

Canada's Nuclear Regulator



Canadian National Report for the Convention on Nuclear Safety

Seventh Report
August 2016



Canadian Nuclear Safety Commission
Commission canadienne de sûreté nucléaire

Canada 

Canadian National Report for the Convention on Nuclear Safety – Seventh Report

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Canadian National Report for the Convention on Nuclear Safety – Seventh Report

In conformance with article 5 of the *Convention on Nuclear Safety*

Executive Summary

This seventh Canadian report demonstrates how Canada continued to meet its obligations under the terms of the *Convention on Nuclear Safety* (CNS) during the reporting period from April 2013 to March 2016. During this period, Canada effectively maintained and, in many cases, enhanced its measures to meet its obligations under the CNS. Enabled by a modern and robust legislative framework, these measures – which focus on the health and safety of persons and the protection of the environment – are implemented by Canada’s nuclear regulator, licensees of nuclear power plants (NPPs), and other government institutions and industry stakeholders. Canada remains fully committed to the principles and implementation of the CNS by undertaking continuous improvements to maintain the highest level of safety of nuclear power reactors in Canada and around the world.

Nineteen Canada Deuterium Uranium (CANDU) reactors were operating in Canada during the reporting period and three reactors were in safe storage.

Nuclear-related activities at NPPs in Canada are governed by robust, modern legislation, with appropriate and well-defined powers to ensure the NPPs remain safe. The most important legislation is the *Nuclear Safety and Control Act* (NSCA), which is complemented by regulations and other regulatory instruments. Canada’s nuclear regulator, the Canadian Nuclear Safety Commission (CNSC), is mature and well established. A system of licensing is in place to control activity related to NPPs and to protect the health and safety of persons, the environment, and national security. To further enhance this system, the CNSC continued its licence reform project and during the reporting period, all existing NPPs had streamlined operating licences and accompanying licence condition handbooks (LCHs) that clarify the regulatory requirements and expectations and facilitate increased regulatory effectiveness and efficiency.

With the 2015 publication of CNSC regulatory document REGDOC-2.3.3, *Periodic Safety Reviews*, and its implementation to the licensing basis of Canadian NPPs, licensees will begin to perform periodic safety reviews (PSRs) for future licence renewals. This closes the one remaining open recommendation from the 2009 Integrated Regulatory Review Service (IRRS) mission to Canada.

The CNSC has a comprehensive program to assure compliance with the regulatory framework and monitor the safety performance of the NPPs. The CNSC continued to enhance the compliance program for operating NPPs during the reporting period.

A comprehensive set of graduated enforcement tools are available to the CNSC to address non-compliances. One of the tools introduced during the previous reporting period, administrative monetary penalties (AMPs), was further developed during the reporting period with the publication of the *Administrative Monetary Penalties Regulations (Canadian Nuclear Safety*

Commission) and CNSC regulatory document REGDOC-3.5.2, *Administrative Monetary Penalties, Version 2*. This tool has been used to enhance the CNSC's effectiveness and flexibility in enforcement.

The CNSC's regulatory framework and processes feature a high degree of openness and transparency. The CNSC continued to foster openness and transparency during the reporting period – for example, through its Participant Funding Program, which facilitates the participation of eligible intervenors in the decision-making process and by issuing discussion papers and soliciting early public feedback on potential regulatory changes.

The Canadian regulatory framework, which is largely non-prescriptive, is continuously updated and aligned with international standards. Renewals of operating licences for NPPs are used to introduce new standards and requirements that the licensees actively implement.

Canada's nuclear industry has an excellent safety record. During the reporting period, NPP licensees fulfilled the basic responsibilities for safety as required by the NSCA, regulations, and the NPP operating licences. The licensees also addressed any safety issues that arose to keep the risk at reasonable levels – and continued to give safety a high priority at every level of their organizations.

None of the safety-significant events that occurred at Canadian NPPs during the reporting period posed a significant threat to persons or the environment. For example, there were no serious process failures at any NPP during the reporting period. The licensees' efforts to address operational events were effective in correcting any deficiencies and preventing recurrence.

