regulation*, Ontario Power Generation pays the CNSC's fees on a quarterly basis.

References

B-1 OPG letter, S. Granville to K. Glenn, A. Viktorov, and M. Santini, "Submission of Preliminary Decommissioning Plans," January 30, 2017, N-CORR-00531-18384.

B-2 OFA Memorandum, R. Kwan to J. Mauti, "Ontario Nuclear Funds Agreement Reference Plan," December 20, 2016, N-CORR-00960-0634854.

Appendix C - Licences, Internal Authorizations, Certificates and Summary of Environmental Regulatory Requirements

C.1 Licences, Internal Authorizations and Certificates

The following provides a list of Licences, Authorizations and Certificates held by OPG that are relevant to the Pickering Nuclear Generating Station. Note this information is current as of February 28, 2017.

Federal (other than CNSC)

Certificates and Authorizations	
Transport Canada	
Permit	**Description**
8200-08- 7095	The Pickering Fish Diversion System (Mesh Barrier) has a permit under the *Navigation Protection Act* (formerly the *Navigable Waters Protection Act*).

Provincial

Certificates and Authorizations	
Technical Standards and Safety Authority (TSSA)	
Registration Number	**Description**
R-8261	The Pickering heating steam boiler (OIN 5.913573) has been issued an Ontario Certificate of Registration of a Plant, Registration Number R-8261 (issue date Aug. 2, 2006 for Standby Boiler and Main Security Building (MSB) HP Chiller Refrigeration unit). The boiler supports Pickering 014 and Pickering 058 (formerly referenced as Pickering A and Pickering B stations) and is physically located at Pickering 058. The chiller supports the MSB only.
Elevators	Licences to operate elevators are granted by the Technical Standards and Safety Authority (TSSA), Elevating Device Branch. The complete list of the licences for elevators at Pickering can be provided as requested.
Pressure Vessels	An electronic register is maintained at Pickering of all valid pressure vessel certificates issued by the Technical Standards and Safety Authority. This register is maintained on an on-going basis. Copies of certificates are available upon request.

Certificates of Authorization	Description
QA 00854	Repair and alteration of boilers and pressure vessels, fittings and piping.
QA 00853	Fabrication of welded and non-welded category A, B, D & H type fittings.
QA 00852	Fabrication and assembly of refrigeration piping.
QA 00851	Fabrication and assembly of process piping.
QA 00850	Fabrication and assembly of power piping.
QA 00845	Fabrication of Class 1, 2 & 3 Welded and Non-Welded category A, B, D & H type fittings.
QA 00844	Fabrication of Class 1, 2, 3 & 4 Welded and Non-Welded Supports.
QA 00843	Class 1, 2, 3 & 4 With Design Responsibility for Appurtenance and Supports; as a Material Organization Supplying Ferrous and Nonferrous Material.
QA 00842	Construction of Class 1, 2, 3 & 4 Piping Systems; Class 1, 2 & 3 Shop Assembly; as a Material Organization Supplying Ferrous and Nonferrous Material.
QA 04144	Repairs, Modifications or Replacements of Class 1, 1C, 2, 2C, 3, 3C, and 4 Nuclear Items.

Ministry of Labour (MOL)			
X-Ray Machine Registrations			
MOL Site Registration Code	Location	Portable/Fixed Equipment	Quantity
0243.3	Main & Aux Security Buildings	Fixed - Baggage Security	6
0243.3	East Complex Warehouse	Fixed – Large Article Security	1
0243.3	PNGS	Portable XRF	3
0243.3	PNGS	Portable Pulsed X-Ray	4
0243.3	PNGS	Portable/Bench Top Analytical XRF	1
0243.3	PNGS	Portable/Bench Top Analytical XRF Analyzer	1

Ministry of the Environment and Climate Change (MOECC)		
Environmental Compliance Approval (ECA)	**Description**	**MOE Routine Reporting Requirements**
4881-5MHQ9F (Industrial Sewage)	Pickering Site Operation Comprehensive Certificate of Approval (sewage) dealing with (but not limited to): • Outfall chemical limits • Service water chlorination and dechlorination limits • Condenser Leak Testing • Condenser Tube Cleaning • Phosphate Detergent use • Secondary Side Discharge volume and chemical limits • Standby Boiler Discharge volume and chemical limits • Spill Containment Discharge chemical limits • Yard Drainage Discharge chemical limits • Inactive Drainage Discharge chemical limits • Standby Generator Spill Containment Discharge chemical limits • Upgrader Discharge chemical limits	Annual performance report by June 1 of following calendar year summarising (but not limited to): • Compliance data • Exceedances and actions taken • Number of condenser leak tests conducted
4881-5MHQ9F Notice 5 (Industrial Sewage)	Station Temperature Limits Catering to: 1. Normal Operation 2. Electricity Supply Emergencies Algae Runs	Notification as follows (but not limited to): • Whenever Electricity Supply Emergency Declared by IESO • Whenever Algae Run results in evident fish kill • Whenever limit exceedances occurs Temperature monitoring data compiled by end of Q1 of following calendar year and provided to MOE upon request.
2460-A2NHF2	PNGS-A Permit to Take Water	Notify Director of complaints received, annual use, changes of address, ownership etc.
2731-8ULK95	PNGS-B (Pickering 058) Permit to Take Water	Notify Director of complaints received, annual use, changes of address, ownership etc.
A390401 (Waste Disposal)	Closure of East Landfill Site	None
A390407 (Waste Disposal)	Closure of West Landfill Site	None

Certificate of Approval (C of A)	Description	MOE Routine Reporting Requirements
4766-A3YMB9 (Air)	Pickering Site Operation Environmental Compliance Approval (Air) (Limited Operational Flexibility)	Annual performance report by June 1 of following calendar year summarising (but not limited to): • Changes to Point of Impingement concentrations or emission rates for Compounds of Concern • Listing of Compounds of Concern Physical changes affecting Compounds of Concern
5683-6XAMAB (Industrial Sewage)	Auxiliary Power System	Notify the District Manager if the process is not operated in accordance with limits/requirements set out in certificate.
0947-A7NM85	New Water Treatment Plant Operation- Environmental Compliance Approval (Sewage) (Limited Operational Flexibility)	OPG, on behalf of Ondeo-Nalco, to provide reports on: • Sampling results as required under MISA Regulation Part II • Sampling point or toxicity testing frequency changes • MISA reports as required under MISA Regulation part VIII. OPG to submit to District Manager no later than 45 days after end of each quarter a summary of the chlorine and anti-scalant monitoring results.

C.2 Summary of Environmental Regulatory Requirements

OPG Law Division maintains a summary list of federal, provincial and municipal environmental regulatory requirements that may be applicable to the nuclear facility. Some examples of environmental regulatory requirements included in the Registry are identified in the table below, a list of all regulations can be provided as requested.

Federal Requirements
Canada Wildlife Act
Canadian Environmental Assessment Act, 2012
Canadian Environmental Protection Act
Environmental Violations Administrative Monetary Penalties Act
Fisheries Act
Migratory Birds Convention Act
National Fire Code
Navigation Protection Act
Pest Control Products Act
Species at Risk Act
Transportation of Dangerous Goods Act

Provincial Requirements
Beds of Navigable Waters Act
Clean Water Act
Conservation Authorities Act
Dangerous Goods Transportation Act
Drainage Act
Emergency Management and Civil Protection Act
Endangered Species Act
Environmental Assessment Act
Environmental Bill of Rights
Environmental Protection Act
Fire Protection and Prevention Act
Fish and Wildlife Conservation Act
Green Energy Act
Highway Traffic Act
Municipal Act
Occupational Health and Safety Act
Ontario Building Code
Ontario Heritage Act
Ontario Water Resources Act
Pesticide Act
Planning Act
Public Lands Act
Road Access Act
Safe Drinking Water Act
Technical Standards and Safety Act
Toxics Reduction Act
Water Opportunities Act
Weed Control Act
Waste Diversion Act

Municipal and Regional Requirements: By-laws of the City of Pickering and Durham Region
Sewer Use By-law
Noise By-Law
Waste By-law
Emergency Management By-law
Tree Conservation By-law
Municipal Waste Collection By-law

Other Provincial Regulatory Requirements
Electricity Act – 1998 and Market Rules

Table of Routine Environmental Regulatory Reporting (not including the CNSC reporting)

Report Title	Frequency	Required By:
Environment Canada		
Halocarbon Release Report	Semi-Annual	Federal Halocarbon Regulations SOR/2003-289 Section 33.1
Environment Canada and Ontario Ministry of Environment and Climate Change		
National Pollutant Release Inventory (NPRI)	Annual	CEPA 99 Sect. 48.
Ontario Ministry of Environment and Climate Change		
Municipal/Industrial Strategy for Abatement (MISA) Report	Annual	O. Reg. 215/95
Municipal/Industrial Strategy for Abatement (MISA) Quarterly Report(3)	Quarterly	O. Reg. 215/95
Landfill Inspection	Biannual	C of A A390401
Registration of Wastes to MOE (hazardous wastes)	Annual	O. Reg. 347
PCB Report	Annual	Director's Instructions for site 304-86A-022 and 304-82-A-009
Waste Reduction Work Plan (Conventional)	Annual	O. Reg. 102/94
Annual Water Taking and Use Report	Annual	O. Reg. 387/04
Certificate of Approval Industrial Sewage Works Annual Performance Report	Annual	C of A Sewage Works # 4881 - 5MHQ9F
Certificate of Approval Air Written Summary	Annual	C of A Air # 9090 - 6SBGEH
Ontario Regulation 127/01 Report	Annual	O. Reg. 127 / 01

Appendix D – CNSC Action Items

(Freeze Date for New Action Items is May 2, 2017)

Action Item	Title	Status	Next Update Due
2017-OPG-9746	Darlington and Pickering NGS: CNSC Type II Compliance Inspection Report: Organization, Roles and Responsibilities	OPG to provide a progress update	13SEP2017
2017-OPG-9721	DNG and PNG: 2016 Third Party Industrial Fire Brigade Drill Audit Reports	OPG to provide a progress update	30JAN2018
2017-OPG-9657	Darlington and Pickering NGS: CNSC Calandria-tube Strain Contact Boiling Experiments	OPG to provide a progress update	15SEP2017
2017-OPG-9637	Darlington and Pickering NGS: Implementation of REGDOC-2.2.4 Human Performance Management -Worker Fatigue	OPG to provide a progress update	30SEP2017
2017-OPG-9636	Darlington and Pickering NGS: Fuel and Pressure Tube Fitness-For-Service	OPG to provide a progress update	15DEC2017
2017-OPG-8928	Darlington and Pickering NGS: Desktop Review of OPG's Procedure N-INS-61400-10008 R005	OPG requested closure of Action Item	N/A
2017-48-9902	PNGS: Morpholine Sampling At The 058 Condenser	OPG to provide a progress update	16FEB2018
2017-48-9791	PNGS: Inspection report: Planned maintenance outage	OPG requested closure of Action Item	N/A
2017-48-9745	PNGS: Type II compliance report: worker dose control	OPG to provide a progress update	01NOV2017
2017-48-9588	Pickering NGS: CNSC Type II Compliance Inspection Report: Q3, Fiscal Year 2016-2017	OPG to provide a progress update	30NOV2017
2017-48-9550	Pickering NGS: CNSC Type II System Inspection Report: Monitoring System	OPG to provide a progress update	30OCT2017
2017-48-9469	Pickering NGS: CNSC Desktop Review Report- Radiation Protection Technician Training Program	OPG requested closure of Action Item	N/A
2017-48-9430	Pickering NGS: CNSC Type II Compliance Inspection Report: Environmental	OPG to provide a progress update	13OCT2017
2017-48-9329	Pickering NGS: CNSC Type II Compliance Inspection Report: Electrical Distribution System	OPG to provide a progress update	25AUG2017
2017-48-9205	Procedures for Obtaining Material Samples with Circumferential Wet Scrape Tool (CWEST)	OPG requested closure of Action Item	N/A

Action Item	Title	Status	Next Update Due
2017-48-10956	PNGS: Accessibility for IAEA inspections	OPG to provide a progress update	08MAR2018
2016-OPG-8975	Darlington and Pickering NGS: Revised CSA N285.8 Compliance Plan	OPG requested closure of Action Item	N/A
2016-OPG-8370	Darlington and Pickering NGS: Supplemental Response Regarding Stack Effluent	OPG to provide a progress update	30SEP2017
2016-OPG-8250	Darlington and Pickering NGS: Post Closure Fuel Management and Surveillance Software Upgrade	OPG to provide a progress update	31MAY2018
2016-OPG-8187	Darlington and Pickering NGS: Engineering Training Programs	OPG to provide a progress update	27OCT2017
2016-OPG-7967	Darlington and Pickering NGS: Direct Plant Data Transfer to the CNSC Emergency Operating Centre (EOC)	OPG to provide a progress update	30NOV2017
2016-OPG-7469	Fukushima- Implementation of the ERP code upgrades	OPG requested closure of Action Item	N/A
2016-OPG-7413	Darlington and Pickering NGS: CNSC Type II Compliance Inspection Report: Environmental Monitoring	OPG to provide a progress update	29SEP2017
2016-48-8871	Pickering Unit 6: 2015 Outage Fuel Channel Inspections -	OPG requested closure of Action Item	N/A
2016-48-8142	Revision of PBRA, include Rod Based GSS	OPG to provide a progress update	15DEC2017
2016-48-8096	Pickering NGS: CNSC Type II Compliance Inspection Report: PRPD-2016-009, Fiscal Year 2015-2016	OPG requested closure of Action Item	N/A
2016-48-8028	Pickering NGS: CNSC Type II Compliance Inspection Report: Configuration management	OPG to provide a progress update	22SEP2017
2016-48-7893	PNGS REGDOC 3.1.1 Preliminary Event Report	OPG to provide a progress update	25AUG2017
2016-48-7797	Pickering NGS: CNSC Type II Compliance Inspection Report: Preservation of Seismic Design Basis	OPG to provide a progress update	16MAR2018
2016-48-7613	Pickering NGS: CNSC Type II Compliance Inspection Report: Fuel Channel Pressure Tubes Supplementary Inspections	OPG requested closure of Action Item	N/A

Action Item	Title	Status	Next Update Due
2016-48-7588	PNGS: Type II Inspection Effluent Control and Monitoring	OPG to provide a progress update	15MAR2018
2016-48-7470	Implementation of the Emergency Mitigating Equipment (EME) and Telecommunications projects	OPG to provide a progress update	07MAR2018
2016-13-7638	PNGS Changes to Site Access Security Clearance Process	OPG to provide a progress update	30SEP2017
2015-OPG-7000	Darlington and Pickering NGS: Acceptance Criterion for Method	OPG to provide a progress update	29SEP2017
2015-48-7304	Pickering NGS: CNSC Type II Compliance Inspection Report, Electrical Power System	OPG to provide a progress update	08NOV2017
2015-48-7237	PNGS: CNSC Type II Compliance Inspection Report: PRPD-2015-019, Fiscal Year 2015-2016	OPG requested closure of Action Item	N/A
2015-48-7043	Type II Compliance Inspection Report - Integrated Aging Management Program	OPG to provide a progress update	23FEB2018
2015-48-6946	Type II Compliance Inspection – Management Review – PRPD-2015-013	OPG to provide a progress update	25AUG2017
2015-48-6623	Request for Acceptance of the Fire Hazard Assessment (FHA) and Fire Shutdown Assessment (FSSA)	OPG requested closure of Action Item	N/A
2015-48-6500	Pickering NGS - Type II Compliance Inspection - System Inspection Irradiated Fuel Bays	OPG to provide a progress update	31DEC2017
2015-48-6459	Pickering NGS - Type II Compliance Inspection - Equipment Inspection	OPG to provide a progress update	24NOV2017
2015-48-6458	Pickering Units 1 &4: Revised Component Disposition – Pressure Tube to Calandria Tube Contact	OPG requested closure of Action Item	N/A
2015-48-6450	Pickering NGS - Type II Compliance Inspection - Maintenance Work Execution	OPG to provide a progress update	25AUG2017
2015-48-6381	Replacement of SDS1 Ion Chamber Amplifiers	OPG to provide a progress update	31JUL2018
2015-48-6303	Pickering Units 5-8: Fire Hazard Assessment (FHA) and Fire Safe Shutdown Assessment (FSSA)	OPG requested closure of Action Item	N/A
2014-OPG-5632	Darlington and Pickering NGS: Request for re-categorization of Safety Issue: Computer Code and Plant Model Validation	OPG requested closure of Action Item	N/A

Action Item	Title	Status	Next Update Due
2014-OPG-4862	Darlington and Pickering NGS: OPG Revised CSA N285.8 Compliance Plan	OPG requested closure of Action Item	N/A
2014-OPG-4782	Approach to Fitness for Service Assessment for Pressure Tubes	OPG to provide semi-annual progress updates	31OCT2017
2014-48-5823	Type II Compliance Inspection - Implementation of Pressure Boundary Program	OPG to provide a progress update	06OCT2017
2014-48-5658	Configuration Management Findings Related to Maintenance Outage	OPG to provide a progress update	13DEC2017
2014-48-5396	P1481 Rolled Joint Scrape Inspection Report	OPG requested closure of Action Item	N/A
2014-48-5386	CNSC Review of 2013 Pickering Nuclear Groundwater Monitoring Program Results Report	OPG to provide a progress update	22FEB2018
2014-48-5348	Pickering Units 5-8: Core Assessments Relating to Pressure Tube Integrity	OPG to provide a progress update	26JAN2018
2014-48-5032	Pickering Units 1 to 4: Type II Compliance Inspection Report - Quarterly Field Inspection Report,	OPG to provide a progress update	12OCT2017
2014-48-4629	Pickering NGS Type II Compliance Inspection - Chlorination and De-Chlorination Systems	OPG to provide a progress update	01DEC2017
2014-4-4856	CNSC Type II Compliance Inspection Report: Planned Maintenance Outage	OPG to provide a progress update	04DEC2018
2013-4-4047	Type II Compliance Inspection - Report #PRPD-PICKA-2012-165	OPG to provide a progress update	31JAN2018
2013-4-3947	Pickering A Type II Compliance Inspection Report, Q2 2012-2013, PRPD-PICKA-2012-155	OPG requested closure of Action Item	N/A
2012-4-3761	Type II Compliance Inspection Electrical Distribution System	OPG to provide a progress update	20APR2018
2012-4-3078	Pickering NGS-A Type II Compliance Inspection Report, Q2 2011-2012, EPRPD-PICKA-2011-120	OPG to provide a progress update	16MAR2018

Appendix E – Periodic Safety Review (PSR2)

E.1 Introduction

OPG is evaluating extended operation of the Pickering station beyond the year 2020. In support of this evaluation and licence renewal a subsequent Periodic Safety Review (PSR) is being conducted in accordance with CNSC Regulatory Document 2.3.3, *Periodic Safety Reviews* and International Atomic Energy Agency's (IAEA) Safety Standards Series, Specific Safety Guide No. SSG-25, *Periodic Safety Review for Nuclear Power Plants.*

CNSC REGDOC-2.3.3 and IAEA SSG-25 identify that subsequent PSRs should focus on changes in requirements, facility conditions, operating experience and new information, rather than repeating activities conducted in previous safety reviews. As such it is forward looking, focusing on: changes to requirements since the last applicable assessment, confirmation that the condition of Pickering NGS supports the additional years of commercial operation, and new operating experience since the last assessments.

The objective of Pickering's PSR is to confirm that the design, operation and safety-significant structures, systems, and components support continued safe operation and to determine reasonable and practical safety enhancements to further improve the already low risk of plant operation.

The subsequent PSR, referred to as PSR2, builds on earlier OPG PSR work (referred to as PSR1) and other associated assessments, specifically:

1. The Pickering B Integrated Safety Review (ISR), which included a comprehensive review of Codes and Standards that was completed in 2009 to support potential refurbishment and continued operation of Pickering 5-8 units for an additional 30 years.

   For economic reasons, OPG decided to not refurbish Pickering Units 5-8, instead pursuing the option of extended operation to the end of 2020 without the replacement of the major reactor components. In support of this approach, safety enhancements were identified (based on the results of the ISR) in the context of an operation timeframe extending to approximately 2025. Outstanding actions from the ISR were subsequently documented in the Continued Operations Plan (COP) for which annual updates have been submitted to the CNSC.

2. Pickering Units 1and 4 integrated safety assessments were performed during the Pickering A Return to Service (PARTS) work in support of approval to restart Units 1 and 4 following the extended shutdown of these units. (The pressure tubes on these units had previously been replaced in the late 1980's and early 1990's). Based on the results of these safety assessments, termed Systematic Review of Safety, Pickering Units 1 and 4 were restarted. Units 2 and 3 were not restarted for economic reasons and were placed in the safe storage state (fuel and water removed, systems isolated/de-energized, and separation from common containment).

3. The Darlington ISR was performed in support of refurbishment and continued operation of the Darlington units for an additional 30 years. Extensive reviews (primarily clause-by-clause reviews) of Codes and Standards were completed.

Much of the compliance assessment and evaluation of Safety Factor health for the Darlington ISR was based on programs and practices that apply across OPG's nuclear operations. As a result, Darlington ISR programmatic conclusions are applicable to the Pickering PSR2 for nuclear programs and practices that are relevant to Pickering.

Pickering PSR1 results are applicable to PSR2 if there was a PSR1 gap that was still open, or if a closed PSR1 gap could be affected by extended operation. If so, these gaps are carried forward into the PSR2 for consideration in the Global Assessment.

E.2 PSR2 Scope

The safety of Pickering NGS is regularly and thoroughly assessed, verified and assured through several processes that are part of the current licensing framework. OPG also applies routine comprehensive safety assessment and improvement programs that deal with specific safety issues, significant events and changes in standards and operating practices as they arise. These programs allow assessment of safety and plant operation to be improved on a continuous basis that can be correlated to all of the Safety Factors reviewed in PSR2. They include programs that ensure safe operations, effective configuration management, equipment reliability, life cycle management, aging management, periodic inspection and maintenance. Programs are also in place in the area of organization management and safety culture that focus on safety-related behaviours and accountability.

A protocol agreement between OPG and the CNSC staff (Reference E-1) is currently in place that documents OPG/CNSC interactions and a schedule for key submissions.

Current Laws, Regulations, Codes and Standards Applicable to PSR2

The PSR evaluates the extent to which the plant meets current laws, regulations, codes and standards. The process to identify those documents that are applicable to the PSR2 assessment basis involved first creating a broad list from multiple sources (potential candidate laws, regulations, codes and standards) and then filtering them to identify those that are most significant, and that are applicable to the PSR2 scope.

For the purpose of the performance of PSR2, OPG has defined the cut-off date for current laws, regulations, codes and standards to be January 15, 2016.

Structures, Systems and Components within the Scope of the PSR2 Review

The Structures, Systems and Components (SSC) within the scope of the PSR2 review encompass the Systems Important to Safety (SIS) and the Safe Operating Envelope (SOE) systems.

The scope of PSR2 is restricted to the facilities that are regulated under the Pickering NGS Power Reactor Operating Licence, therefore the Pickering Waste Management Facility, which has a separate operating licence, is not considered within the Pickering PSR2 scope.

E.3 PSR2 Overview

The general process overview for PSR2 is shown in Figure E.1. Pickering's PSR2 is comprised of the following four key elements which are explained in the sections that follow:

1. PSR2 Basis Document
2. Safety Factor Reviews
3. Global Assessment
4. Integrated Implementation Plan

Additional assessments (COP and Fukushima Action Items) were also performed to confirm the impact of extended operation beyond 2020. Where there are implications for extended operation, an associated gap was identified for consideration in the Global Assessment.

E.4 PSR2 Basis Document:

The Pickering PSR2 basis document, which was submitted by OPG and accepted by the CNSC in References E-2 and E-5 respectfully, defines the approach for completing the PSR2, specifically;

- The proposed operating strategy of the facility,
- Scope and methodology, including the conduct of Safety Factor reviews and identification of compliances and gaps,
- The process for categorizing, prioritizing, tracking and resolving Gaps arising from the Safety Factor reviews,
- Conduct of the Global Assessment,
- The methodology for preparing the Integrated Implementation Plan,
- Applicable current versions of Laws, Regulations, Codes and Standards,
- The major milestones, including the freeze date for document revisions, and,
- The project management and quality management processes.

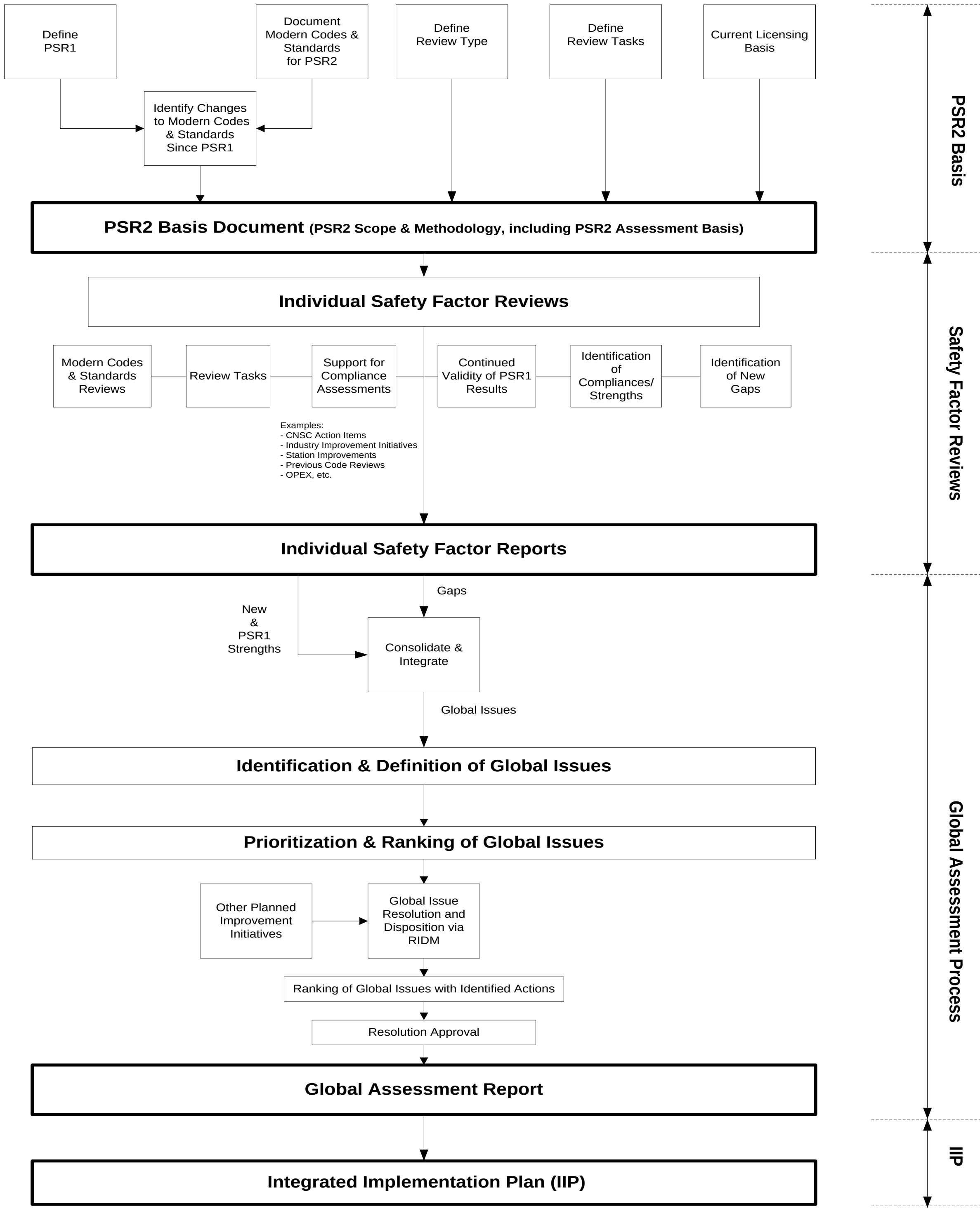

Figure E.1: Pickering PSR2 Process Flowchart

E.5 Safety Factor Reviews:

Safety Factors cover all aspects important to the safety of an operating nuclear power plant. There are 15 Safety Factors used in the PSR2 review; 14 are identified in IAEA SSG-25, and one additional Safety Factor (Radiation Protection) as identified in CNSC REGDOC-2.3.3.

OPG has submitted all 15 Safety Factor Review reports for CNSC staff review.

1. Safety Factor Report 1: Plant Design
2. Safety Factor Report 2: Actual Condition of Structures, Systems and Components Important to Safety
3. Safety Factor Report 3: Equipment Qualification (Seismic and Environmental)
4. Safety Factor Report 4: Aging
5. Safety Factor Report 5: Deterministic Safety Analysis
6. Safety Factor Report 6: Probabilistic Safety Assessment
7. Safety Factor Report 7: Hazard Analysis
8. Safety Factor Report 8: Safety Performance
9. Safety Factor Report 9: Use of Experience from Other Nuclear Power Plants and Research Findings
10. Safety Factor Report 10: Organization, Management System and Safety Culture
11. Safety Factor Report 11: Procedures
12. Safety Factor Report 12: Human Factors
13. Safety Factor Report 13: Emergency Planning
14. Safety Factor Report 14: Radiological Impact on the Environment
15. Safety Factor Report 15: Radiation Protection

These reports conclude that there are no fundamental safety issues and that OPG has in place effective programs and processes for continued safe operation of the Pickering NGS until 2024. Any identified gaps from these Safety Factor Reviews are being assessed in the Global Assessment.

As a subsequent PSR, the PSR2 Safety Factor reviews focused on changes in requirements (Laws, Regulations, Codes and Standards), updated plant conditions, operating experience and information from research, rather than repeating the activities of previous reviews. The methodology for performing the Safety Factor reviews takes full advantage of the safety assessments and Law, Regulation, Code and Standard compliance work previously completed by OPG.

This approach is in accordance with the guidance provided by the CNSC in REGDOC-2.3.3 that the effort required to undertake a subsequent PSR should require considerably less effort, subject to confirmation that previous conclusions remain valid.

Safety Factor Results and Reports

The Safety Factor reviews identified compliances and gaps with respect to the review elements in the PSR2 assessment basis. Specifically:

Compliance:

- For Clause-by-Clause reviews of current Laws, Regulations, Codes and Standards, Compliance indicates that the safety requirement is met.
- Where a High Level review has been performed, Compliance indicates that the intent of the safety requirement is met.
- Where an Incremental review has been performed, Compliance indicates that the change in the safety requirement, per the topical review, is met.
- For reviews of Safety Factor Review Tasks, Compliance indicates that either the safety requirement or the intent of the Review Task is met.

Gap:

- For Clause-by-Clause reviews of current Laws, Regulations, Codes and Standards, a gap indicates that the safety requirement is not met.
- Where a High Level review has been performed, a gap indicates that the intent of the safety requirement is not met.
- Where an Incremental review has been performed, a gap indicates that the change in the safety requirement, per the topical review, is not met.
- For reviews of Safety Factor Review Tasks, a gap indicates that the intent of the Review Task is not met.

Compliances that are equivalent to or surpass PSR2 assessment basis requirements or practices will be forwarded into the global assessment process for consideration as strengths. Gaps will be evaluated by the global assessment methodology to identify global issues and, with justification, acceptable deviations.

The results of the Safety Factor reviews have been documented in Safety Factor Reports that have been submitted to CNSC. These reports include:

- The scope of the review,
- Applicable elements of the PSR2 Assessment Basis (Review Tasks and applicable Laws, Regulations, Codes and Standards),
- Review methodology,
- Assessment of compliance with Review Tasks,
- Effectiveness review of OPG programs supporting compliance assessments,
- Review findings (Compliances and Gaps),
- Impacts on other Safety Factor reviews,
- Overall assessment of the Safety Factor.

Separate reports have been produced to document:

(a) The reviews of Laws, Regulations, Codes and Standards in the PSR2 assessment basis, and
(b) The derivation of the safety factor review tasks from IAEA SSG-25 and CNSC REGDOC-2.3.3. The Safety Factor reports have drawn on the information in these reports.

Safety factor compliance assessments will incorporate information from:

- OPG programs and procedures listed in the LCH, and any other programs and procedures which support the compliance arguments;

- Plant Condition Assessments (for Safety Factor 2);
- Commitments previously made to the CNSC, open CNSC action items, and exemptions granted by CNSC since the current operating licence was issued (safety significant issues, per the Pickering LCH) to determine if there are any impacts associated with Pickering operation past 2020.
- Previously identified ISR gaps related to each Safety Factor and the status of OPG's improvement plans or other dispositions to address these;
- Assessments and reviews performed since the PSR1 documents were completed.

E.6 Global Assessment:

The objective of the Global Assessment is to provide an overall assessment of the safety of the plant, and to arrive at a judgement of the plant's suitability for continued operation on the basis of a balanced view of the results from the reviews of the separate Safety Factors. This judgement takes into account the safety enhancements identified in the Global Assessment (plant and process modifications), strengths and residual global issues/acceptable deviations that impact on aggregate effects of the results, and consideration of existing planned safety enhancements and recent overall station safety performance.

Consistent with the requirements of IAEA SS-25, the Global Assessment is being conducted by an interdisciplinary team with appropriate expertise in Operations, Design and plant safety, including appropriate participants from the safety factor reviews, and members who are independent from the safety factor review teams.

The Global Assessment Process consists of the following elements:
1. Identification and consolidation of Strengths and Gaps from the Safety Factor Reports.
2. Identification of Global Issues.
3. Assessment of interfaces between the various Safety Factors, Aggregate Impact of Global Issues.
4. Prioritization of Global Issues.
5. Development of Resolutions / Dispositions of Global Issues (and Gaps).
6. Consideration of defence-in-depth and aggregate impact of residual Global Issues / Acceptable Deviations.
7. Ranking of Global Issues with identified actions.
8. Senior Management Scope Review Board approval of proposed modifications for the purposes of PSR2.
9. Assessment of overall acceptability of operation of the plant over the period considered in PSR2.
10. Preparation of the Global Assessment Report to summarize the assessments, and document the Global Assessment.

Global Assessment Logistics

The strengths and gaps from the 15 individual Safety Factor Reports are being consolidated and grouped by topic area to support the Global Assessment.

Recommendations from the component condition assessments conducted in support of Safety Factor 2 will also be considered as part of this review.

Identification of Global Issues:

The consolidation of gaps into global issues provides a means to assemble gaps of a common nature, facilitating the assessment of safety impact and identifying and assessing practical and effective resolutions. The global issues will be tabularized, tracking sources of the issues, to facilitate further review and assessment.

Interfaces between the Various Safety Factors, Aggregate Impact of Global Issues:

With the assembly of global issues and strengths, and considering the recommendations from component condition assessments, the aggregate impact of the global issues is being assessed. In this way, the interaction between issues can be identified. New global issues may be identified as part of this consolidation review that support the prioritization and ranking of Global Issues as described below.

Prioritization of Global Issues

PSR2 global issues will be prioritized with respect to their importance to nuclear safety. This will support the resolution evaluation method and the outcome of the resolution process. This methodology is consistent with OPG prioritization processes used in previous Integrated Safety Reviews and industry practice.

The safety significance level will consider deterministic and probabilistic safety analysis impact, as appropriate. The assignment of safety significance values for prioritization was derived based on OPG experience and takes into account the priority values from the OPG guidelines for evaluating and prioritizing Safety Report Issues, the COG benefit-cost analysis processes, and the OPG station condition record categorization process. Probability levels selected for delineation between categories are based on significance and engineering judgement, and are as used in previous Integrated Safety Reviews. These values account for overall safety impact and align, where appropriate, with requirements and limits in relevant safety standards. The relationship between safety significance level and impact on nuclear safety is shown in the table E.1.

Safety Significance Level	Impact on Nuclear Safety
1	High
2	Medium
3	Low
4	Very Low

Table E.1 Relationship between Safety Significance Level and Impact on Nuclear Safety

Development of Resolutions/Dispositions of Global Issues (and Gaps)

Resolution options are being developed and assessed using risk-informed decision making techniques utilizing the following strategy:

- In assessing potential dispositions, defence-in-depth elements will be considered.
- In developing the resolutions, consideration of overall safety significance will guide the resolution process.
- For Global Issue resolution – the process will be:
  - Evaluate the Global Issue to understand the safety basis, and intent of the requirement.
  - Consider possible options for resolution/mitigation. Consider safety significance and defence-in-depth elements.
  - Evaluate options with respect to effectiveness, cost, schedule, practicality. For potential plant modifications, this may require an evaluation of the safety impact, via both deterministic and probabilistic methods. If it is not practicable to fully resolve a Global Issue, other mitigation options will be considered for enhancements.
  - Practicality of a proposed resolution will be evaluated in terms of cost, resources, schedule, and considered in relation to the overall safety impact.
  - Propose recommended resolution/mitigation.
  - Document the decision making process.

- Items of High or Medium impact on nuclear safety (safety significance levels 1 and 2) will require more in-depth analysis to fully understand the issue and potential impact, and to develop the proposed resolution/mitigation. This may require deterministic and/or probabilistic assessments to determine the nuclear safety impact of modifications and more detailed evaluation of the cost/practicality of proposed resolutions. Insights from available probabilistic safety analyses may be used in evaluating the benefit/practicality of potential options. This will be done concurrent with the development of the Integrated Implementation Plan.

- Items of Very Low Impact on nuclear safety (safety significance level 4) will generally be deemed as acceptable deviations within the context of PSR2 (with the rationale provided). While these items will not be tracked beyond the Global Assessment, they will be shared with the accountable organizations for consideration as potential enhancement initiatives for their future work program planning purposes. This will allow the organizations to prioritize the initiatives as part of their integrated programs to ensure the focus is on the right overall priorities. A similar treatment will be applied for items of Low Impact on nuclear safety (safety significance level 3) for which a practicable solution is not readily evident.

- Proposed resolutions will be categorized as follows:
  i) Programmatic (changes to procedures and programs),
  ii) Engineering (plant modifications), or
  iii) Analytical (e.g., safety analysis)

- In some cases, the development of resolutions/dispositions to the global issues will be part of an OPG or industry initiative underway or planned. Or, the resolution and development of options may require more detailed analysis and assessment, extending beyond the timelines for submission of PSR2. In these instances, the status of the initiative and plans will be included in the disposition. The work will be included in the global assessment to facilitate continued tracking.

- The results of previous global assessments for OPG stations will be considered in the review.

- If in the assessment it is determined that a global issue/gap has been closed, due to work done in the interim or for other reasons, the rationale will be documented and the global issue/gap will be set to resolved and closed.

- At the recommendation of the senior management team, an alternate process / resolution may be utilized for a particular global issue/gap.

Consideration of Defence-in-Depth and Aggregate Impact of Residual Global Issues / Acceptable Deviations

An important element of the development of proposed recommendations will be to assess the overall defence-in-depth and aggregate impact of the residual global issues/acceptable deviations. After evaluating a range of resolutions for global issues, and determining a recommended resolution to be selected, the impact on defence-in-depth, considering both deterministic and probabilistic elements, will be evaluated to assess the aggregate impact on overall safety. It may be necessary to refine the proposed resolutions based on the results of this review. This overall assessment will be an important element in supporting the enhancement plans and the planned operational strategy over the period of PSR2.

Ranking of Global Issues with Identified Actions

All global issues whose resolution involves identified actions will be ranked from 1 through N, where N is the total number, in accordance with overall safety significance. This will be based on engineering judgement applied by the assigned Global Assessment team. The ranking process will consider factors such as the priority previously determined (safety significance level), the contribution to defence-in-depth, the significance of the source (e.g., the type of document that generated the gap(s) leading to the global issue). The ranking process will also account for the extent of impact on multiple safety factors or areas.

Senior Management Scope Review Board Approval of Proposed Modifications for the Purposes of PSR2

The enhancements identified in the PSR2 Global Assessment Report, with their priority and safety basis, will be presented to the OPG Senior Management Scope Review Board for approval. This review will ensure alignment with the resolutions proposed, their basis and context, and will be the means to obtain concurrence that the proposed enhancements are practicable and effective. This will also allow the senior management team to consider potential realignment of overall priorities based on the insights from PSR2. Consistent with OPG project management processes, additional approval gates will be required as the resolution development continues towards full implementation.

Assessment of Overall Acceptability of Operation of the Plant Over the Period Considered in PSR2

As a final step in the assessment process, the team confirms the overall acceptability of operation of the plant over the period considered in the PSR2. This entails a review of the results of the safety factor reviews, a consideration of enhancements planned (both newly identified in PSR2 and from other station initiatives) and a consideration of plant performance.

Global Assessment Report

Preparation of the Global Assessment Report is being conducted to summarize the assessments and document the Global Assessment by presenting the results, assessing the overall defence-in-depth of the plant, and documenting the conclusions, corrective actions, and enhancements to be considered. The Global Assessment Report will include a ranked list of those global issues with identified actions, with rationale for the ranking. This will be done concurrent with the development of the Integrated Implementation Plan.

Residual global issues and acceptable deviations will be noted in the report, summarizing the assessed aggregate impact on safe operations. These items will be conveyed to the responsible organizations for their consideration as potential enhancement initiatives for their work program. These initiatives will be weighed against other important program and plant modifications as part of the base and project work within these organizations. These items will not be tracked further beyond the Global Assessment Report or carried forward into the Integrated Implementation Plan.

The Global Assessment Report will include a statement of OPG's assessment of the overall acceptability of operation of the plant. Reviews and approval of the report will be conducted as required under the OPG Management System. The Global Assessment Report will be submitted to CNSC staff for review.

As documented in Reference E-1, the Global Assessment Report is scheduled to be submitted to the CNSC by October 31, 2017.

E.7 Integrated Implementation Plan:

The proposed enhancements resulting from the Global Assessment will be documented in the Integrated Implementation Plan (IIP) which will provide the proposed timeline for the implementation of the enhancements and it will also document and confirm the resulting enhancement.

The enhancements summarized in the IIP will be mapped to the CNSC Safety and Control Areas (per Appendix B of CNSC REGDOC-2.3.3) to facilitate CNSC review.

Integrated Implementation Plan Logistics

The IIP listing of enhancements will include those resulting from the Global Assessment Report, including both new modifications proposed as part of the resolution of global issues, and also considering the existing planned station modifications that were integral to the overall assessment of safety.
A review will be conducted with program owners and appropriate managers to derive plans for implementation based on priority and resources. These plans will be developed with due consideration of the other important initiatives underway or planned at Pickering NGS as part of continual improvement.