During the reporting period, all Canadian NPPs operated with acceptable safety margins and acceptable levels of defence in depth. The maximum annual worker doses at NPPs were below annual dose limits, and all radiological releases from NPPs were very low – below 1 percent of derived release limits. The CNSC's ratings of NPP safety performance confirmed that regulatory requirements and performance expectations in all 14 of its safety and control areas were met or exceeded at all NPPs during the reporting period.

The 2015 *Vienna Declaration on Nuclear Safety* (VDNS) was adopted by Contracting Parties to the CNS. The declaration provides principles for the implementation of the objective of the *Convention on Nuclear Safety* to prevent accidents and mitigate radiological consequences. Canada has demonstrated its fulfillment of the VDNS principles through the activities of the CNSC and its licensees in all aspects of operating NPP facilities. Specifically, the principles of the VDNS have been achieved through the following means:

- The national regulatory framework for siting, design, and construction of NPPs aligns with the International Atomic Energy Agency (IAEA) safety standards, which themselves have been demonstrated to fulfill the principles of the VDNS.
- The designs of Canada's NPPs include features that prevent accidents and mitigate impacts should an accident occur. In addition, actions by the CNSC and licensees have strengthened defence in depth and enhanced emergency response.
- Licensees have implemented updated safety analyses and safety analysis reports that align with the requirements in revised CNSC regulatory documents. Also, licensees are meeting the safety goals associated with probabilistic safety assessments (PSAs).
- Integrated safety reviews for the refurbishment of specific NPPs have been completed. The introduction of PSRs for 10-year operating licences will enhance the systematic adoption of safety improvements at existing NPPs.

During the reporting period, the CNSC and Canadian nuclear industry addressed the six specific CNS challenges that were identified for Canada at the Sixth Review Meeting:

- Challenge C-1 Complete the implementation of the *CNSC Integrated Action Plan* in response to the Fukushima accident
- Challenge C-2 Enhance probabilistic safety assessment (PSA) to consider multi-units and to consider irradiated fuel bays (spent fuel bays)
- Challenge C-3 Establish guidelines for the return of evacuees post-accident and to confirm public acceptability of it
- Challenge C-4 Invite an IAEA emergency preparedness review (EPREV) mission
- Challenge C-5 Update emergency operational interventional guidelines and protective measures for the public during and following major and radiological events
- Challenge C-6 Transition to decommissioning approach

The following steps were taken to address the six challenges.

Canadian NPP licensees completed the Fukushima action items (FAIs) by December 31, 2015, as specified in the CNSC Action Plan. The FAIs address safety improvements aimed at strengthening defence in depth, and enhancing onsite emergency response. The CNSC completed enhancements to its regulatory documents and is amending its regulations to address lessons learned from Fukushima.

The CNSC published regulatory document REGDOC-2.4.2, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*, in May 2014, which introduced new requirements related to multi-units, irradiated fuel bays, and re-evaluation of site-specific external initiating events. REGDOC-2.4.2 will be included in the licensing basis for NPP licensees as their operating licences are renewed. All licensees are expected to be fully compliant by 2020. Full-scope PSAs are either completed or the licensees are making acceptable progress towards completion. The licensees are developing a safety goal framework and pilot application of a whole-site PSA methodology.

With respect to guidelines for the post-accident return of evacuees, the CNSC is collaborating with Health Canada to develop a discussion paper on a proposed regulatory document that will address this topic. The discussion paper is targeted for publication in the fall of 2016 and the goal is to publish the regulatory document during the next reporting period.

Health Canada continues to work with stakeholders to implement the lessons learned from the 2014 Exercise Unified Response, with a planned completion date of mid-2016 for federal-level actions. Health Canada and the CNSC have initiated planning for a future EPREV mission and an invitation for an EPREV mission is expected during the next reporting period.

Health Canada is updating the draft *Canadian Guidelines for Protective Actions during a Nuclear Emergency*. It will be released by mid-2016 for final consultation with federal, provincial, municipal and non-governmental organizations.

The CNSC established a licensing strategy for decommissioning NPPs in the context of the 2016 licence renewal for Gentilly-2. The licence application from Hydro-Québec is to replace the current licence with a 10-year power reactor decommissioning licence. Hydro-Québec is expected to continue activities related to the preparation for the decommissioning of Gentilly-2 and CNSC is providing oversight, adapting its compliance program to the decommissioning phase.