The initiatives will be tabularized with owners assigned and planned implementation dates. Existing initiatives integral to the overall assessment of safety during the Global Assessment will also be included in this listing. The listing will include the priority and the basis for the priority. The implementation of the initiatives will be tracked and reported.

The IIP will be presented to OPG senior management to obtain support for the initiatives and plans. As the IIP will be based on initial conceptual consideration of the resolution plans (or range of plans), a change management process will be implemented to manage any IIP required changes. Senior management approval for any proposed changes to resolution scope and/or completion timeframes will be required, and documented, consistent with OPG Project Management processes. The Integrated Implementation Plan will be tracked and progress will be regularly reported throughout the implementation period.

Integrated Implementation Plan Format

The IIP will be structured to allow a reader to understand the implementation plan and the basis for the plan. The plan will begin with a summary of work completed in the Safety Factor Reports and the Global Assessment Report.
The tabularized IIP will be included in the report to facilitate understanding of the related safety enhancement initiatives, their priority, and safety basis. These will include the new initiatives that came from the Safety Factor Reviews and the Global Assessment, and the existing initiatives that were integral to the overall assessment of safety.

To facilitate the CNSC review of the IIP, the plan will be presented in a manner aligned with the CNSC Safety and Control Areas. The report will also summarize the implementation tracking and reporting process and the IIP change management process. The processes will allow tracking of initiatives to completion or resolution in an auditable manner, consistent with OPG's management system.

Consistent with CNSC REGDOC-2.3.3 and Reference E-1, the IIP is scheduled to be submitted to CNSC staff for acceptance by November 30, 2017.

E.8 Continued Operations Plan (COP) Reassessment

In accordance with the PSR Basis Document (Reference E-2), the Pickering Units 5-8 Continued Operations Plan (COP) actions were reviewed to determine if there were implications for PSR2. Specifically, the COP actions pertaining to the Pickering Units 5-8 Integrated Safety Review from 2009 and the fitness for service actions were reassessed for implications given the intent to operate Pickering Units 5-8 beyond 2020.

In addition, implications for Pickering Units 1, 4 were also identified. Where there are implications for extended operation of Pickering Units 5-8, or for Pickering Units 1, 4, a PSR2 gap was identified that will be considered in the Global Assessment process describe above.

The COP reassessment report was submitted to the CNSC (Reference E-3).

E.9 Fukushima Action Plan Reassessment

Following the events at Fukushima Daiichi in March 2011, the CNSC issued Fukushima Action Items to the Canadian Nuclear Utilities to ensure that the lessons learned from the event were appropriately incorporated into Canadian nuclear operations.

OPG has been recognized for its achievements in operational and management excellence in its response to the Fukushima Daiichi event and has confirmed that its stations remain safe with systems and procedures in place to deal with beyond design basis events.

OPG has taken the key lessons learned from the Fukushima event and incorporated changes to further enhance the safety of OPG's nuclear facilities. In 2015, all Fukushima Action Items (FAIs) for the Darlington and Pickering units were closed (Reference E-4).

In accordance with the PSR2 Basis Document, all of the FAIs pertaining to Pickering were reassessed to determine if the basis for their closure remained valid in the context of intended extension of commercial operations of the station beyond 2020. This FAI reassessment, which was submitted to the CNSC in March 2017 did not identify any gaps for PSR2, however, two items will be carried over to the Global Assessment as additional gaps as identified by CNSC staff.

E.10 Preliminary PSR2 Results

The 15 Safety Factor Review reports conclude that there are no fundamental safety issues and that OPG has in place effective programs and processes for continued safe operation of the Pickering NGS until 2024.

1. Organization, Management Systems and Safety Culture was reviewed as a safety factor for Pickering PSR2. Specifically, this review confirmed that the Pickering NGS organization, management system and safety culture are effective.

2. Human Factors was reviewed as a safety factor for Pickering PSR2. Specifically, this review confirmed that the various human factors that may affect the safe operation of Pickering NGS have been appropriately addressed, and are effective.

3. Safety Performance was reviewed as a safety factor for Pickering PSR2. Specifically, this review confirmed that the safety performance indicators and records of operating experience, including the evaluation of root causes of plant events, exist and are utilized.

4. OPEX and Research Findings was reviewed as a safety factor for Pickering PSR2. Specifically, this review confirmed that for Pickering NGS there is adequate feedback of relevant experience from other nuclear power plants and from findings of research, and that this is used to introduce reasonable and practicable safety improvements at the plant or in the operating organization.

5. The area of Procedures was reviewed as a safety factor for Pickering PSR2. Specifically, this review confirmed that the Pickering NGS processes for managing, implementing and adhering to operating and working procedures and for maintaining compliance with operational limits and conditions and regulatory requirements are adequate and effective and ensure plant safety.

6. Deterministic Safety Analysis was reviewed as a safety factor for Pickering PSR2. Specifically, this review confirmed that the deterministic safety analysis programs and procedures at OPG are comprehensive, resulting in a systematic and disciplined approach to identifying, prioritizing and addressing any safety analysis related issues.

7. Hazard Analysis was reviewed as a safety factor for Pickering PSR2. Specifically, this review has confirmed that Pickering NGS has robust protection against internal and external hazards, taking into account the plant design, site characteristics, the actual condition of the Structures, Systems and Components (SSCs) important to safety.

8. Probabilistic Safety Assessment (PSA) was reviewed as a safety factor for Pickering PSR2. Specifically, this review has confirmed that the PSA programs and procedures at OPG are comprehensive, resulting in a systematic and disciplined approach to identifying, prioritizing and addressing safety analysis related issues.

9. Plant Design was reviewed as a safety factor for Pickering PSR2. This review confirmed, by assessment against the current licensing basis and applicable standards, requirements and practices that the physical design and documentation supports continued safe operation of Pickering NGS.

10. Equipment environmental and seismic qualifications were reviewed as a safety factor for Pickering PSR2. Specifically, this review confirmed that the Pickering NGS equipment important to safety has been properly environmentally and seismically qualified and that these qualifications are being maintained through maintenance, inspection and testing programs.

11. Actual condition of Structures, Systems and Components (SSCs) important to safety was reviewed as a safety factor for Pickering PSR2. Specifically, this review concluded that the majority of the plant’s SSCs are in good condition and support safe extended station operation to 2024. Recommendations for improvement have been made when required, of which many are in progress. For this life extension period, no major concerns have been identified and the SSCs Important to Safety continue to operate as per the design basis requirements.

12. Plant aging was reviewed as a safety factor for Pickering PSR2. Specifically, this review confirmed that aging aspects affecting SSCs important to safety are being effectively managed and that an effective aging management program is in place.

13. Radiation Protection was reviewed as a safety factor for Pickering PSR2. Specifically, this review has confirmed that radiation protection has been accounted for in the design and operation of Pickering NGS, and that radiation protection provisions (including design and equipment) protect workers from radiation and ensure that contamination and radiation exposures and doses to persons are monitored and controlled and maintained As Low As Reasonably Achievable (ALARA).

14. Radiological Impact on the Environment was reviewed as a safety factor for Pickering PSR2. Specifically, this review has confirmed that Pickering NGS has in place an effective program for monitoring the radiological impact of the plant on the environment, which ensures that emissions are properly controlled and are as low as reasonably achievable.

15. Emergency Planning was reviewed as a safety factor for Pickering PSR2. Specifically, this review has confirmed that OPG Nuclear has in place adequate plans, staff, facilities and equipment for dealing with emergencies. In addition, arrangements are in place for regular emergency training and exercises, and interaction and coordination with local and national authorities.

All planned improvements identified through the PSR process will be documented in a Global Assessment Report and an Integrated Implementation Plan that will be submitted to the CNSC in October and November 2017 respectively.

E.11 References

E-1 Protocol, “OPG-CNSC Protocol for the Conduct of a Periodic Safety Review in Support of Pickering NGS Licence Renewal”, January 17, 2017, e-Doc 5143721, CD# P-CORR-00531-04725 R001.

E-2 OPG Letter, B. McGee to H. Khouaja, “Submission of Pickering NGS Periodic Safety Review 2 Basis Document Revision 002”, July 6, 2016, CD# P-CORR-00531-04780.

E-3 OPG Letter, B. McGee to A. Viktorov, "Pickering NGS Periodic Safety Review 2 - Submission of Continued Operations Plan (COP) Reassessment", February 13, 2017, CD# P-CORR-00531-04927.

E-4 OPG Letter, W.S. Woods to M. Santini and F. Rinfret, "OPG Progress Report No. 7 on CNSC Action Plan - Fukushima Action Items", November 30, 2015, CD# N-CORR-00531-06906.

E-5 CNSC Letter, H. Khouaja to B. McGee, “Pickering NGS: CNSC Staff Acceptance of Pickering NGS Periodic Safety Review 2 (PSR2) Basis Document”, July 8, 2016, e-Doc 5037314, CD# P-CORR-00531-04789.

Appendix F - CANDU Safety Issues

A safety issue is defined as an issue related to the design or analysis of a nuclear power plant that has the potential to challenge safety functions, safety barriers or both.

In 2007, the CNSC assessed the status of CANDU Safety Issues (CSIs) and, while the safety case was not in question, the CNSC identified control measures to address residual concerns on nuclear safety. The initial list of issues was developed using the IAEA TECDOC-1554 "Generic Safety Issues for Nuclear Power Plants with Pressurized Heavy Water Reactors and Measures for their Resolution", and each issue was classified into one of the following three categories:

- Category 1: Not an issue in Canada.
- Category 2: The issue is a concern in Canada. However, the licensees have appropriate control measures in place to address the issue and to maintain safety margins.
- Category 3: The issue is a concern in Canada. Measures are in place to maintain safety margins, but further experiments and/or analysis are required to improve knowledge and understanding of the issue, and to confirm the adequacy of the measures

At present, Pickering has four Category 3 issues pending CNSC re-categorization. One issue is a Non-Large Break Loss of Coolant Accidents (LBLOCA) and three issues are related to LBLOCA.

1) Non-LBLOCA CSI – Category 3:

- IH 6 Need for systematic assessment of high energy line break effects

The methodology to assess high energy pipe breaks inside containment for Pickering was developed and presented to the CNSC. For Pickering 5-8, High Energy Line Break Assessments (HELBA) were completed and presented to the CNSC. These assessments followed the aforementioned methodology and concluded that none of the postulated line breaks would pose safety risks beyond those already documented in the Safety Report. Re-categorization of IH6 for Pickering 5-8 was requested in 2016 (Reference F1).

The results and conclusions of the Pickering 5-8 assessments could not be directly applied to Pickering 1-4 because the two stations have different design provisions for pipe supports. Consistent with the existing methodology, a leak before break (LBB) disposition strategy was adopted. LBB analyses are being completed and once the results are available, re-categorization of IH6 for Pickering 1-4 will be requested. OPG has well established programs to monitor and inspect high energy piping and to take appropriate actions when required.

2) LBLOCA CSIs – Category 3:

- AA 9 Analysis for void reactivity coefficient
- PF 9 Fuel behaviour in high temperature transients
- PF 10 Fuel behaviour in power pulse transients

OPG has requested re-categorization of these LBLOCA CSIs based on the development of the Composite Analytical Approach (CAA) (References F-2 and F-3), in collaboration with the CANDU Owners Group. More recently, OPG provided the CNSC with an update on the latest activities to address LBLOCA safety margins using the CAA as part of OPG's short-term and long-term plans to address these issues (Reference F-4). Further confirmatory research and analysis are ongoing.

References:

F-1 OPG letter, W.S. Woods to A. Viktorov, "Re-Categorization Request for CANDU Safety Issue IH6 for Pickering NGS 5-8 and Status for Pickering NGS 1-4", December 5, 2016, CD# N-CORR-00531-18288.

F-2 CNSC letter, G. Rzentkowski to W. M. Elliott, "Darlington and Pickering NGS: Large LOCA Safety Margins - Assessment of the Proposed Composite Analytical Approach," January 7, 2015, e-Doc # 4610410, CD# N-CORR-00531-07358.

F-3 CNSC letter, M. Santini, F. Rinfret to W.M. Elliott, "Darlington and Pickering NGS: Large LOCA Safety Margins - Assessment of the Proposed Composite Analytical Approach (CAA)," June 4, 2015, e-Doc # 4767575, CD# N-CORR-00531-06922.

F-4 OPG letter, W. S. Woods to M. Santini and F. Rinfret, "Resolution of Large Break LOCA (LBLOCA) Safety Margins Issues," April 25, 2016, CD# N-CORR-00531-18022.

Enclosure 1

Pickering NGS Hazardous Substances

CD# P-REP-08965-0633695 R001

(15 pages including this coversheet)

ONTARIO POWER GENERATION

Report

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Document Number: P-REP-08965-0633695	Usage Classification: N/A
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PICKERING NGS HAZARDOUS SUBSTANCES

Pickering NGS Hazardous Substances

P-REP-08965-0633695 Rev 01

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The purpose of this report is to document a list of hazardous materials at the Pickering Nuclear Generating Station with respect to a licence application requirement under Class I Nuclear Facilities Regulations SOR/2000-204.

Under Class I Nuclear Facilities Regulations SOR/2000-204, Licence Applications, General Requirements, S. 3.,

> An application for a licence in respect of a Class I Nuclear Facility, other than a licence to abandon, shall contain the following information in addition to the information required by section 3 of the *General Nuclear Safety and Control Regulations*.
>
> 3 (e) the name, form, characteristics and quantity of any hazardous substances that may be on the site while the activity to be licensed is carried on.

Table 1 contains a list of the hazardous substances.

In addition to the CNSC licensing requirement above, Ontario's Occupational Health and Safety Act Sections 37-42 and Canada Labour Code Section 125.1 require employers to identify, label and control "hazardous substances" in the workplace. These substances must be labeled and material safety data sheets made available. Pickering Nuclear tracks hazardous substances (as defined by those regulations) coming on site through its hazardous materials (HAZMAT) database, enabling the Workplace Hazardous Materials Information System (WHMIS) and Material Safety Data Sheet (MSDS) regulatory requirements. The database is fully accessible to all employees on site.

This report will be reviewed on a frequency of every two years, tracked as MGMT actions in Asset Suite. If any significant changes to the hazardous substances are made, the report will be updated.

Table 1: Pickering NGS Hazardous Substances List

Chemical	Where Used (System)	Purpose	Storage	Disposal	Inventory	In system	Form	Characteristics
Boric acid	Moderator system	Reactivity control	Mixed with D2O in the liquid poison tanks	Removed by ion exchange (IX) resin in the moderator purification system	~54 pcs of 500g bottles of Boric Oxide	Pickering 014: ~1700L Pickering 058: ~850L	Solid, made into solution for addition	Toxic, irritant
Gadolinium Nitrate	Moderator system	Reactivity control	Mixed with D2O in the liquid poison tanks	Removed by IX resin in the moderator purification system	~36 pcs of 5kg bags	Pickering 058: LISS: ~19,000 L Moderator: ~1700 L	Solid, made into solution for addition	Toxic, severe irritant
Helium gas	Cover gas for moderator; Liquid zone control;	Cover gas to prevent air ingress	Gas cylinders	Periodically purged to reactor building exhaust for chemistry control	~80 cylinders 291ft^3 per cylinder	Moderator Cover Gas: P014 and P058 combined ~6000ft^3 LZC: P014 and P058 combined: ~7000ft^3	Compressed Gas	Compressed gas, simple asphyxiant, lighter than air.

Chemical	Where Used (System)	Purpose	Storage	Disposal	Inventory	In system	Form	Characteristics
Oxygen gas	Moderator cover gas; annulus gas	Added to recombine with D2 gas; to maintain pressure integrity	Gas cylinders	Consumed; emitted to reactor building exhaust	~2 cylinders 335ft^3 per cylinder	Moderator Cover Gas P058: ~2600ft^3 P014: none Annulus Gas P014 and P058 combined ~1000ft^3	Compressed Gas	Strong oxidizer - increases flammability of flammable or combustible material.
Hydrogen gas	Heat transport system; main generators	Remove O2 from the heat transport system; cooling for the generators	Mobile trailer and gas cylinders	Consumed in the heat transport system and vented to reactor building exhaust; periodically vented to atmosphere from the main generators	~2 cylinders @ 196ft^3; 5 cylinders @ 2.77m^3	HTS:P014 and P058 combined: ~ 6500ft^3 Main Generator: P014 and P058 combined: ~115,000ft^3 In a Mobile trailer hooked up directly to the system.	Compressed Gas	Flammable Compressed Gas, lighter than air.

Chemical	Where Used (System)	Purpose	Storage	Disposal	Inventory	In system	Form	Characteristics
Hydrazine (35% solution)	Emergency coolant injection system; steam generator feedwater; condensate feedwater; recirculating cooling water system; end shield cooling water	Removal of O2 and pH control	Oil and Chemical Storage Building – Totes and drums – Totes in chemical addition station in turbine hall	Consumed but residual may be discharged to lake or atmosphere. A breakdown product in feedwater is ammonia.	Pickering 014 uses drums. ~ 12 drums @ 208.65kg per drums as hydrazine hydrate Pickering 058 uses totes. ~1800 L (2x 900L totes) as hydrazine hydrate	Pickering 014: typically 1 drum (205 L) connected to the system. Pickering 058: ~1800 L This is in totes connected to the system.	Liquid	Corrosive base, Toxic
Lithium hydroxide	Heat transport system; end shield cooling system; recirculating cooling water system	pH control	Station – chemical addition systems	Consumed (used when pH must be rapidly corrected; usually the pH is controlled by lithiated IX columns)	~14 pcs of 0.5kg bags	P014 and P058 combined: HTS: ~ 240g (in solution) (0.24kg) RCW: ~2.7kg (in solution)	Solid, made into solution for addition.	Corrosive base

Chemical	Where Used (System)	Purpose	Storage	Disposal	Inventory	In system	Form	Characteristics
IX resin: Neutral Mixed Bed Resin- IX resin: Neutral Mixed Bed Resin (cont)	Moderator system; irradiated fuel bay; auxiliary fuel bay; liquid zone control Stator Cooling Water	pH control and removal of impurities	Purification IX columns	Temporary storage – spent resin tank	~45 pcs of $1ft^3$ package 2pcs of $35ft^3$ package	P014 and P-58 combined: Moderator: $\sim 55ft^3$ IFB: ~ $240ft^3$ AIFB ~ $200ft^3$ LZC ~ $4ft^3$ SCW ~ $14ft^3$	Solid	Toxic, irritant
IX resin: Lithiated mixed bed resin	Heat transport system; end shield cooling system; recirculating cooling water system	pH control and removal of impurities	Purification IX columns	Temporary storage – spent resin tank	~243 pcs of $0.5ft^3$ bags	All P014 and P058 combined: HTS ~$30ft^3$ RCW ~$4ft^3$ ESC ~$23ft^3$	Solid	Toxic, irritant
IX resin: Deoxygenating Resin	Stator cooling water system	Removal of O2	IX column	Industrial waste disposal	~4 pcs of $1ft^3$ packages	All P014 and P058 combined: $\sim 14ft^3$	Solid	Toxic, irritant

PICKERING NGS HAZARDOUS SUBSTANCES

Chemical	Where Used (System)	Purpose	Storage	Disposal	Inventory	In system	Form	Characteristics
IX resin Cation	Moderator (PB only)	Removal of cations	Purification IX columns	Industrial waste disposal	~50 pcs of 1ft^3 packages (28.32 l/bag)	Moderator (P058 only) ~1ft^3	Solid	Toxic, irritant
Carbon dioxide gas	Annulus gas system; generator	Annulus gas system – carrier gas; generator – purging gas	Outdoor tank (gas cylinder)	Annulus gas system – to reactor building exhaust; generator – vented to atmosphere	~33 pcs of 12 pack cylinders (K size container)	Annulus Gas: P014 and P058 combined: ~120ft^3	Compressed Gas	Mildly toxic, asphyxiant in high concentrations, heavier than air.
Morpholine The liquid is 45%; The drum is 50%	Steam generator feedwater; condensate feedwater	pH control and corrosion control	Totes in Oil and Chemical Storage Building and chemical addition station in turbine hall	Partly consumed; atmospheric discharge; and steam generator blowdown	Pickering 014 uses drums ~45 drums @ 441lb/drum of 50% solution. Pickering 058 uses totes ~ 1800L of 45% solution	Pickering 014: typically 1 drum (205 L) connected to the system. Pickering 058: ~ 1800L. This is in totes connected directly to the system	Liquid	Combustible liquid, toxic, corrosive base.

Chemical	Where Used (System)	Purpose	Storage	Disposal	Inventory	In system	Form	Characteristics
Sodium Hypochlorite 7%	Low pressure service water	Zebra mussel control	Four tanks in chlorination house	Consumed and residual to Lake Ontario	Pickering 014: ~52,000L Pickering 058: ~54,000L	Tanks connected to the system directly	Liquid	Corrosive acid, oxidizer - increases flammability of flammable or combustible material.
Sodium Metabisulphite 38% aqueous	Inactive drainage; reactor building service water	Dechlorination	Outdoor tanks with secondary containment	Consumed	Pickering 014: ~ 32,000L Pickering 058: ~ 40,000L	Tanks connected to the system directly	Liquid	Corrosive acid, toxic
Sulphur hexafluoride	Condenser circulating water system	Leak detection	Gas cylinders	To lake (small volumes only)	~2 cylinders of 350 ft^3 (size 30 cylinder)	Pickering 014 and 058 combined: ~1800 ft^3	Compressed Gas	Compressed Gas, mildly toxic

Chemical	Where Used (System)	Purpose	Storage	Disposal	Inventory	In system	Form	Characteristics
Grade B#2 oil (litres)	Standby generator; emergency power generators,	Fuel	Outdoor tanks with secondary containment	Consumed resulting in waste gases CO_2, NO_x, SO_x, etc.	Pickering 014 SG: ~1,900,000L Pickering 058 SG: ~1,900,000L Pickering 058 EPG: ~550,000L	Directly connected to the system	Liquid	Combustible Liquid, toxic
Lubricating oil and seal oil Teresso #46	Turbine lubricating oil system; generator seal oil system	Lubrication and sealing	Three tanks on the north side of the turbine hall	Reused or removed by contractor	~570drums @ 205L each	P014 and P058 combined: ~375,000L	Liquid	Non-toxic during normal use.

Chemical	Where Used (System)	Purpose	Storage	Disposal	Inventory	In system	Form	Characteristics
Insulating oil (litres)	Main output and service transformers	Cooling for the transformers	Brought in by truck	Removed by contractor	P014 and P058 combined: ~65,000 L per transformer for six units (12 transformers in total)	Directly connected to the system	Liquid	Non-toxic during normal use.
Ethylene glycol	Various Systems	Chillers	Small head tanks in powerhouse	Removed by licensed contractor if necessary	~2 drums @ 205L	~1000L	Liquid	Toxic
Reolube Turbofluid 46XC [Fire Resistant Fluid (FRF)]	Turbine governor	Hydraulic fluid for turbine governor valves	Tanks in powerhouse	Reused or drummed for disposal	Pickering 014 and 058 combined: ~3400L	Tanks directly connected to the system	Liquid	Mildly toxic
Diesel (Fire pumps) (litres)	Diesel Fire Pumps	Operating Pumps	Tanks	Consumed resulting in waste gases CO_2, NO_x, SO_x, etc.	Pickering 014: ~ 7200 L	Directly connected to the system	Liquid	Combustible Liquid, toxic

Chemical	Where Used (System)	Purpose	Storage	Disposal	Inventory	In system	Form	Characteristics
Hydraulic Oil Teresso 46 (litres)	Fuelling Machines	Operating Fuelling Machine	Tanks	Reused or removed by contractor	~3800 L per unit for six units	Directly connected to the system	Liquid	Non-toxic during normal use.
Gas, Mixed, 3% Nitrogen, 1.5% Oxygen	QC gas – Chemical Lab use as per chemical assessment	Quality control	gas cylinder	Vented to atmosphere	K and A size bottles	Chem Lab use	Gas	Compressed gas
GAS, Freon R134A Refrigerant	Used as a refrigerant	Maintenance - HVAC	gas cylinder	In the system	100 lb cylinder	In the station chillers on Units 0, 1,2,3,4.	Gas	Compressed gas
GAS, Argon, refrigerated liquid	Used in chem. Lab instrumentation. Also used by BTU as a cover gas for their metal analyzer	Ultra high purity ICP grade	gas cylinder	Return to empty gas bottle storage area and/or vendor as per HIS/MSDS	230 litre cylinder	Chem lab use for instrumentation	Gas	Compressed Gas
Sodium hydroxide	stator cooling water system	Alkalization	NaOH tank on 254' in the Turbine Bay	There is a plan to use this material in 2018	Not available	Dilute 2%	Liquid	Corrosive.

Chemical	Where Used (System)	Purpose	Storage	Disposal	Inventory	In system	Form	Characteristics
Xylene	various	Solvent, thinner	Flammable cabinet	Industrial waste disposal	4IX23	Used as required	Liquid	Flammable
Refrigerant "DUPONT SUVA 123 refrigerant"	HVAC	Refrigerant	HVAC System	Re-used in the system	45.4 KG DRUM	Contained within equipment	Gas	Toxic
Desiccant	CID: 193074 Compressed Air Circuit HP & LP Instrument Air	Adsorbents	General Storage Area/ Bulk Storage as per HIS/MSDS 570	Disposed as conventional waste or active waste if active as per HIS/MSDS 570	25 kg containers (140 kg and 150 kg steel drums for molecular sieve)	Connected to the system as child CAT ID 193074 to Parent CAT ID 188684 (Inlet Filter)	Solid	Not WHMIS controlled
	CID: 328987 Boiler Vapour Recovery (72210) Reactor Vault Vapour Recovery (72230) Mod Room Vapor Recover (72220)	Adsorbent material used as moisture remover in system driers.	Requires compress gas storage as per HIS/MSDS 1440	Dispose as conventional waste or active waste if active – take to appropriate chem. Waste drop off area as per HIS/MSDS 1440		connected to the system	Beads or Pellets	Toxic
Scintillant	FOR ON LINE TRITIUM MONITORS	Monitors	Corrosive cabinet	Industrial waste disposal	5LX110 bottle	Used as required	Liquid	Corrosive

Chemical	Where Used (System)	Purpose	Storage	Disposal	Inventory	In system	Form	Characteristics
Solvent, Degreaser	Varies	Cleaning compound, for parts washer	Flammable storage cabinet	Industrial waste disposal	45 GAL DRUM	Used as required	Liquid	Flammable

In addition to above chemicals, Designated Substance Assessments were conducted as per Ontario Regulation. The Ontario Occupational Health and Safety Act defines a designated substance as a biological, chemical or physical agent, or combination of agents to which the exposure of a worker is prohibited, regulated, restricted, limited, or controlled by a specific regulation.

Designated Substances	Assessment #	Form	Comments
Asbestos	P-REP-08965-0413252	Other than asbestos on plant system components (e.g., pipe insulation) there are gaskets in station as well.	A program is in place under direction of the Asbestos Program Administrator (APA) to control asbestos-containing materials.
Silica	P-REP-08965-0333820	Products containing crystalline silica ingredients can be classified as follows: Painting and coating materials, caulking products, sealants, cements, concrete and grouting products, sand, hardener, joint Treatment, adhesive, and construction activities (modification projects) such as drilling, grinding and chipping concrete.	
Lead	P-REP-08965-0412357	Lead could be found in product categorised below: Lead Sheets, Lead blankets, Lead wool, Hilti categories, Lead shot, Solders alloy, Lead wire, Lead batteries, Abrasive shot (copper slag with minor lead contamination), lab standards.	In addition lead also is in structural material such as lead bricks, radiation shielding and some paints.

Isocyanates	P-REP-08965-0333818	Products are: DECOTHANE SP, SIKAFLEX PRIMER 429/202, BELZONA 2911 (ELASTOMER QD CON), 2000.35952 359B9500 DEVTHANE 3 (Two parts MSDS), STONFLEX MP7, SIKAFLEX-221	These products are Largely used by the contractor.
Arsenic	P-REP-08963.21.DSA-0463389	Most products are batteries and one Lead Alloy and one Ebony Grit.	Concentration of Arsenic in these products was very low. The highest was .2%.
Mercury	P-REP-08963.21.DSA-0468663	Mercury-containing components and equipment on site are switches, relays, manometers, hygrometers, thermometers, lighting lamps and tubes, dry-cell batteries and a blood-pressure gauge.	Since the assessment blood pressure gage has been removed from site.
Benzene	P-REP-08963.21.DSA-0466050	3 gasoline products plus paints and primers(, Loctite 7649 Primer, 4020.01000 DEVFLEX DTM INEX, 4020.07100 DVFLX DTM FLA RD 4020−710 ER, and 4308-9020H DEVGUARD 4308H (also Carbopol 941 Polymer which has not been used for years).	Regulation 490/09 does not apply to delivery of gasoline to vehicles by gasoline pump.
Acrylonitrile	P-CORR-08963.21-0461966	No product containing Acrylonitrile	
Coke Oven Emissions	P-CORR-08963.21-0461479	No Metallurgical Coke–Oven at Pickering	
Ethylene Oxide	P-CORR-08963.21-0461995	No product was found.	This search yielded no results. There was no use of Ethylene oxide or Ethylene oxide-Containing products.
Vinyl Chloride	P-CORR-08963.21.DSA-0462279	No product was found.	

Enclosure 2 to OPG Letter, R. Lockwood to M. Leblanc, "Pickering NGS –Notice of Participation at CNSC Public Hearing 2018-H6 and Written Submission – Application for the Renewal of Power Reactor Operating Licence", CD# P-CORR-00531-05310

Enclosure 2

Supplementary Information to the Application for Renewal of the Pickering Nuclear generating Station Power Reactor Operating Licence,

P-CORR-00531-05223

(Total pages including cover sheet 44)

ONTARIOPOWER GENERATION

1675 Montgomery Park Road, P.O. Box 160, Pickering, Ontario L1V 2R5

December 11, 2017

CD# P-CORR-00531-05223

MR. M.A. LEBLANC
Commission Secretary

Canadian Nuclear Safety Commission
280 Slater Street
Ottawa, Ontario
K1P 5S9

Dear Mr. Leblanc:

Supplementary Information to the Application for Renewal of the Pickering Nuclear Generating Station Power Reactor Operating Licence

The current Pickering Power Reactor Operating Licence (PROL) 48.04/2018 expires on August 31, 2018. OPG has applied for a 10-year licence renewal of the Pickering Nuclear Generating Station (NGS) to include continued commercial operation of all reactor units until the end of 2024 as well as post-shutdown activities associated with removal of fuel and water in preparation for the safe storage of all units.

The information required to demonstrate that the Pickering NGS meets or exceeds all of the applicable requirements of the *Nuclear Safety and Control Act (NSCA)* and the associated regulations was provided in the application sent on August 28, 2017 (Reference 1).

CNSC staff determined that the application contained the information required under the NSCA and the regulations during a completeness review of the application (Reference 2). CNSC staff requested further information on some of the sections in the licence application based on the technical sufficiency review of the application (Reference 3).

Additionally, due to an amendment to the Pickering PROL in October 2017 (Reference 4), the request for the licensed activities has been updated for licence renewal, as requested in Reference 2.

The supplementary information to the Pickering application for licence renewal is provided in Attachment 1.

M. A Leblanc
CD# P-CORR-00531-05223

Should you have any questions, or requests for further information, please contact Jack Vecchiarelli, Manager, Regulatory Affairs – Relicensing at (905) 839-6746, extension 5444.

Randy Lockwood
Senior Vice President
Pickering Nuclear

cc: CNSC Site Office – Pickering
CNSC Pickering Regulatory Division (Copy to each staff)

References:

1. OPG Letter, R. Lockwood to M.A. Leblanc, "Application for Renewal of Pickering Nuclear Generating Station Power Reactor Operating Licence", August 28, 2017, CD# P-CORR-00531-05055.

2. CNSC Letter, A. Viktorov to R. Lockwood, "CNSC Staff Completeness Review – Ontario Power Generation (OPG) Application for Renewal of the Pickering Nuclear Generating Station Power Reactor Operating Licence (PROL) 48.03/2018", September 13, 2017, e-Doc 5301022, CD# P-CORR-00531-05152.

3. CNSC letter, A. Viktorov to R. Lockwood, "Pickering NGS: CNSC Staff Technical Sufficiency Review of the Application for Renewal of the Pickering NGS Power Reactor Operating Licence (PROL)". October 17, 2017, e-doc 5343935, CD# P-CORR-00531-05181.

4. CNSC Email, J. Villeneuve to L. Moraru, "Applications to Amend OPG's Darlington and Pickering Nuclear Power Reactor Operating Licences", October 26, 2017, CD# P-CORR-00531-05192.

Attachment:

1. Supplementary Information to the Application for Power Reactor Operating Licence Renewal for the Pickering Nuclear Generating Station

ATTACHMENT 1

Supplementary Information to the Application for Power Reactor Operating Licence Renewal for the Pickering Nuclear Generating Station

(41 pages including this coversheet)

Attachment 1

Supplementary Information to the Application for Power Reactor Operating Licence Renewal for the

Pickering Nuclear Generating Station

Table of Contents

1 Overview 5

1.1 Introduction 5

2 Supplementary Information 6

2.1 Fitness for Service until 2024 [Items #1, 2 and 3] 6

2.2 Disposition Process of Periodic Inspection Results [Item #4] 6

2.3 Sustainable Operations Plan [Item #6] 8

2.4 Management System and Organization [Item #8 and 9] 8

2.5 Knowledge Management [Item #10] 14

2.6 Management of Contractors [Items #11 and #12] 15

2.7 Performance Assessment and Improvement [Item #13] 16

2.8 Records Management [Item #14] 17

2.9 Human Performance Program [Item #15] 18

2.10 Training [Items #16 and 17] 20

2.10.1 Personnel Training 20

2.10.2 Certification Table [Item #17] 20

2.11 Fitness for Duty [Item #18] 21

2.11.1 Limits of Hours of Work 21

2.11.2 Regulatory Documents RD-204 and RD 363 21

2.12 Operations [Items #19 – 23] 22

2.12.1 Operational Focus 22

2.12.2 Plant Status Control 23

2.12.3 Work Protection 24

2.12.4 Operating Procedures 25

2.13 Engineering Change Control (Items #24-25] 26

2.14 Procurement Engineering [Item #26] 27

2.15 Software [Item #27] 28

2.16 Reactor Components and Structures [Item #28] 28

2.17 Fitness for Service [Item #29] 29

2.17.1 Aging Management 29

2.17.2 Periodic Inspection Program [Item 30] 29
2.18 Radiation Protection [Items #31 – 37] 31
2.18.1 Radiation Protection Program 31
2.18.2 Application of ALARA 33
2.19 Environmental Management System [Items #38 – 42] 35
2.19.1 REGDOC-2.9.1 Compliance 35
2.19.2 Protecting the Public 35
2.19.3 Category C Spills 35
2.20 Emergency Preparedness Program [Item #43] 36
2.21 Waste Management [Items #44 – 45] 37
2.22 Appendix E [Item #46 and #47] 38
3 List of Activities under the Operating Licence 39
3.1 Amended List of Activities under the Operating Licence 39
3.2 Import and Export of Nuclear Substances 40
4 References 40

List of Tables

Table 1- Programs Owned Outside of the Nuclear Organization 9
Table 2- Number of Pickering Certified Staff (October 30, 2017)........ 20
Table 3 - Number of Operator Challenges (as of October 2017)........ 23
Table 4 - Procurement Engineering Governance........ 28
Table 5 - N285.4 and N285.5 Inspections........ 30

List of Figures

Figure 1 - Program Ownership (Page 1)........ 10
Figure 2 - Program Ownership (Page 2)........ 11
Figure 3 - Program Ownership (Page 3)........ 12
Figure 4 - Program Ownership (Page 4)........ 13
Figure 5 - Work Protection Performance Index........ 24
Figure 6- Operating Memo Totals........ 25
Figure 7- Open Procedure Change Requests........ 26
Figure 8 - Collective Radiation Exposure (CRE)........ 34

1 Overview

1.1 Introduction

The current Pickering Power Reactor Operating Licence (PROL) 48.04/2018 expires on August 31, 2018. OPG has applied for a 10-year licence renewal of the Pickering Nuclear Generating Station (NGS) to include continued commercial operation of all reactor units until the end of 2024 as well as post-shutdown activities associated with removal of fuel and water in preparation for the safe storage of all units.

The licence application provided the information required to demonstrate that the Pickering NGS meets or exceeds all of the applicable requirements of the *Nuclear Safety and Control Act (NSCA)* and the associated regulations. The application described the management system and the various programs, processes, and personnel that Pickering has in place to ensure that all work is performed with quality to the appropriate standard and with minimal impact to the public and the environment. Collectively, these elements ensure that safety is the overriding priority in all of the necessary activities undertaken to maintain safe and reliable operation of the station.

The licence application for renewal of the Pickering PROL was sent on August 28, 2017 (Reference 1). It was determined by CNSC staff that the application contained the information required under the NSCA and the regulations during a completeness review of the application (Reference 2). As a result of the technical sufficiency review of the application, CNSC staff requested further information on some of the sections in the licence application (Reference 3).

This supplementary licence application document provides further information as requested by the CNSC staff on some of the areas in the licence application and it should be read in conjunction with the licence application submitted as Reference 1.

Item numbers which are referenced in this supplementary document correspond to the itemized list of CNSC staff comments in Reference 3. Note that some item numbers did not require a response.

Further, as discussed in Reference 2, the Pickering PROL was amended on October 26, 2017 and the Licence Conditions Handbook was revised, to allow for the import and export of nuclear substances consisting primarily of contaminated laundry. The additional purpose of this document is to revise the requested list of activities to be authorized under the new operating licence term.

In summary, the licence application, together with this supplementary document contains sufficient information to demonstrate that Pickering NGS meets all of the legal requirements of the NSCA and the associated regulations, and to demonstrate that OPG is qualified to carry on the licensed activities and makes adequate provisions to protect the health, safety and security of persons, and the environment.

2 Supplementary Information

2.1 Fitness for Service until 2024 [Items #1, 2 and 3]

OPG has in place well established Fitness-for–Service (FFS) programs for major components that will ensure fitness for service is demonstrated until the end of commercial operation. OPG has high confidence that these programs will continue demonstrating the continued fitness for service of major components and system, structures and components important to safety.

The Life Cycle Management Plans (LCMPs) for the major components document the strategies and actions planned to facilitate demonstration of fitness-for–service of the components throughout the planned operating period.

Fitness-for–service of major components is demonstrated and re-assessed on an on-going basis through planned periodic inspections and maintenance in accordance with the requirements of the periodic inspection standards, CSA N285.4, N285.5 and N285.8, and OPG's integrated aging management program and the major components program.

Fitness-for–service assessments are in accordance with industry standard guidelines that set out the permissible assessment methodologies and the mandatory requirements. The results are submitted to the CNSC in accordance with the standards.

Operation of Pickering NGS until 2024 is supported by the Periodic Safety Review 2 (PSR2). OPG is confident that the Pickering fuel channels will remain fit-for-service for continued commercial operation to the end of 2024. The PSR2 action plan for the fuel channels as documented in the Integrated Implementation Plan (IIP) will ensure the required actions are taken, for continued FFS through to the end of 2024.

Further information on the fitness for service of fuel channels has also been provided to the CNSC, as requested, in OPG letter, P-CORR-00531-05201.

2.2 Disposition Process of Periodic Inspection Results [Item #4]

Programs are in place at Pickering to perform planned periodic inspections in accordance with program and regulatory requirements. OPG has robust processes in place for dispositioning inspection or surveillance results, and for responding to relevant operating experience that could impact fuel channel fitness for service or plant operability. These processes are described below, and in *Fuel Channel Life Cycle Management*, N-PROC-MA-0044.

Periodic inspection is considered to include the fluid boundary portions of components and piping, including their supports, that comprise systems that: directly transports heat from nuclear fuel; systems essential for the safe shutdown of the reactor or the safe cooling of the fuel, or both, in the event of a process system failure; and other systems or components whose failure could jeopardize the integrity of the aforementioned systems.

The periodic inspections standards address failure aspects; classification of areas subject to inspection; provision for access; inspection techniques and procedures; personnel qualifications; frequency of inspection; responsibilities; documentation; records; evaluation of inspection results; dispositioning; and repair, replacement, and modification requirements.

Inspection results are evaluated and dispositioned in accordance with N-PROC-MA-0052, *Flaw Dispositioning*, which establishes generic process and accountabilities for evaluation of CSA N285.4 and N285.5 periodic inspection results. This procedure also describes the process for the preparation and submission of a component disposition to the CNSC for acceptance, and describes how component disposition limits are monitored to ensure disposition conditions are not exceeded.

Station Condition Records (SCR) are initiated to identify fuel channel non-conformances in accordance with N-PROC-RA-0022, *Processing Station Condition Records* which provides a consistent reporting and evaluation process for identified adverse conditions. This process is used to ensure the adverse condition is adequately documented, the cause of the adverse condition is determined, corrective action is implemented to correct the adverse condition, as appropriate, to prevent the recurrence or reduce the risk of recurrence of a similar adverse condition. Lessons learned are captured in the SCR database and provide a valuable resource to OPG and industry through Operating Experience (OPEX) mechanisms in accordance with N-PROC-RA-0035, *Operating Experience Process*.

When fuel channel non-conformances are identified, a Technical Operability Evaluation is initiated, when required, in accordance with N-PROC-MP-0045, *Technical Operability Evaluation*. A Technical Operability Evaluation (TOE) is the process dealing with uncertainty about operability, i.e. scenarios where the ability of a System, Structure, or Component (SSC) to carry out its nuclear safety-related function(s) comes into question. A formal TOE is initiated when, following an initial assessment of a degraded condition, there persists doubt about SSC operability, but there is also an expectation that, with or without compensatory actions, SSC operability can be demonstrated by performing the TOE.

In addition, a Discovery Issue Resolution Process is initiated, when required, in accordance with N-PROC-RA-0094, *Discovery Issue Resolution Process* (DIRP) which identifies due diligence actions required of staff when the safety analysis of an OPG nuclear station is suspected to be less than adequate, or when a gap is discovered in the definition of the safe operating envelope. The DIRP is a managed process for dealing with discovery issues associated with the safety analysis. The DIRP, similarly to the TOE, deals with issues having potential bearing on operability, and is intended for cases when the operation of a nuclear facility conforms with its defined safe operating envelope, but an issue or situation is not addressed in the existing safety analysis. The DIRP, in this way, complements the TOE process for potential operability issues.