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Acronyms, Abbreviations and Specific Expressions

ACR	Advanced CANDU Reactor
action level	a specific dose of radiation or other parameter that, if reached, may indicate a loss of control of part of a licensee’s radiation protection program and triggers a requirement for specific action to be taken
AECL	Atomic Energy of Canada Limited
ALARA	as low as reasonably achievable
AMP	administrative monetary penalty
AOO	anticipated operating occurrence
BDBA	beyond-design-basis accident
Canadian report	the [n th] Canadian report refers to the [n th] <i>Canadian National Report for the Convention on Nuclear Safety</i> , submitted on behalf of Canada for the [n th] Review Meeting of the Convention on Nuclear Safety
CANDU	Canada Deuterium Uranium
CCP	commissioning control point
CEAA	<i>Canadian Environmental Assessment Act, 2012</i>
CIIT	CANDU Industry Integration Team
CMD	Commission member document (prepared for Commission hearings and meetings by CNSC staff, proponents and intervenors)
CNL	Canadian Nuclear Laboratories
CNS	<i>Convention on Nuclear Safety</i>
CNSC	Canadian Nuclear Safety Commission
CNSC Action Plan	<i>CNSC Integrated Action Plan on the Lessons Learned from the Fukushima Daiichi Nuclear Accident</i>
COG	CANDU Owners Group (Inc.)
ConvEx	Convention Exercise (operated under the framework of the IAEA <i>Convention on Early Notification of a Nuclear Accident</i>)
Commission	the tribunal component of the Canadian Nuclear Safety Commission
COP	continued operations plan
CSA	Canadian Standards Association (now called “CSA Group”)
CSI	CANDU safety issue
CSS	Commission on Safety Standards
CVC	compliance verification criteria
desktop review	all verification activities limited to the review of documents and reports submitted by licensees (including quarterly technical reports, annual compliance reports, special reports and documentation related to design, safety analysis, programs and procedures)
DG-IAEA Report	<i>The Fukushima Daiichi Accident: Report by the Director General</i>
DLA	dynamic learning activity
DRL	derived release limit
EA	environmental assessment

EC6	Enhanced CANDU 6
EFPH	equivalent full-power hours
EIR	event initial report
EIS	environmental impact statement
EME	emergency mitigating equipment
EMEG	emergency mitigating equipment guideline
EPREV	Emergency Preparedness Review
EPRI	Electric Power Research Institute
ERA	environmental risk assessment
event review	all verification activities related to reviewing, assessing and trending of licensees' event reports
FAI	Fukushima action item
FERP	Federal Emergency Response Plan
FNEP	Federal Nuclear Emergency Plan
focused inspection	a special Type I or Type II inspection that is performed as a regulatory follow-up in response to an event, inspection findings or a licensee's performance
G7	Group of seven nations (Canada, United States of America, France, United Kingdom, Germany, Italy, Japan and representatives of the European Union)
GoCo	government-owned, contractor-operated
Harmonized Plan	the CNSC's corporate improvement plan that integrates and aligns all cross-functional improvement initiatives into a single, prioritized plan with clear deliverables
HFE	human factors engineering
HOP	human and organizational performance
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IEMP	independent environmental monitoring program
IFB	irradiated fuel bay
INES	International Nuclear Event Scale
INFCIRC	Information Circular (IAEA publication)
INPO	Institute of Nuclear Power Operations
INSAG	International Nuclear Safety Group
IPPAS	International Physical Protection Advisory Service
IRS	Incident Reporting System
IRRS	Integrated Regulatory Review Service
ISO	International Organization for Standardization
ISR	integrated safety review
KI	potassium iodide
LBLOCA	large-break loss-of-coolant accident
LCH	licence conditions handbook
LRF	large release frequency
MDEP	Multinational Design Evaluation Programme
METER	medical emergency treatment for exposure to radiation
MOL	Ministry of Labour