Repairs, replacements and modifications are performed in accordance with N-PROC-MA-0065, *Administrative Requirements for the Periodic Inspection of Nuclear Power Plant Components* which provides the administrative process for complying with the periodic inspection requirements.

2.3 Sustainable Operations Plan [Item #6]

The Sustainable Operations Plan (SOP) will be developed to address the unique challenges that could be faced as the end of commercial operations approaches. The SOP is based on each of the Safety and Control Areas (SCAs) as defined by the CNSC. This plan will be submitted to the CNSC 5 years prior to the permanent shutdown of the first unit at the Pickering station.

Fitness for Service (FFS) of station systems, structures and components (SSCs) will be assured to the end of 2024 by the successful implementation of the Integrated Implementation Plan (IIP) actions. The SOP will point to existing nuclear programs and the results of these programs to demonstrate FFS while approaching the End of Commercial Operation (ECO). OPG is committed to maintaining its effective robust nuclear programs, such as the Integrated Aging Management Program (IAMP) to ensure the FFS of SSCs. The SOP will include specific supplemental FFS actions to augment existing programs where it is determined that programmatic changes or stand-alone actions within existing programs are required to resolve unique challenges while approaching ECO.

2.4 Management System and Organization [Item #8 and 9]

OPG's nuclear management system provides the framework for programs, standards and other governing documents and processes which collectively ensure that Pickering NGS operates safely and that safety is the foremost consideration in management decisions and actions. The program N-PROG-AS-0001, *Managed Systems,* ensures that the applicable regulatory requirements and applicable codes and standards are embedded in the nuclear management system.

The nuclear management system has evolved over the past licence period to support the OPG business model. Several programs have transitioned from being only in the nuclear management system, to being owned by corporate business units. For these programs, ownership and accountability for the program resides with the corporate program owner, but the programs remain in the nuclear management system.

The Nuclear President and Chief Nuclear Officer (CNO) is accountable for establishing and implementing the nuclear management system and is accountable for its effectiveness. For programs within corporate business units, the CNO will delegate accountability to the interfacing organization and this role is identified as the authorization authority. The program owner receives approval from the authorization authority prior to issuing changes to the program document, while the authorization authority is accountable to the CNO for maintaining the integrity of the nuclear management system. The program owner is accountable for the content, accuracy, and execution of the program, including assurance that regulatory requirements are met. Specific roles and additional responsibilities are outlined within the program.

Table 1 lists all programs that are owned by corporate business units which perform licensed activities:

Former Program within Nuclear Business Unit		Current Program within Corporate Business Unit		
Document Number	**Program Name**	**Document Number**	**Program Name**	**Business Unit**
		N-PROG-TR-0005	Training	People & Culture
		N-PROG-OP-0006	Environmental Management	Environment
N-PROG-AS-0006	Records and Document Control	OPG-PROG-0001	Information Management	Finance – Information Management
N-PROG-MM-0001	Materials Management	OPG-PROG-0009	Items and Services Management	Supply Chain
N-PROG-HR-0004	Conventional Safety	OPG-PROG-0010	Health and Safety Management System	People & Culture – Health & Safety
N-PROG-RA-0018	Nuclear Pandemic Plan	OPG-PROG-0033	Business Continuity	Finance – Enterprise Risk Management
N-PROG-AS-0007	Project Management	OPG-PROG-0039	Project Management	Nuclear Projects

Table 1- Programs Owned Outside of the Nuclear Organization

The attached organizational charts (Figures 1-4) represent the organizational structure with respect to the nuclear program governance. The organizational charts include the person accountable for the management system (Nuclear President and Chief Nuclear Officer) and all positions with responsibilities for the management and control of the licensed activities, which includes program owners for programs listed under the 14 Safety Control Areas.

Figure 1 - Program Ownership (Page 1)

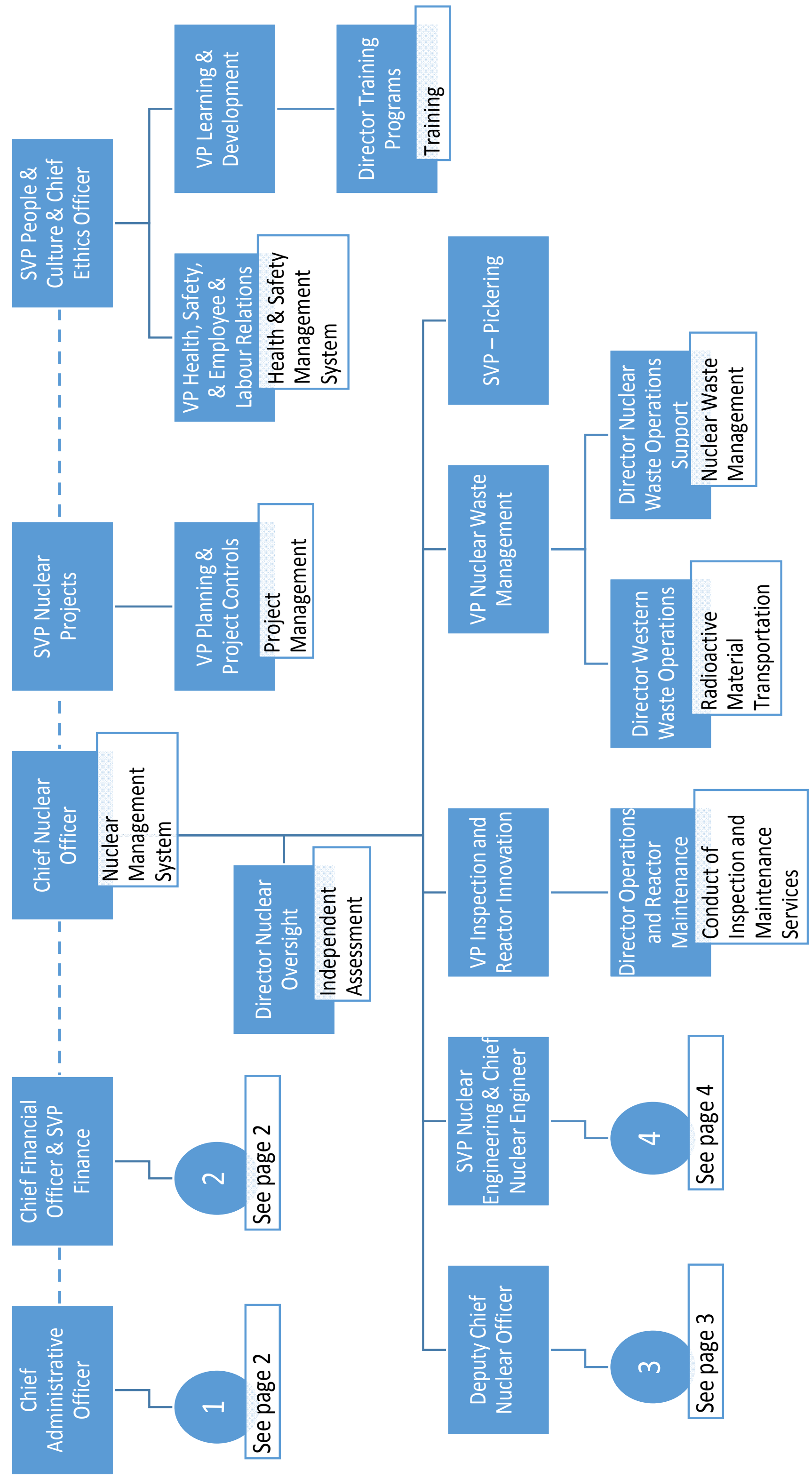


Figure 2 - Program Ownership (Page 2)

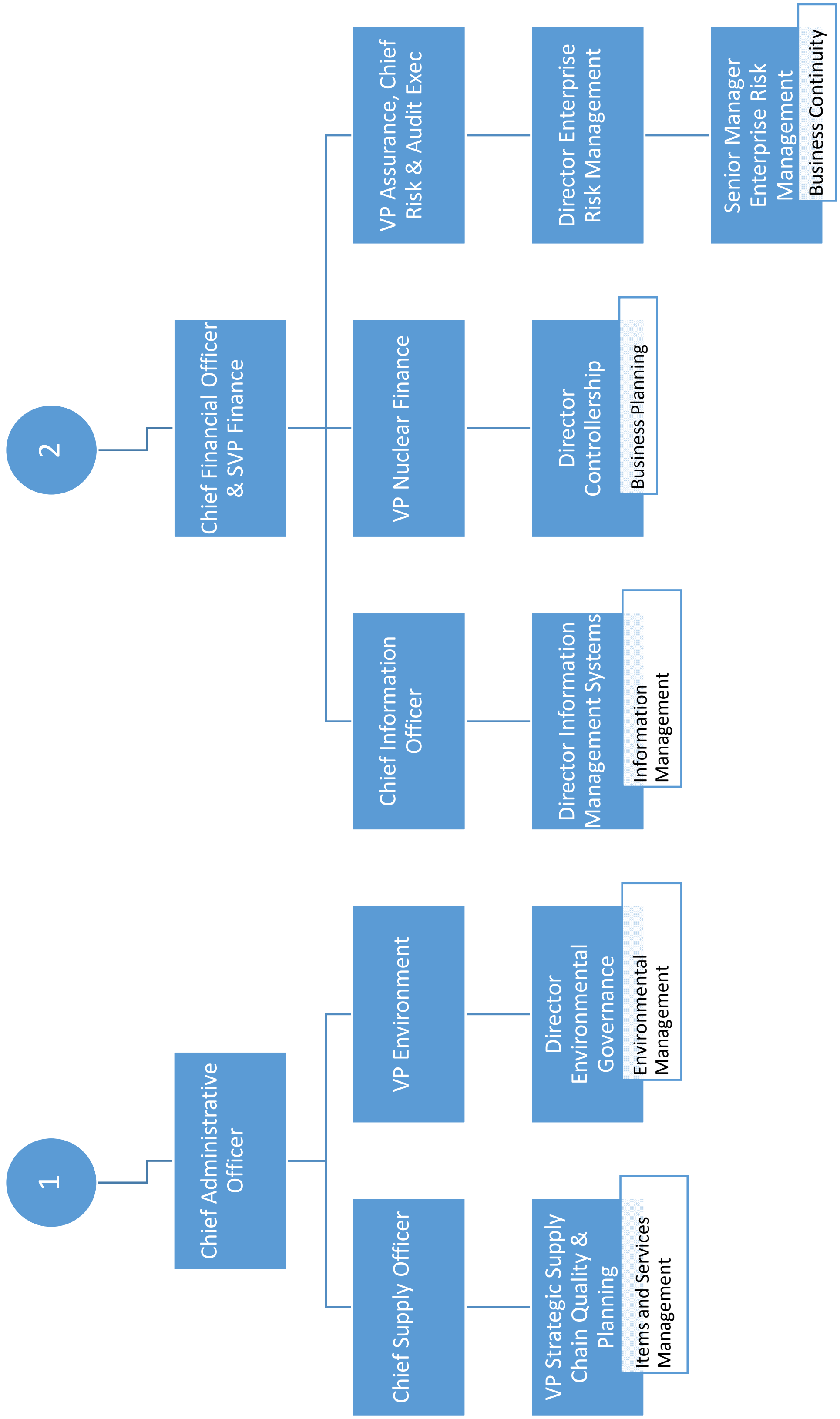


Figure 3 - Program Ownership (Page 3)

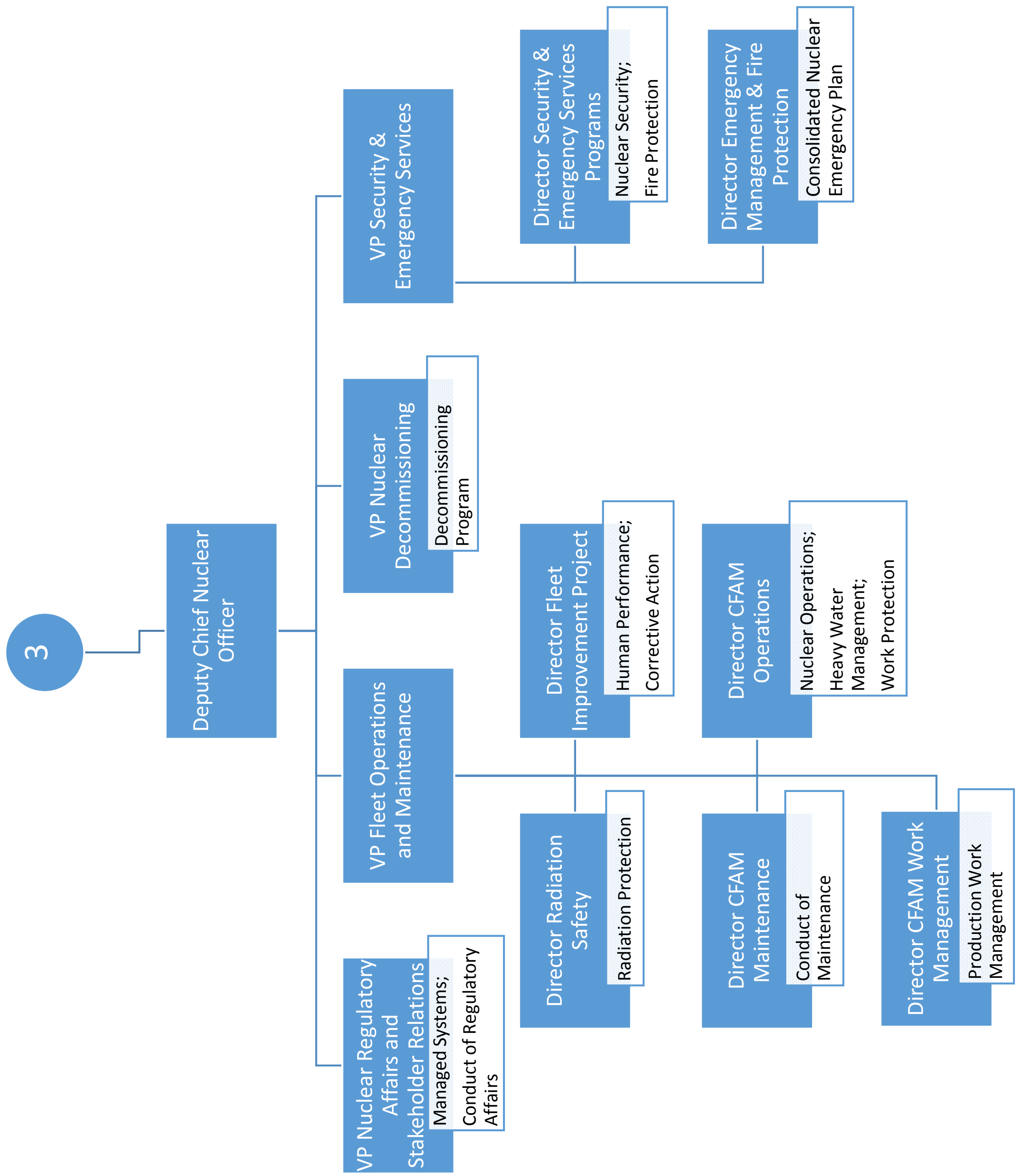
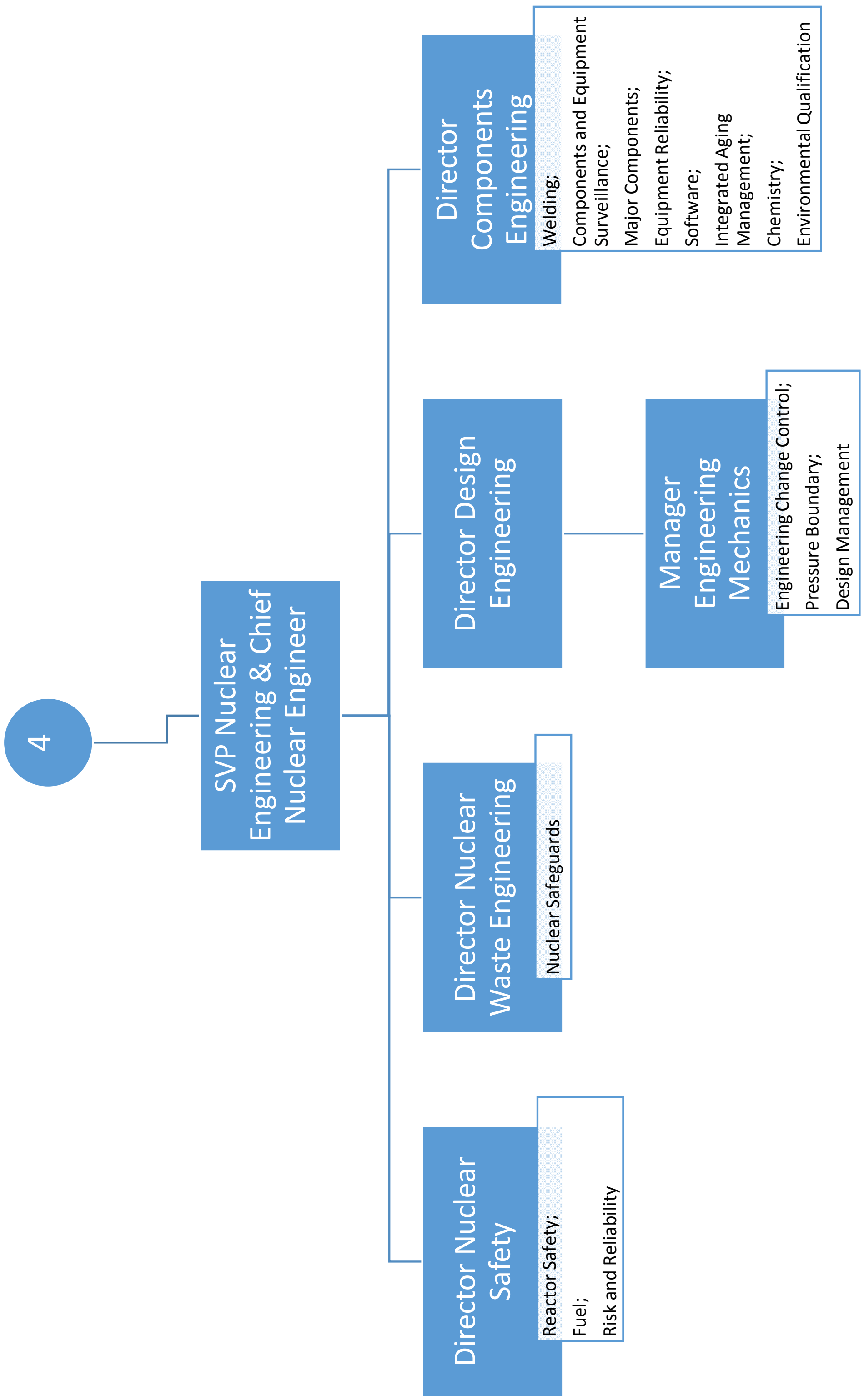


Figure 4 - Program Ownership (Page 4)



2.5 Knowledge Management [Item #10]

OPG has many well established methods to ensure people working in the organization have the qualifications, knowledge and skills required to perform competently. The knowledge management program complements these foundational programs by providing tools and techniques to consider and share tacit knowledge.

Given OPG's demographics, employee attrition and the lengthy training and development required for specialized roles, OPG has invested in knowledge management for ongoing operations as well as the delivery of projects and initiatives to ensure that the critical knowledge and expertise of employees is sustained.

OPG has adopted a corporate-wide approach for Knowledge Management (KM) and Retention. This approach comprises three steps designed to identify and mitigate knowledge risk within the organization: 1) Risk Assessment and Analysis, 2) Action Planning and Implementation, and 3) Verification and Sustainment activities.

Twice a year, an analysis is performed which lists potential retirement attrition within various business groups, viewed over a multi-year period. The areas of highest potential impacts are identified, and the business is alerted through the Human Resources Business Partners (HRBPs) of affected divisions/departments. A Knowledge Management Toolkit, along with associated messaging and tools, is available with support provided through OPG's Talent Centre of Expertise (COE). These Knowledge Management tools help determine knowledge risk for departing employees. The Knowledge Management Toolkit is comprised of an overview of OPG's approach to KM, and evaluation forms which help determine the severity of knowledge risk, as well as suggesting mitigation options. Mitigation options include a description of activities and solutions that can be used to help transfer knowledge (e.g., job shadowing, documentation, audio-visual recording of tasks). The tools are easy to understand and use, and are intended to be primarily self-serve in nature to give the business maximum agility.

Both short and long term mitigation strategies are presented as part of the planning and action portion of the KM approach, with the business group choosing the solution that works best for them. The creation of Individual Development Plans (IDPs) are available to all employees, and the business is encouraged to use the IDP to assign Knowledge Management activities for both incoming and outgoing parties. The IDP identifies the specific KM activities that the person will undertake to absorb and operationalize the critical knowledge required for the role. Mid-year and year-end reviews of these development goals with their Leader will help to verify the success of knowledge transfer and determine ongoing activities to sustain the implementation/use of this knowledge, and further embed it into the business.

Areas of higher risk within the business are able to leverage additional formalized tools and processes to reflect their needs. As an example, a high-risk group may declare certain KM activities mandatory on a prescribed cadence, and may measure compliance accordingly.

OPG's new Human Capital Management system will allow the IDPs to be created electronically and stored within the system. Using this system, the IDPs can be catalogued and reported upon to maximize visibility and impact. Information is visible to Leaders about their organizations, who can use this information to confirm that objectives are aligned with OPG strategic imperatives, thus helping maximize the positive impact of these activities on the business.

2.6 Management of Contractors [Items #11 and #12]

OPG Supply Chain Quality Services is responsible for prequalifying suppliers (vendor, seller, contractor, subcontractor, etc.) of items and services which require a quality program using N-PROC-MM-0010, *Establishing and Maintaining Ontario Power Generation Approved Supplier List.* All of the vendors performing directly under contract to OPG are evaluated, audited and qualified on the OPG Approved Suppliers List by the OPG Supply Chain Quality organization or their delegates who also establish and maintain the Ontario Power Generation Approved Suppliers List (ASL).

The quality performance of the top critical suppliers is continually monitored and reported by Supply Chain and corrective actions are initiated when required as per N-PROC-MM-0041 *Quality Engineering and Supplier Performance Management*. This procedure supports improvement of the quality of items and services procured from suppliers on the ASL. Processes described include methods for measuring and managing supplier's quality performance, investigation and management of supplier corrective actions related to Station Condition Records (SCR) and Operating Experience (OPEX), reduction of initial receipt inspection material quarantine, management of supplier reported non-conformances and development of suppliers. This includes maintaining ASL Criticality Supplier List, Quality Key Performance Indicators (KPIs), ASL Critical Supplier Quality Health Index, and supplier quality escalation process.

The supplier escalation process is as follows:

- Supplier quality performance is measured using scorecards of key performance indicators.
- A list comprised of OPG business critical, quality critical and low-performing suppliers is generated each year.
- Ongoing quality performance management of the list of suppliers is performed via a key performance indicator review, quality review meetings, focused supplier development and site visits.
- Non-conformance and corrective action requests are initiated in order to investigate and manage supplier corrective actions in response to any supplier quality related issues that are identified.
- These corrective actions to non-conformance enhance the suppliers' quality systems resulting in continuous improvement.

Contractors are qualified by OPG Supply Chain Quality Services under a process that ensures that the contractor has developed and implemented a management system that meets the applicable requirements outlined in CSA N286-12, management system requirements for nuclear facilities.

Oversight of the Contractor's performance in field execution is subject to pre-planned and risk based oversight by various groups. In the Projects and Modifications department, oversight starts with the Field Engineering teams who also execute the OPG Quality Assurance (QA) program. A separate oversight group in the Projects and Modifications department looks at trend indications, collected from all data generating bases, and ensures corrective actions are initiated and followed up.

Work to be contracted by OPG prior to the actual award of a contract has followed OPG processes covered in many levels of governance including (but not limited to):

OPG-PROG-0038 *Contract Management*, is the governance that establishes the program requirements for managing the contracted services, including the roles and accountabilities in significant detail from the Business Level Authorities through Safety, Legal, and Environment accountabilities and all contract management roles including: Contract Owner; Contract Administrator; Contract Monitor; Supply Chain; Constructor's Supervisor. For the contract management roles, an individual may fill one or more of these roles, depending on the complexity of the contract, but all roles are fulfilled. The organizational level of the individuals accountable may change depending on the risk and complexity of the contract. Although some roles may be merged, there shall always be a contract owner, and a separate and distinct supply chain purchasing agent.

Additionally, OPG-PROC-0204 *Contract Management* takes authority from OPG-PROG-0038 and goes further by establishing the minimum process requirements within OPG for managing contracted services including the identification of roles and accountabilities, contract planning, procurement, post award, execution and the closeout of contracted services. This procedure applies to all service-based activities contracted by OPG. It outlines in detail the responsibilities of the contract owner including; determining the scope of work for the contracted service, identifying all stakeholders that may be affected or impacted by the contracted service, determining labour requirements, determining which external agency approvals are required for the contracted service and assigns accountability to the appropriate party (i.e. OPG or the contractor). It also identifies the quality requirements and controls for the contracted service and assigns accountability to the appropriate party etc. Similarly, this procedure includes the responsibilities of the Contract Administrator, Contract Monitor and the Purchasing Agent.

2.7 Performance Assessment and Improvement [Item #13]

Nuclear Oversight (NO) performs audits in accordance with N-PROC-RA-0048, *Conducting Performance Based Audits and Assessments.* The audit is a planned and documented activity and may identify insights that are opportunities for improvement and for consideration by the line organizations. A 3-year audit plan provides the schedule for the audits that will be performed. As well, performance is also rated using specific audit rating criteria.

Nuclear Oversight performs annual self assessments and management reviews to confirm program coverage. The programs within the Nuclear Management System charter are aligned into three areas of Nuclear Oversight responsibility: Nuclear Cross-Functional, Engineering, and Operations and Maintenance. As specified in N-PROC-RA-0097, *Self-Assessment and Benchmarking*, NO conducts a self-assessment every year to review coverage by audits and assessments of programs identified in these areas of responsibility. This procedure requires management to conduct self-assessments to identify opportunities for continual improvement and to confirm that work meets the requirements of the management system.

The Self-Assessment and Benchmarking Program is utilized to evaluate actual performance against management expectations, industry standards of excellence and regulatory requirements. An effective Self-Assessment and Benchmarking Program exhibits self-critical behaviours which allow for achievement of higher quality and performance standards by identifying and addressing gaps and eliminating adverse conditions within programs and processes.

At the end of each 5-Year program coverage plan cycle, the Senior Manager Nuclear Oversight conducts a review to demonstrate adequate coverage of all the programs identified in the three areas of NO responsibility. In addition, NO may perform an annual aggregate self-assessment of line management feedback collected for all the audits.

Nuclear Oversight performance indicators are based on Nuclear Quality Management Leadership (NQML) committee and best industry input. The goal of these indicators are to measure NO's ability to influence improvement at the station. Any performance indicator that is not to industry standard is required to have an improvement plan.

The performance indicators are:

- Issue Resolution Time, which is a measure of the effectiveness of the influence NO has on station management to resolve those issues requiring causal analysis (Root, Apparent, and Common), in a timely manner;
- Escalated Issue Average Age, which is a measure of the time it takes station management to resolve those issue escalated by NO;
- Staffing Health, which is a measure of NO's ability to maintain a core group of quality assurance professionals and a healthy rotation program; and
- Audit Feedback, which is a measure of the quality of the audits.

2.8 Records Management [Item #14]

OPG-PROC-0001, *Process Administrative Governance Documents* is used for governing documents including policies, charters, programs, procedures and standards. A governing document stipulates philosophy, mandatory rules, regulations, licensing requirements, and management controls, in order to implement business processes. This procedure describes review, comment disposition, validation and approval activities to ensure adequacy prior to being issued for use.

N-PROC-AS-0028, *Development, Review, and Approval of Technical Procedures*, describes the required activities to ensure documents are correct, meet the intended function, and are usable by a qualified individual. This includes controls for performing verification activities that ensure adequacy, such as checking that the procedure is operationally correct, the required reviews have been completed and mandatory changes, if any, have been adequately dispositioned. Verifiers of technical procedures are persons who are knowledgeable of the system or equipment to which the procedure applies, and qualified to at least the minimum level position necessary to perform the procedure or be considered a system expert. N-PROC-AS-0028 also defines the required approval level for the procedure, prior to issuance.

OPG-PROC-0019, *Records and Document Management* provides direction to ensure that records in the custody or control of OPG are consistently managed, protected, and accessible throughout their life cycle.

OPG has robust processes in place to establish record retention periods, security and access control. OPG-MAN-08133-0001, Sheet 01-03-01, *Records Retention*, provides the requirements of a records retention program including how to establish retention periods.

The security of records is documented in OPG-STD-0030, *Protecting OPG's Information and Intellectual Property*, which provides instructions for the protection of information and intellectual property owned by or entrusted to OPG. This standard covers protection of information through: the use of classifications; release of information by defining a set of criteria to assist in determining if the information should be released; requirements for storing information to ensure information is not left exposed to unauthorized persons during the workday or after work hours; and critical data protection which is an ongoing initiative to protect OPG's most critical/sensitive information.

OPG-PROC-0178, *Controlled Document Management* defines a process for managing the life cycle of Controlled Documents (CD) across OPG in order to: ensure latest applicable revision of CD is identified and available, including minor revisions; minimize risk of inadvertent use of obsolete and superseded documents, ensure approved document change requests (DCR) are maintained, dispositioned, and available; and perform quality checks (QC). OPG's QC Program is a programmatic self assessment completed by an independent organization on a sampling of documents indexed in the records repository and on controlled copies in the plant locations. The assessment is focused on ensuring the documentation is available, retrievable, and is at correct revision number. This assessment is performed twice a year using the instructions provided in OPG-MAN-08133-0003, *Quality Check Process for QA Records*.

OPG-PROC-0179, *Nuclear Quality Assurance Records* is specific to submissions, access control and maintenance of both paper and electronic records. This procedure provides instructions for consistent management, throughout the life cycle, of Nuclear QA records that are generated or collected by or for OPG, including quality checks. This procedure ensures that nuclear QA records and QA vaults are managed to protect records against damage by fire, flooding, environmental deterioration, theft, and misuse by unauthorized personnel.

2.9 Human Performance Program [Item #15]

Human Performance is one of Pickering's top 3 station priorities. Human Performance (Hu) is integrated into our culture. Human Performance training is provided to all new employees, and a refresher course is provided to every nuclear employee annually through the Nuclear General Employee Training (NGET) computer based training. It is also embedded into initial and continuing training for operations, maintenance and engineering staff and the associated behaviours are reinforced by peers and supervision, in day to day work activities. Supervisors are given supplementary Hu training during the leadership training. The training is based on the supervisory perspective of reinforcing standards.

The initial human performance training is also reinforced by incorporation into the pre-job briefing process. Applicable human performance tools (e.g. Event Free Tools) are discussed as part of the preparation for every task. Correct use of the tools is ensured through field observations by peers and supervisors.

Observations are summarized by crew supervision, and monitoring of trends is done by line management, as part of the crew Management Review Board (MRB) process. These meetings are held at regular intervals to maintain a continuous feedback loop on the crew's performance. Each department then incorporates all of their crew observation data, and will present their findings on a rotating schedule at the Human Performance Steering Committee Meeting, where input and feedback can be obtained by other department managers, and the Human Performance Department. The department will follow up the next month and provide an update on corrective actions, and whether further action is required for their findings.

The role of the Hu department is to monitor for trends in Human Performance across the site, and provide assistance and guidance to departments and the site to reinforce standards, as well as monitor for improvements in Hu techniques throughout industry.

Paired Observation training is used to maintain high standards in observations that the supervisors complete for these MRBs. The focus is on having an engaging conversation between supervisors and their workers. The approach of "Ask, don't tell" is used to allow the worker to be more engaged in understanding the need for maintaining high standards.

Managers and supervisors are required to complete an 8-hour course on the requisite skills that are applicable to paired observations, and all observations in general. These skills are required to enable managers to develop their direct reports as leaders. This is followed up by a graded field observation to complete the qualification. They are also required to complete an 8-hour course on the requisite skills that are applicable to Observation and Coaching. These skills are required for supervisors to be able to coach their staff, for performance improvement.

The objectives of the training is for Leaders to learn to:

- Recognize that observation and coaching supports Human Performance (Hu) and continuous improvement through a visible and active leadership presence in the workplace; assess the effectiveness of their current coaching skills;
- Distinguish between coaching and correcting;
- Learn how to acknowledge and reinforce positive behaviours;
- Learn how to engage in a coaching conversation and ask questions when it appears as though standards aren't being met;
- Obtain commitment on what the person being coached will do in the future to change behavior;
- And take detailed notes and share organizational learning.

The overall metric for Human Performance is the Site Event-Free Day reset total for the year. The hierarchy of Event Free Day Resets (EFDR) from highest consequence to lowest is: Site, Department, and Crew. The Station Condition Record (SCR) program is used to capture these events as they happen, and then Site, Department, and higher consequence Crew level resets are analysed using the process described in N-INS-09030-10001, *Human Performance Event Communication and Analysis*. This instruction is used to determine how the event occurred, and what Hu barriers failed, in an effort to prevent recurrence of events. Lower level trends are recognized from SCR frequency, and site wide communications are used to refresh the standards, expectations, or good behaviour in order to reverse the trend.

Lower level Hu events are also monitored and used as opportunities for learning, and being proactive at recognizing the behaviours that could contribute to significant events. This provides the opportunity to stop negative trends through communication, education and focused observations in the area.

2.10 Training [Items #16 and 17]

2.10.1 Personnel Training

Personnel training is discussed in Section 2.2.2 of the Pickering licence renewal application, and states that the training program for regular staff, contractors, temporary personnel and other staff assigned work at OPG is defined by N-PROG-TR-0005, *Training*.

The training program provides the structure, processes, and tools for defining, developing, implementing, documenting, assessing, and improving the training required to ensure staff have the appropriate knowledge, skill, and attitudes for safe and efficient plant operation.

The training program is in compliance with regulatory document REGDOC-2.2.2, version 2 (2016), *Personnel Training*.

2.10.2 Certification Table [Item #17]

The initial training programs are in accordance with N-PROC-TR-0008, *Systematic Approach to Training*. As shown in Table 2, there are adequate numbers of individuals for each position that requires CNSC certification. As well, there are on-going training programs preparing trainees to move into these positions.

Training programs are in accordance with CNSC regulatory document RD-204, *Certifications of Persons Working at Nuclear Power Plants.*

Certified Position	Pickering 1 & 4		Pickering 5 to 8	
	Shift Manager and Control Room Shift Supervisor	Authorized Nuclear Operator	Shift Manager and Control Room Shift Supervisor	Authorized Nuclear Operator
# of Certified Staff	15	36	19	58
Minimum # of Certified Staff Required	10	20	10	30
# of Trainees for Certified Position	16	22	9	24
Certified Position	Pickering 1 & 4 and 5 to 8			
	Responsible Health Physicist			
# of Certified Staff	4			
Minimum # of Certified Staff Required	1			

Table 2- Number of Pickering Certified Staff (October 30, 2017)

2.11 Fitness for Duty [Item #18]

2.11.1 Limits of Hours of Work

Effective August 2017, the procedure, N-PROC-OP-0047, *Limits of Hours of Work* replaced the previous governance, N-PROC-HR-0002, *Limits of Hours of Work*. This procedure identifies the expectations and the process for monitoring and controlling hours worked and documents the regulatory limits pertaining to hours of work and shift assignments in order to control the effects of fatigue of OPG staff in support of safe reactor operation.

All OPG nuclear employees whose hours are input into the *TEMPUS* time reporting tool, are included in the hours of work monitoring and compliance.

As an exception to N-PROC-OP-0047, those employees who conduct work in a location which is outside of the protected area of the nuclear plants are subject to the applicable restrictions of the Employment Standards Act.

Additional personnel who are exceptions in N-PROC-OP-0047 are as follows:

- Workers not employed by Ontario Power Generation,
- Decommissioning and Nuclear Waste Management staff,
- Nuclear Refurbishment Employees working on units that have been fully defueled are exempted from the restrictions in N-PROC-OP-0047, Section 1.2.
- Casual Construction Trades Persons

As well, OPG has submitted an implementation plan for meeting the requirements of REGDOC-2.2.4, *Fitness for Duty: Managing Working Fatigue* in Reference 4. It is the intention of OPG to complete implementation by January 1, 2019.

2.11.2 Regulatory Documents RD-204 and RD 363

Regulatory document RD-204 requires that a fitness for duty program be established for certified staff. This program is implemented as follows:

Section 1.5.2 of N-CHAR-AS-0002, *Nuclear Management System*, identifies expectations for all staff in OPG Nuclear. The expectations are communicated to all staff through adherence to the Corporate Safety Rules (under Common Safety Rule 1.2). These expectations are also reinforced through the security access and control process.

All supervisors in OPG Nuclear including supervisors of certified and security personnel are required to complete a training course on the "Continuous Behaviour and Observation Program" (CBOP) followed by refresher training every three years. The CBOP trains supervisors to detect insider threats, by developing awareness to recognize and respond to behaviours, including drug and alcohol abuse that may include a risk to the security, safety or health of employees, facilities and the public.

In addition, Pickering Instruction, P-INS-09110-00005, *Operations Manager Expectations* documents the expectations for Shift Managers, Control Room Shift Supervisors, and Authorized Nuclear Operators to monitor the performance of staff. Shift Managers and Control Room Shift Supervisors are also provided additional training regarding the application of the Fitness for Duty Program as per training objective, N-OBJ-60630-00001, *SM/CRSS Personnel Module 3 - Fitness for Duty*.

Certified staff performance is also observed during simulator training. Instruction, N-INS-09110-10059, *Simulator Performance Observation and Crew Critiques* provides certified staff performance expectations during simulator training. Team and individual performance feedback is provided and documented during this training.

OPG has been in compliance with RD-363, Nuclear *Security Officer Medical, Physical, and Psychological Fitness* since 2008. Compliance to the requirements of this regulatory document is established within (OPG Confidential - Security Protected) N-INS-61400-10044, *Nuclear Specialized Training, Weapons and Equipment*. To ensure CNSC objectives and criteria for regulatory evaluations of training, licence conditions, and applicable standards are met, RD-363 was utilized in the development of the managed system for security training outlined in N-INS-61400-10044. OPG has implemented the requirements of this regulatory document by retaining medical, physical, and psychological certificates on file for each Nuclear Security Officer and has made these available for review, inspection, or audit purposes when required to do so.

2.12 Operations [Items #19 – 23]

2.12.1 Operational Focus

An Operational Focus Oversight Committee has been established at Pickering to ensure that operational focus is maintained within station processes. A key function of the oversight committee is to monitor the unavailability of equipment that is important to the safe and reliable operation of the station and to ensure that deficiencies are being addressed through approved work management processes with the correct priority. Two examples of these work processes are the Emergent Work and Fix-It Now Centre of Excellence (FINCOE) processes, both of which ensure that high priority work is addressed in a timely fashion while the FINCOE process identifies and resolves barriers to execution of new incoming and long standing deficiencies. By maintaining this operational focus, the number of unavailable important equipment has decreased in 2017 and is expected to continue to decrease in 2018.

The Operational Focus Oversight Committee also monitors the station response to operational challenges. Operational challenges constitute deviations from an intended state that may challenge Operations. Operational challenges are classified as operator workaround, operator burden, or control room equipment. An operator workaround requires operating staff to take compensatory actions to comply with procedures during a plant transient. An operator burden requires compensatory operator action or a response that is different from normal practice outside of transient conditions. A control room equipment deficiency affects control panels such that the performance of indications, switches or controllers is degraded. There are currently no operator work arounds at the station and the remaining number of operator burdens and control room deficiencies is below target.

	Unit 1	Unit 4	Common Services	Unit 5	Unit 6	Unit 7	Unit 8	Target per unit	Status
Operator Burden	3	0	2	1	0	1	0	3	At or Below Target
Control Room Equipment Deficiency	0	1	0	1	2	0	2	3	Below Target
Operator Work-Around	0	0	0	0	0	0	0	1	Below Target

Table 3 - Number of Operator Challenges (as of October 2017)

2.12.2 Plant Status Control

Plant status control is implemented by the use of Temporary Change Records per procedure, N-PROC-OP-0027, *Temporary Change Records,* and the use of Plant Status Tags per N-PROC-OP-0008, *Use and Control of Plant Status Tags.*

Two performance indicators are used to measure the effectiveness of plant status control:

The primary indicator is Misposition Index Value (MIV). A misposition is declared when a component is found to be off its baseline position without documented approval; or a component is incorrectly operated; or the incorrect component is operated. The MIV incorporates the risk level associated with each misposition by assigning increased weight to higher level events to provide an indication of the extent of compliance of the plant with its analyzed state. This indicator is reported to the CNSC quarterly under REGDOC-3.1.1.

The secondary indicator is Plant Alignment Index (PAI), which monitors approved deviations from the station design configuration greater than 90 days. This is a lagging indicator that monitors off base devices that are still within an analyzed state and are procedurally controlled.

These parameters are reviewed monthly by station management to ensure standards are maintained or improved and opportunities for improvement identified.

2.12.3 Work Protection

Pickering maintains a constant focus on Work Protection (WP) performance as a key safety program. The current continuous improvement initiatives in this area include:

- Passion for work protection: which includes supervisory oversight, oral review boards, escalated responses to work protection events, engagement of field staff for solutions,
- Process drivers; which includes verification practices improvement, and
- Training enhancements for operations and maintenance staff.

A primary focus has been to ensure staff are aware of their roles and responsibility. This focus has resulted in improvement in work protection performance at Pickering as indicated by the Work Protection Performance Index (WPPI) and the six month rolling WPPI as shown in Figure 5.