mSv	millisievert
MW	megawatt
MWe	megawatt (electrical)
NAYGN	North American Young Generation in Nuclear
NBEMO	New Brunswick Emergency Measures Organization
NEA	Nuclear Energy Agency (OECD)
NEWS	Nuclear Event Web-based System (IAEA)
NPP	nuclear power plant
NRCan	Natural Resources Canada
NSCA	<i>Nuclear Safety and Control Act</i>
NSCMP	Nuclear Safety Culture Monitoring Panel
NSRB	Nuclear Safety Review Board
OAG	Office of the Auditor General of Canada
OECD	Organisation for Economic Co-operation and Development
OP&P	operating policies and principles
OPEX	operating experience
OPG	Ontario Power Generation (Inc.)
OSART	Operational Safety Review Team
OSCQ	Organisation de la sécurité civile du Québec
PAR	passive autocatalytic hydrogen recombine
person-Sv	person-sievert
PMUNE	Plan des mesures d'urgence nucléaire externe
PNERP	Provincial Nuclear Emergency Response Plan
PSA	probabilistic safety assessment (same as probabilistic risk assessment)
PSR	periodic safety review
R&D	research and development
RANET	Response and Assistance Network
REGDOC	regulatory document (CNSC publication)
reporting period	April 2013 to March 2016
RN-Med-Prep	Radiological/Nuclear Medical Emergency Preparedness and Response
RPD	Regulatory Program Division
SAM	severe accident management
SAMG	severe accident management guideline
SCA	safety and control area
SCDF	severe core damage frequency
SMR	small modular reactor
SOE	safe operating envelope
SOP	sustainable operations plan
SSCs	structures, systems and components
TBq	terabecquerel
TBq-MeV	terabecquerel-million electron volts
TECDOC	Technical Document (IAEA publication)
Type I inspection	all verification activities related to onsite audits and evaluations of licensee programs, processes and practices

Type II inspection	all verification activities related to routine (item-by-item) checks and rounds
UNENE	University Network of Excellence in Nuclear Engineering
UOIT	University of Ontario Institute of Technology
USNRC	United States Nuclear Regulatory Commission
VDNS	<i>Vienna Declaration on Nuclear Safety</i>
WANO	World Association of Nuclear Operators
WiN	Women in Nuclear

Chapter I – Introduction

A. General

Canada was one of the first signatories of the *Convention on Nuclear Safety* (CNS, also referred to as the Convention), which came into force on October 24, 1996. Canada has endeavoured to fulfill its obligations as a Contracting Party to the Convention, as demonstrated in the Canadian reports presented at the review meetings of the Convention. Canada remains fully committed to the principles and implementation of the Convention by undertaking continuous improvements to maintain the highest level of safety of nuclear power plants (NPPs) in Canada and around the world.

This seventh Canadian report, which is for the Seventh Review Meeting, was produced on behalf of the Government of Canada by a team led by the Canadian Nuclear Safety Commission (CNSC). Contributions to the report were made by representatives from Bruce Power, NB Power, Ontario Power Generation (OPG), Atomic Energy of Canada Limited (AECL), Canadian Nuclear Laboratories (CNL), SNC-Lavalin Nuclear, the CANDU Owners Group (COG), Natural Resources Canada (NRCan), Health Canada, Public Safety Canada and the emergency response organizations of the provinces of New Brunswick, Ontario and Quebec.

A.1 Scope

As required by article 5 of the Convention, this seventh Canadian report demonstrates how Canada fulfilled its obligations under articles 6 to 19 of the Convention during the reporting period, which extended from April 2013 through March 2016. The report closely follows the form and structure established by the Contracting Parties to the Convention, pursuant to article 22 and the International Atomic Energy Agency (IAEA) document INFCIRC/572/Rev.5, *Guidelines regarding National Reports under the Convention on Nuclear Safety*, which was revised in January 2015. This seventh Canadian report describes the basic provisions that Canada has made to fulfill its obligations of the Convention and provides details on the changes that have taken place since the publication of the sixth Canadian report. A particular focus is placed on the challenges identified for Canada at the Sixth Review Meeting.

The nuclear installations referred to in the articles of the Convention are taken to specifically mean NPPs. The Canadian report does not cover nuclear research reactors.