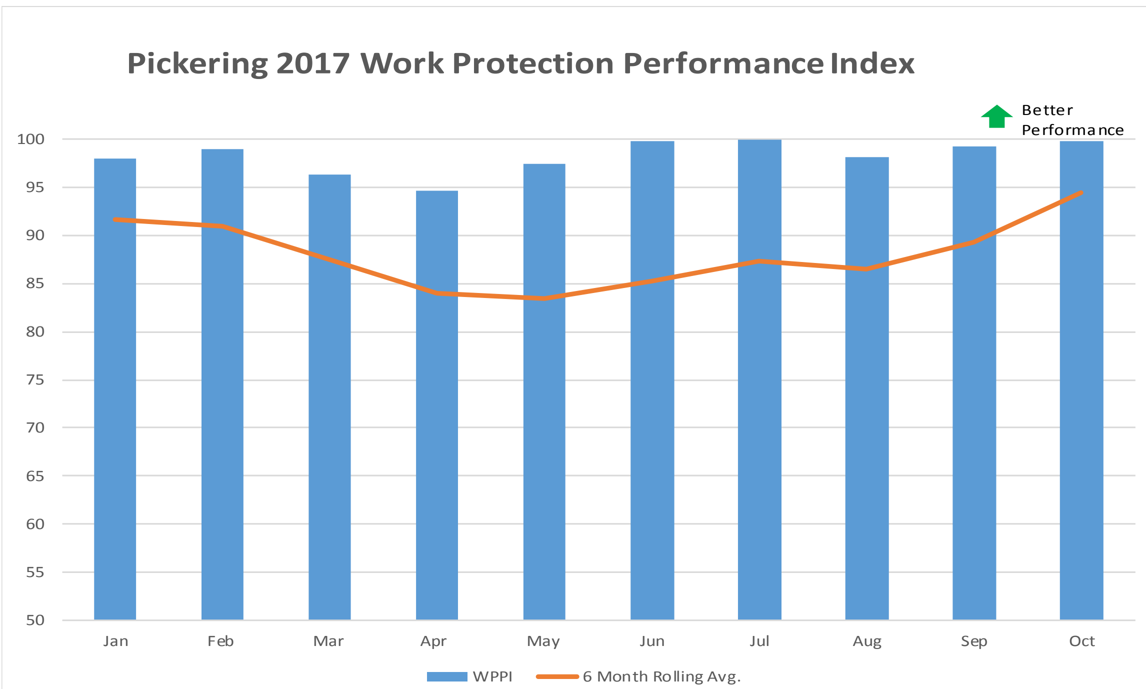


Figure 5 - Work Protection Performance Index

All work protection events are reviewed to identify trends and develop actions to improve performance and ensure that operating experience is used to inform improvement strategies.

2.12.4 Operating Procedures

The control measures for ensuring the adequacy of technical procedures prior to being issued for use are documented in the following OPG governance documents:

OPG Standard, N-STD-AS-0014, *Requirements for Technical Procedures*. The Standard specifies the requirements for the structure, content and format of technical procedures.

OPG Procedure, N-PROC-AS-0028, *Development, Review, Validation & Approval of Technical Procedures.* The procedure establishes the requirements for development, review, validation, approval and issue of Technical Procedures. For procedures that have been issued, a history docket with all relevant forms are maintained for future use/reference/audit.

Operating Memos (OPMs) are issued to provide temporary operating instructions, for example, during planned outages, and Technical Procedure Action Requests (TPARs) are issued when a new procedure is required or an existing procedure needs to be updated. The number of OPMs and TPARs are tracked to ensure that the plant configuration is controlled and consistent with station documentation thereby minimizing error likely situations and to ensure the best possible set of procedures is available to station staff.

Performance in this area is tracked using the following two metrics:

1) Number of OPMs. The target for active OPMs is ≤ 27. Performance is shown in Figure 6, and has met or bettered the target generally for the last 24 months. The increase in number of active OPMs in August and September 2017 is due to outage work and Pickering expects to reduce the number below target by the end of 2017.

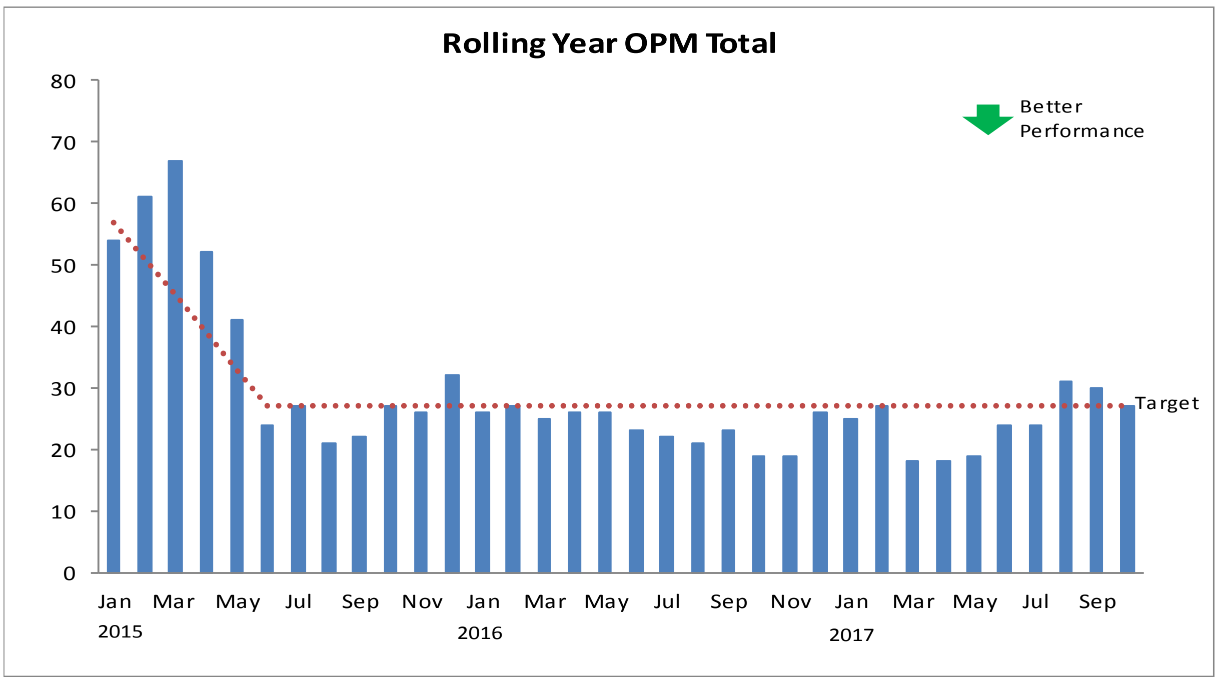


Figure 6- Operating Memo Totals

2) Number of operationally significant procedure changes (T-type TPARs) that are open greater than 90 days. The target for this metric is less than five outstanding procedure changes. As seen in Figure 7, once the target was reached, Pickering has met or bettered the target for all months except November 2016.

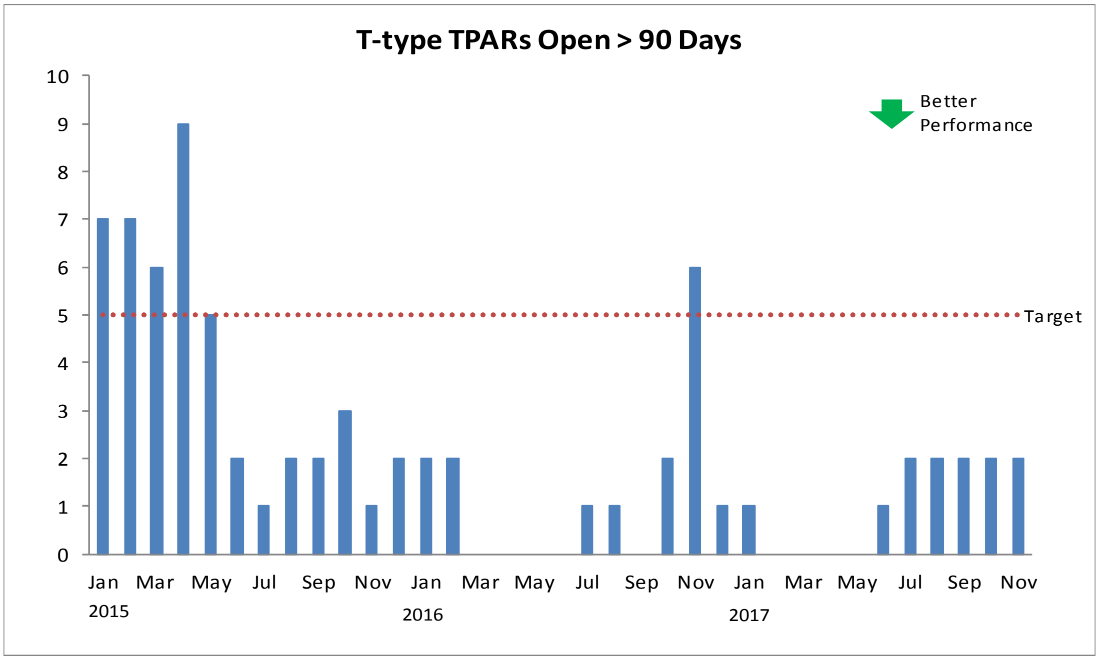


Figure 7- Open Procedure Change Requests

2.13 Engineering Change Control (Items #24-25]

The Engineering Change Control program ensures that all modifications to systems, structures and components are planned, designed, installed, commissioned, place in service, or removed from service to be compliant with applicable codes and standards and the licensing basis. All modifications are reviewed prior to approval to ensure they improve or maintain operability, maintainability, radiological and conventional safety, and regulatory or licence compliance. The risks and impacts of a proposed modification are documented and reviewed by stakeholders, subject matter experts and approved by the facility Design Authority.

OPG program document, N-PROG-MP-0001, *Engineering Change Control* and implementing procedures and forms document the required reviews and evaluations to be undertaken for each engineering change.

Human Factors Engineering (HFE) is explicitly considered in all engineered changes to the nuclear design basis. OPG program document, N-PROG-MP-0001, *Engineering Change Control* and implementing procedures and forms require identification of any HFE scope in the modification and an assessment of the HFE scope of a modification to determine the level of HFE effort that is required. The program will be compliant with the requirements of standard

CSA N290.12-14, *Human Factors in Design for Nuclear Power Plants*. Minor revisions of the documents are in progress, for compliance by the end of 2017.

Temporary modifications are defined in the Engineering Change Control process, and are generally minor in scope and of short duration. OPG has implemented key points of industry best practice for control and implementation of temporary modifications. These key points involve ensuring that the scope of what defines a temporary modification is aligned with other utilities and focussing on minimizing both the use of temporary modifications and the duration when used. OPG's target is to keep temporary modifications installed for less than 6 months or one outage cycle, per industry practice. Benchmarking of the temporary modification process was performed and OPG's process is aligned with other similar utilities.

The average age of temporary modifications has been reduced by 60% over this licensing period while the number of temporary modifications remained relatively constant. During the current licensing period, efforts were made to reduce the backlog of modification closeouts to maintain a robust configuration management program. The number has decreased by 75% over the licensing period and further progress is planned into the next licensing period.

2.14 Procurement Engineering [Item #26]

The following Table 4 provides the governance associated with the procurement engineering process at OPG.

Control Measure Requested	Document	Program Area
Procurement engineering process.	N-PROC-MP-0098, Procurement Engineering Activities	N-PROG-MP-0009, Design Management
Qualification of suppliers of items and services.	N-PROC-MM-0010, Establishing and Maintaining Ontario Power Generation Approved Suppliers List	OPG-PROG-0009, Items and Services Management
Procurement process for ensuring obsolescence replacement parts in a timely manner.	N-STD-MA-0024, Obsolescence Management covers proactive obsolescence management. Note: OPG's Procurement Process for items and services does not change regardless of an item's obsolescence solution.	N-PROG-MP-0008, Integrated Aging Management OPG-PROG-0009, Items and Services Management
Assessment process for ensuring fit form and function of item.	N-INS-08173-10048, Item Equivalency Evaluation	N-PROG-MM-0001, Engineering Change Control

Control Measure Requested	Document	Program Area
Examination process of received items and verification of services.	Examination process of received items: N-PROC-MM-0021, Supply Inspection Verification of services: OPG-PROG-0009, Items and Services Management	OPG-PROG-0009, Items and Services Management

Table 4 - Procurement Engineering Governance

2.15 Software [Item #27]

Software Engineering Tools, pertaining to items used in production of software, are covered under the *Software* program, N-PROG-MP-0006 and identified during software classification. Software is classified to determine the set of applicable standards and procedures for the development, maintenance, acquisition, qualification, use and retirement.

Software is defined as a software engineering tool if it consists of computer programs used in development, testing, analysis, or maintenance of Real-Time Process Computing (RTPC) or Scientific, Engineering or Safety Analysis (SESA) software. The *Software* program imposes software engineering tools requirements on developers and maintainers of RTPC and SESA systems in the associated RTPC and SESA sections accordingly. An example of a software engineering tool is software used to support the production of the Digital Control Computer (DCC) software.

2.16 Reactor Components and Structures [Item #28]

Specific additional technical information was requested by the CNSC on an item in the following document: N-PLAN-01060-10003, *Reactor Components and Structures Life Cycle Management Plan.*

The primary conclusion of the calandria vessel integrity assessment is that changes in material properties due to irradiation do not represent a credible threat to the integrity of the vessels.

Due to the temperatures, fluences, materials and chemical conditions, the calandria vessels are not at sufficient risk of degradation by helium embrittlement, hydrogen embrittlement or stress corrosion cracking, to require inspection. The risk of irradiation-assisted stress corrosion cracking is also considered to be very low and does not justify inspection of the calandria vessel welds. Routine monitoring of moderator chemistry provides assurance that this degradation is highly improbable.

Evaluation of end-of-extended life properties results in a definition of a threshold fluence, and the conclusion that irradiation embrittlement is not of concern for which the estimated end-of-extended life is below the threshold.

Furthermore, the Pickering A and B fluence estimated values were derived with an intended 425,000 EFPH and 475,000 EFPH respectively, and as such, the estimated fluence values provide additional conservatism. The conclusion of the OPG calandria vessel integrity assessment is that the changes in material properties due to irradiation do not represent a credible threat to the integrity of the vessels within their respective extended operating years.

2.17 Fitness for Service [Item #29]

2.17.1 Aging Management

The condition of the plant has been reviewed under OPG's Integrated Aging Management Program (IAMP), which ensures that appropriate maintenance, testing and monitoring is ongoing at Pickering.

Over a half million components and supporting Fitness for Service (FFS) programs (including the relief valve testing program and balance-of-plant pressure boundary component inspections) covering all plant SSC's were reviewed through a defined process; findings and recommendations were documented in respective Life Cycle Management Plans (LCMPs) and over 1000 Condition Assessment (CA) reports. The findings and recommendations have been rationalized and actions to be taken documented.

The remaining condition assessment work relating to the extended operations period has been captured by the Periodic Safety Review (PSR) and documented as actions in the Integrated Implementation Plan (IIP). The goal of these IIP actions is to confirm the completeness of the Pickering Aging Management Program for the extended operating period and the effective tracking and status reporting of any further actions to be taken.

A review element of a PSR is to assess the performance and effectiveness of station programs. External inspections and internal audits of the IAMP implementation at Pickering were conducted in 2015 and 2016. These reviews and resulting corrective action plans were further evaluated by the Pickering PSR2 which concluded that the corrective action plans were adequate and that additional actions are not required to assure effectiveness. The remaining corrective actions are included in the Pickering PSR2 IIP to track them to completion.

With respect to future updating of the IAMP, OPG reviews all of its programs for comprehensiveness and effectiveness on an ongoing basis and concluded that the IAMP implementation at Pickering is robust.

2.17.2 Periodic Inspection Program [Item 30]

The Periodic Inspection Program (PIP) requires that components essential to the safe operation of the plant are inspected in order to provide assurance that equipment inspected under this program will continue to be fit for service.

Table 5 summarizes the status of execution of N285.4 and N285.5 inspections during the current licensing period. Included is the number of inspections completed and required for each unit under both codes, as well as the last year in the current 10-year cycle. The number of completed inspections does not include the ongoing online N285.5 2017 inspection campaign, nor the inspections ongoing during the 2017 Unit 1 planned outage campaign.

Unit	Completed N285.5 Inspections	Total N285.5 Inspections	Percentage of N285.5 Inspections Remaining	N285.5 Cycle End	Completed N285.4 Inspections	Total N285.4 Inspections	Percent of N285.4 inspections remaining	N285.4 Cycle End
Unit 0	261	1093	76.1%	2023	N/A	N/A	N/A	N/A
Unit 1	64	369	82.7%	2023	30	261	88.5%	2021
Unit 4	155	396	39.1%	2023	94	318	70.4%	2023
Unit 5	174	676	25.7%	2023	420	437	3.9%	2017
Unit 6	213	485	56.1%	2023	286	346	17.3%	2018
Unit 7	38	404	91.6%	2023	222	252	11.9%	2019
Unit 8	86	210	29.5%	2023	112	214	47.7%	2020

Table 5 - N285.4 and N285.5 Inspections

All remaining inspections are scheduled in the Periodic Inspection Program (PIP) Databases/Schedule documents. These inspections are planned to be completed prior to the end of their respective inspection interval. Any potential deferral beyond 10-year interval is reviewed and assessed and is subject to CNSC approval.

All inspections findings requiring corrective actions are addressed before the unit is restarted if the inspection is performed during a planned maintenance outage. Further, when an unacceptable condition is found there are extent of condition inspections performed on similar/identical components, as per code requirements. Similar extent of condition inspections are completed for unacceptable conditions found during on-line inspections, with repairs scheduled through the on-line scoping process according to their priority.

There have been no major issues found under the PIP inspection program, the inspections results are almost entirely comprised of minor in nature, such as nut tightening jobs on supports.

An example of one indication that was found, was a weld crack found in the boiler room during the most recent CSA N285.5 Unit 4 planned outage inspection campaign. This weld crack opened up a flow path through the containment boundary that needed to be corrected. This condition was communicated to the CNSC through an official correspondence, as well as the N285.5 Inspection Report. This indication was repaired during the same Unit 4 planned outage wherein it was identified. A Station Condition Record (SCR) was also filed to document this condition and to perform an investigation into the cause of this crack, as well as the required corrective actions moving forward.

Challenges such as overall outage scope and priorities, accessibility and dose exposure, and resources affect the execution of the inspection programs, including the completion of planned inspections and repairs. These are tracked through bi-annual health reports created by

Pickering site engineers for the execution of the CSA N285.4 and CSA N285.5 PIPs. Regulatory compliance is tracked in the program health reports. As well, the program health is assessed to ensure regulatory requirements are met, backlog reduction is monitored, and also to ensure that a strong program governance/structure in place. Included in these health reports are corrective actions required to complete any outstanding inspections or repairs.

Further, efforts are made to schedule inspections such that the scope is minimized near the end of an inspection cycle. This is done to ensure that any execution issues (i.e. access, dose, etc.) can be understood and addressed ahead of time so all the required inspections can still be completed within the inspection cycle. Meetings are also held with the inspection team on a yearly basis to review for lessons learned from previous campaigns and to discuss upcoming campaigns. These activities help inform the scoping and scheduling of PIP inspections, which is governed both by the station PIP documents and the station work management process, by identifying issues that must be addressed.

2.18 Radiation Protection [Items #31 – 37]

2.18.1 Radiation Protection Program

The *Radiation Protection* (RP) program, N-PROG-RA-0013, includes the requirement to implement and maintain a program to maintain doses to persons as low as reasonably achievable, social and economic factors being taken into account.

Management control over work practices is demonstrated through the documentation of the radiation protection program via governing procedures and standards implemented by the RP program and associated governance support documents, and the inclusion of key activities in other interfacing procedures and standards. Workers are required to comply with the RP procedures and standards or stop work if the worker believes following the procedure will result in an unsafe condition, in accordance with document N-STD-AS-0002, *Procedure Use and Adherence*.

All personnel working at a nuclear site are assigned an RP qualification level based on successful completion of training. Personnel maintain their qualification through the successful completion of periodic retraining and testing. Maintenance of qualification is also contingent on ongoing demonstrated ability to perform appropriately at the qualification level. Training is in sufficient detail that workers can carry out their obligations as specified in the CNSC regulations. Qualified trainers, using approved training packages designed to meet approved training objectives, deliver RP training, in accordance with the training program, documented in N-PROG-TR-0005, *Training*.

Personnel with access to the site are limited as to the areas they may enter independently and the radiation protection activities they may perform without assistance, based on their qualification level. Personnel performing radioactive work are either qualified to perform the associated activities or an individual who is qualified is assigned to the work to provide radiological protection.

Key positions in the radiation protection program organizations are given additional radiation protection related training to become qualified to perform in their specialized positions within the program. Specialized training includes initial and continuing training delivered in accordance with N-PROG-TR-0005, *Training*.   The training program includes initial and requalification training, examinations and tests for the certified position of Senior Health Physicist, in accordance with Regulatory Document RD-204, *Certification of Persons Working at Nuclear Power Plants*. The role of the Senior Health Physicist is documented in N-MAN-08131-10000-CNSC-031, *Responsible Health Physicist.*

Control of occupational exposure to radiation is addressed through established dose limits in accordance with N-PROC-RA-0019, *Dose Limits and Exposure Control*. Control of public exposure to radiation is addressed through N-PROG-OP-0006, *Environmental Management*. Planning for unusual situations is addressed through N-PROG-RA-0001, *Consolidated Nuclear Emergency Plan*.   The ascertainment of the quantity and concentration of any nuclear substance released as a result of the licensed activities is addressed via N-STD-OP-0031, *Monitoring of Nuclear and Hazardous Substances in Effluents* and N-STD-OP-0042, *Controlling Radiation Exposure to the Public and the Environment to as Low as Reasonably Achievable*.

Where OPG collects personal information related to the administration of the Act and these regulations, persons document their consent in writing for OPG to collect, use and disclose dose records for the purpose of fulfilling its legal rights and obligations and those of the workers employer, if other than OPG, under Federal and Provincial laws, including, without limitation, the Radiation Protection Regulations, the General Nuclear Safety and Control Regulations and Ontario's Occupational Health and Safety Act as amended, replaced or restated from time to time.

As part of the RP program, persons designated as nuclear energy workers are informed that they are nuclear energy workers, of the risks associated with radiation exposure to which they may be exposed during the course of work, and the associated dose limits prescribed in the CNSC regulations as documented in N-PROC-RA-0019, *Dose Limits and Exposure Control*. Written acknowledgement is obtained to demonstrate that a worker has been informed that they are a nuclear energy worker and of the risks of radiation exposure, and the obligation of females to notify the licensee in writing upon becoming aware they are pregnant.

Further, OPG complies with the requirement to report doses to workers to the National Dose Registry, and reports in accordance with Regulatory Document, REGDOC-3.1.1. The system of dose limitation has been successful as no exposures in excess of CNSC regulatory dose limits have occurred.

In accordance with N-PROG-RA-0013, RP program performance is monitored and non-compliances with the Radiation Protection Regulations are documented and investigated as per N-PROC-RA-0022, *Processing Station Condition Records*. Such events are reported to the CNSC in accordance with Regulatory Document, REGDOC-3.1.1.

2.18.2 Application of ALARA

In accordance with N-STD-RA-0018, *Controlling Exposure as Low as Reasonably Achievable (ALARA)*, senior leadership support of the ALARA program is demonstrated through participation in the Site ALARA Committee. The committee is chaired by the facility Site Vice President, and the functions include review and approval of facility dose targets and ALARA plans, and review of ALARA program performance. Quorum members include representatives from the Operations and Maintenance, Engineering, Work Management, Chemistry, and Radiation Protection departments. Worker representatives are also invited to participate.

ALARA plans are prepared for activities where collective dose exceeds 30 mSv. Plans are also approved by line managers and Radiation Protection staff. Dose performance is monitored through the year, and for each ALARA plan, and station condition records are raised for ALARA plans where performance is worse than target.

Annual collective radiation exposure targets are established based on the planned scope of work, including planned maintenance outages and dose associated with the operation and maintenance of running units; anticipated radiological conditions and accounts for dose savings as a result of the planned implementation of ALARA initiatives. Each year, three planned maintenance outages are scheduled for execution; each unit is on a two year outage cycle. Note that in 2013, only two outages were executed, which explains the significantly lower dose performance versus target that year. Collective radiation exposure performance has been better than target each year since 2013 as a result of the successful implementation of source term mitigation, work methods improvements and improvements in radiation worker practices. This performance is attributed to the successful implementation of initiatives to mitigate radiation source term, including: custom shielding developed for reducing doses to workers on the reactor faces during planned maintenance outages; leveraging technology to provide real time monitoring of radiation hazards, to provide workers with timely information on current radiation hazards; use of robotics to perform tasks in radiation areas to avert dose to workers; improvements in vapour recovery dryer efficiency. A dose reduction initiative was introduced in 2016 to establish dose goals for radioactive work tasks. This results in an opportunity for the worker and supervisor to discuss the job dose goal and identify any opportunities to reduce individual exposure.

Multidisciplinary teams have been successful in implementing dose reduction initiatives, such as: the deployment of an ion exchange resin with improved radionuclide removal capabilities in Unit 1, implementation of modifications to vapour recovery dryers to allow operation when containment is isolated, and improvements to vapour recovery dryer desiccant management to improve efficiency, which demonstrates the management support for the ALARA program.

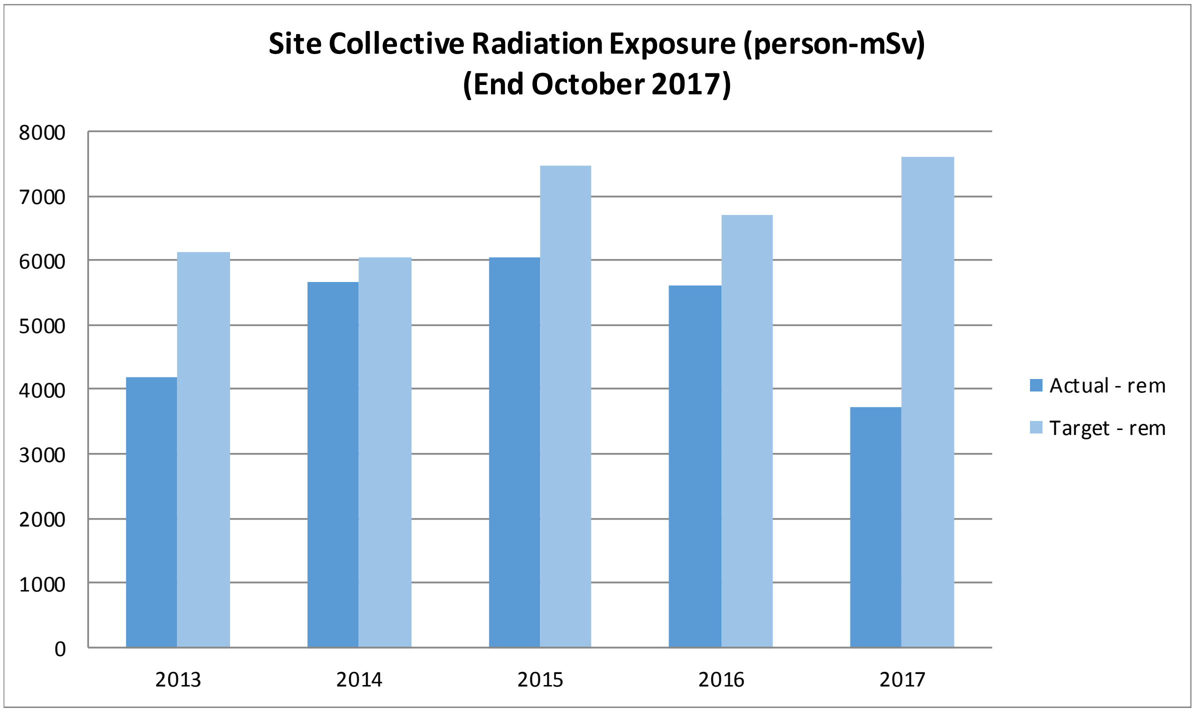


Figure 8 - Collective Radiation Exposure (CRE)

Pickering has been successful at keeping Collective Radiation Exposure (CRE) below targets. This has been achieved through the implementation of increased line accountability for dose improvements driven through lessons learned during planned maintenance outages.

For example:

1. Collective exposure improvements were realized for the removal and reinstallation of reactor face insulation panels on Unit 5. In 2013, the dose associated with this job was 67 mSv. By identifying work efficiencies and incorporating operating experience and lessons learned, the dose for this job was reduced to 49 mSv in 2017.

2. Exposure reduction improvements for fuel channel reconfiguration were realized on a dose per channel basis. In 2015, the average dose per channel reconfigured for Unit 1 was 0.72 mSv per channel during the Unit 1 planned maintenance outage; the average dose was reduced to 0.24 mSv per channel reconfigured in the 2016 Unit 4 planned outage. When the radiation hazard conditions were normalized across the two units, a 30% dose reduction was realized. The reduced dose is attributed to improved reactor face shielding, improved worker experience and incorporation of operating experience and lessons learned.

3. Continual outage over outage improvements have been realized for the opening and closing of steam generators. This is attributed to the use of a dedicated crew, incorporation of lessons learned and improvements in tooling.

2.19 Environmental Management System [Items #38 – 42]

2.19.1 REGDOC-2.9.1 Compliance

OPG conducted a clause-by-clause analysis for compliance with regulatory document, REGDOC-2.9.1 (2013), *Environmental Protection Policies, Programs and Procedures* against the existing environmental protection program for the Pickering Nuclear Generating Station including the Pickering Waste Management Facility. There are no compliance gaps, therefore Pickering NGS is compliant and this regulatory document can be included in the licensing basis.

2.19.2 Protecting the Public

As part of Environmental Management governance (N-PROG-OP-0006), N-STD-OP-0031, *Monitoring of Nuclear and Hazardous Substances in Effluents* addresses monitoring criteria for station streams. Both performance and control monitoring requirements are outlined based on the Maximum Probable Emission Rates (risk based) requiring either direct or indirect/estimation monitoring.

P-PLAN-03480-00001, *Pickering Nuclear Radioactive and Hazardous Emission Monitoring Plan* documents station points of release, maximum probable emission rates and concentrations and reference volume and flow rates for both radioactive and hazardous substances. This document demonstrates compliance to N-STD-OP-0031, *Monitoring of Nuclear and Hazardous Substances in Effluents*.

Control of releases of nuclear hazardous substances are governed by N-STD-OP-0031, *Monitoring of Nuclear and Hazardous Substances*. Performance and control monitoring requirements are documented in P-PLAN-03480-00001, *Pickering Nuclear Radioactive and Hazardous Emissions Monitoring Plan.*

Additional measures include control of Active Liquid Waste (ALW) system through authorized pump outs as referenced in P-OM-018-79210-03, *Radioactive Liquid Waste Management*; and installed exhaust ventilation control filters (HEPA/CA) which are performance tested as defined in N-PROC-OP-0042, *Contaminated Exhaust Ventilation Control Filter Testing*.

2.19.3 Category C Spills

Category C spills are listed in the Pickering licence renewal application (Reference 1) and the following description is offered here as a more complete description of the June 13, 2017 event that was reported to the Ministry of the Environment and Climate Change and the CNSC:

125 L of lubricating oil was accidentally spilled to the floor. The majority of this oil (75 L) was recovered from the floor. An estimated 50 L of the product entered bermed floor drains which lead to the Condenser Cooling Water Discharge Duct with a lake outfall (outfall P014).

2.20 Emergency Preparedness Program [Item #43]

OPG confirms that Pickering is fully compliant with REGDOC-2.10.1 (Version 1, 2014), *Nuclear Emergency Preparedness and Reporting*. This CNSC regulatory document requires that licensees ensure that their emergency planning basis consider all hazards that could have an adverse impact on the environment and the health and safety of the public and onsite personnel. OPG is in compliance with this requirement, as the analysis of the risks and hazards the EP program addresses existed within several documents. As an enhancement, OPG compiled the applicable documentation of the planning basis considerations and referenced it in OPG's Consolidated Nuclear Emergency Plan (CNEP) N-PROG-RA-0001 in order to demonstrate full compliance. OPG continues to work closely with regional and provincial authorities to ensure that they are provided the necessary information to maintain effective emergency plans.

Licensees are required to have real time radiological detectors around the perimeter of their nuclear facilities, and communicate the results to the offsite authority and CNSC. OPG has had real time fixed radiological detection and monitoring devices operating around the perimeter of the Darlington and Pickering nuclear facilities since 2012. These devices are equipped with appropriate backup power. Previously the offsite authority and CNSC would have received this information hourly from OPG on a form. In order to improve the timeliness of communicating the results, OPG developed a process for real time access to the offsite monitoring data for the offsite authority and CNSC. This process provides real time access to key plant information and is referenced in the CNEP.

OPG has existing agreements with the applicable offsite agencies and organizations which are outlined in Memorandums of Understanding (MOU) and other types of agreements. OPG formally compiled those agreements and referenced them in the CNEP.

Public evacuation time estimates were previously completed for the Pickering and Darlington areas using 2006 census data. Both studies were updated in 2015-2016 with the most recent census data and population growth estimates for 2015 and each decade thereafter. The study assumptions were based on REGDOC-2.10.1 and best international practices using US NRC approved methodology. The firm contracted to update the ETE studies had completed the previous OPG ETE studies and more than 50 studies for US nuclear facilities. Throughout the process, there was consultation between the firm, OPG, and key stakeholders to gather information, present results and elicit feedback. Both documents are publicly available on OPG's website. OPG's CNEP includes the requirement to develop and maintain public evacuation time estimates based on current census data, and future population growth projections on a per-decade estimation.

Although changes to the emergency plan and its implementing documents already followed a formal process that included mandatory reviews by position holders and subject matter experts, and use in drills and exercises with revision based on feedback to ensure continued effectiveness; OPG further developed a validation process in compliance with REGDOC-2.10.1, which is referenced in the CNEP.

In 2015 OPG supported distribution of potassium iodide (KI) pills to all homes and businesses within the primary zone, as well as developing a process for people within 50 km to obtain the pills. OPG participated in the Provincial Working Group which oversaw distribution and communication strategies. In addition, OPG formed a local working group with Durham Emergency Management Office (DEMO), Toronto Office of Emergency Management (TOEM) and Durham Health to develop and implement a program that would fit the needs of the communities surrounding Pickering Nuclear.

At the same time, a communication campaign was developed, beginning with focus groups established in the primary zones. A two-part communications strategy for pre-distribution and distribution campaigns was implemented, with the pre-distribution campaign being a focused intensive education campaign that raised public awareness of KI distribution by explaining why it's taking place, and what it meant.

As part of the overall campaign, a website was created (www.preparetobesafe.ca). The website's purpose was to provide an online site for people within 50 km of Pickering NGS to order KI pills and provide information using FAQs (Frequently Asked Questions).

On-going public awareness campaigns by the local health department and OPG remind residents of pill availability and other preparedness information. New neighbours, (including households and businesses), are identified 3 times per year by Canada Post and sent information packages. All information distributed (including website content) met Provincial Working Group guidelines and was approved by OPG, City of Toronto and Region of Durham. To assist in answering questions from the public, KI pill fact sheets were distributed to operators at local and provincial health help lines and local physicians.

OPG's CNEP reflects the requirement (in consultation with the designated municipalities) to procure stable iodine tablets and maintain them within expiry dates; and also to establish and maintain a program that ensures continued availability and ensure information is available to the general public.

In 2015, OPG implemented a program at Pickering NGS to ensure that in the event of an extreme external event that requires essential staff to be sequestered at site, there are adequate supplies to sustain them. 72 hour emergency supplies provide minimum food, water, hygiene and sleeping requirements until outside aid can be brought in. In addition, Radiation Personal Protective Equipment (RPPE) is stocked and maintained at both sites in quantities that consider a response to an emergency with no off-site aid for up to 72 hours. The RPPE is located in regular inventory locations, and maintained in accordance with OPG's existing inventory control procedures and processes. Distribution of 72 hour supplies is intended for extreme emergency situations only.

2.21 Waste Management [Items #44 – 45]

The most effective aspect of the waste minimization program has been the phased introduction of washable products over several years, whereby previously disposable Radiation Protection Equipment (RPE) was replaced with washable, reusable products. They include items such as Anti-Contamination suits, mop heads, rubber gloves and cotton liners, tool bags, scaffold bags, booties, and micro fibre wipe cloths. As a result Pickering has been successful in reducing Low Level and Intermediate Level Radioactive Waste (LILRW) significantly. To date, more than thirty different products have been implemented into the washable / reusable program. Most recently, washable wet mops have been introduced. This washable program represents approximately 1000 m^3 of savings per year of solid radioactive waste for Pickering Nuclear that would have been generated if not implemented. A significant trend over this licensing period is the decrease in the average yearly waste. For the previous licensing period, the average yearly waste generated was 2015 m^3/yr. In this licensing period (2012-2017 with projected year end this year of 1710 m^3), the average waste generated is 1676 m^3/yr**.** That represents a 17% reduction in waste generated.

During the licensing period, a conscious effort has been made to drive improvement to annual targets. This goal has been achieved over the past several years. Waste volume reduction includes initiatives such as: reducing packaging at Pickering warehouse/stores prior to items being delivered to the shop floor; communication packages to station personnel on methods of minimizing generation of radioactive waste; reduction of size of zone 3 areas, thus minimizing risk of radioactive contamination.

Waste performance is influenced by the amount of work in the station planned from year to year. More planned outage work with will likely generate more waste. The objective is to educate the workers on the necessary waste minimization strategies during that work, so that LILRW is kept to a minimum and established targets are met. Expectations for implementing these waste minimization strategies is also considered during the planning stages of outages and projects, which include waste minimization strategies in the assessment of work .

OPG continues to meet federal and provincial requirements in processing and disposing of hazardous and chemical wastes. The following governing documents are used for managing hazardous waste at Pickering NGS:

N-PROC-OP-0043, *Waste Management*

P-PROC-WM-0001, *Disposal of Oil and Chemical Waste*

2.22 Appendix E [Item #46 and #47]

Appendix E in the Pickering licence renewal application (Reference 1) gives a description of the Periodic Safety Review (PSR) and the major deliverables for licence renewal.

In the description of the global assessment, OPG stated that, "In some cases, the development of resolutions/dispositions to the global issues will be part of an OPG or industry initiative underway or planned. Or, the resolution and development of options may require more detailed analysis and assessment, extending beyond the timelines for submission of PSR2. In these instances, the status of the initiative and plans will be included in the disposition. The work will be included in the global assessment to facilitate continued tracking". The CNSC has requested clarification on whether the anticipated results of this work will be included in the global assessment or some other form.

OPG would like to clarify that where there are instances where activities are underway or planned and are documented in the disposition of the global issues, these are either tracked internally or will be part of the Integrated Implementation Plan (IIP).

Also, the wording in Appendix E stated that, "as a final step in the assessment process, the team confirms the overall acceptability of operation of the plant over the period considered in the PSR2". The CNSC requested a clarification on the word 'team' in this statement.

The senior leadership team at OPG have overall responsibility for continued safe operation of all of OPG facilities. In the context of the Pickering PSR2, the reference to a team in Appendix E, Section E.6 of the application was meant to represent the team preparing the Pickering PSR2 in conjunction with the senior management team at OPG.

3 List of Activities under the Operating Licence

3.1 Amended List of Activities under the Operating Licence

OPG applied for a licence amendment to allow the import and export of nuclear substances consisting primarily of contaminated laundry. This licence amendment was approved on October 26, 2017 as PROL 48.04/2018. OPG requests that these amended licence activities be continued in the renewed licence in 2018.

LICENSED ACTIVITIES:

This licence authorizes the licensee to:

(i) Operate the Pickering Nuclear Generating Station (hereinafter "the nuclear facility") units 1, 4, 5, 6, 7 and 8, for power production, and operate units 2 and 3 in the safe storage phase at a site located in the City of Pickering, in the Regional Municipality of Durham, in the Province of Ontario.

(ii) Possess, transfer, use, package, manage and store the nuclear substances that are required for, associated with, or arise from the activities described in [i].

(iii) Import and export nuclear substances, except controlled nuclear substances that are required for associated with, or arise from the activities described in [i]. [Added 2017.10]

(iv) Possess and use prescribed equipment and prescribed information that are required for, associated with, or arise from the activities described in [i].

(v) Possess, use, manage and store enriched uranium as required for fission chambers for the Pickering Nuclear Generating Station units 1 and 4 Shutdown System Enhancement, including spares.

(vi) Possess, produce, manage, transfer and store Cobalt-60.

(vii) Possess, manage and store Cobalt-60 sealed sources.

(viii) Possess, transfer, manage and store heavy water from other nuclear facilities. [Added 2016.06]

(ix) Possess, transfer, package, manage, store and export nuclear substances, except controlled nuclear substances, from the Western Waste Management Facility. [Added 2017.10]

3.2 Import and Export of Nuclear Substances

Pickering NGS has been licensed to import and export nuclear substances other than controlled nuclear substances as defined in the *Nuclear Non-Proliferation Import and Export Control Regulations*. The nuclear substances are materials consisting primarily of contaminated laundry originating from Pickering NGS and the Western Waste Management Facility (WWMF).

Under the licence, Pickering NGS is allowed to accept contaminated laundry from WWMF to combine with the Pickering laundry prior to export to the United States for laundering**.** In addition to contaminated laundry, the licence condition allows for import and export of packaging, shielding or equipment with low levels of contamination similar to laundry.

Import and export of controlled nuclear substances, equipment and information as identified in the *Nuclear Non-proliferation Import and Export Control Regulations* is done in accordance with applicable regulations.

4 References

A-1 OPG Letter, R. Lockwood to M. Leblanc, "Application for Renewal of Pickering Nuclear Generating Station Power Reactor Operating Licence", August 28, 2017, CD# P-CORR-00531-05055.

A-2 CNSC Letter, A. Viktorov to R. Lockwood, "CNSC Staff Completeness Review – Ontario Power Generation (OPG) Application for Renewal of the Pickering Nuclear Generating Station Power Reactor Operating Licence (PROL) 48.03/2018", September 13, 2017, e-Doc 5301022, CD# P-CORR-00531-05152.

A-3 CNSC Letter, A. Viktorov to R. Lockwood, "Pickering NGS: CNSC Staff Technical Sufficiency Review of the Application for Renewal of the Pickering NGS Power Reactor Operating Licence (PROL)", October 17, 2017, e-Doc 5343935, CD# P-CORR-00531-05181.

A-4 OPG Letter, G. Jager to G. Frappier and H. Tadros, "OPG Implementation Plan for REGDOC 2.2.4 Fitness for Duty: Managing Worker Fatigue, Action Item 2017-OPG-9637", September 25, 2017, CD# N-CORR-00531-18759.