In addition, this report does not cover nuclear security and safeguards, nor does it cover spent fuel and radioactive waste, except for the discussion in subarticle 19(viii). Spent fuel and radioactive waste are addressed thoroughly in the fifth *Canadian National Report for the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*, published in October 2014.

A.2 Contents

Chapter I provides important context for the rest of the report. Section A provides a general introduction to the report while section B summarizes the outcomes of the Sixth Review Meeting for Canada, including the specific good practices and challenges that were identified for Canada. Section C describes aspects of nuclear power policy and nuclear-related activity in Canada. Section D provides a high-level description of the nuclear power industry in Canada and recent major developments (life extensions and new-build projects). Although these sections do not

directly apply to any particular article of the Convention, they represent the context within which the articles are met. Section E describes the *Vienna Declaration on Nuclear Safety* (VDNS) and the parts of this report that address it.

Chapter II provides an overview of the report's conclusions, including a summary statement of Canada's fulfillment of the articles of the Convention. It also summarizes:

- progress on addressing the challenges identified for Canada at the Sixth Review Meeting
- progress on other important issues not covered by the challenges identified for Canada
- measures that addressed the VDNS
- planned future activities to improve safety

Chapter III includes detailed material that demonstrates how Canada implemented its obligations under articles 6 to 19 of the Convention during the reporting period. Chapter III is subdivided into four parts that correspond to the subdivision of the Convention articles:

- Part A – General Provisions (article 6)
- Part B – Legislation and Regulation (articles 7 to 9)
- Part C – General Safety Considerations (articles 10 to 16)
- Part D – Safety of Installations (articles 17 to 19)

The sections in each chapter begin with a grey box that contains the text of the relevant article of the Convention. The term “Contracting Party” in an article refers to each signatory to the Convention. For each article, the description of Canada's provisions to fulfill the relevant obligations is organized in subarticles that follow the structure and numbering of the obligations as presented in the article itself. Where a breakdown into finer subsections is used, lowercase letters have been appended to the article or subarticle numbering, for reference purposes (e.g., subsection 8.1(a)).

The challenges identified for Canada at the Sixth Review Meeting are highlighted in boxes near the beginning of the relevant discussion.

There are two bodies of supplementary information at the end of the report: appendices and annexes. The appendices (identified by letters A through F) provide detailed information that is relevant to more than one article. The annexes, on the other hand, provide supplementary, specific information that is directly relevant to the manner in which Canada fulfills a particular article. Each annex's number corresponds to the number of the article, subarticle, or subsection to which the annex is relevant.

The full text of previous Canadian reports, the Canadian report to the Second Extraordinary Meeting and related documents can be found on the websites of the CNSC and the IAEA. A list of websites of relevant organizations mentioned throughout this report is included in appendix A. This seventh Canadian report will be available on the IAEA website upon submission in August 2016 and will be posted to the CNSC website in late 2016 or early 2017, in both of Canada's official languages (English and French). The annual CNSC staff reports on the regulatory oversight of Canadian NPPs, as well as the annual reports of the CNSC, can also be found on the CNSC website.

B. Outcome of the Sixth Review Meeting

At the Sixth Review Meeting of the Convention, held in Vienna in March 2014, Canada was part of Country Group 6 (CG6), which also included Germany, the Czech Republic, Hungary,

Kazakhstan, Norway, Senegal, Uruguay, Bangladesh, Denmark, Indonesia and Libya. Canada presented its report at the Sixth Review Meeting to an audience of 35 attendees, not including Canadian delegation members and the CG6 officers. Canada responded to 26 comments and questions from numerous country delegations. These comments and questions pertained to topics such as Canada's expectations for its new enforcement tool (administrative monetary penalties), the criteria for deciding who receives money under the CNSC Participant Funding Program, budgets allocated for nuclear safety research in Canada, integrated safety reviews, periodic safety reviews, reviews of operating experience, aging of reactors, radiation protection, public disclosure, and others. The discussion related to the Fukushima nuclear accident focused on Canada's work in areas such as severe events, multiple-unit events, utilization of probabilistic safety assessments and emergency response.

The following table lists the challenges identified for Canada at the Sixth Review Meeting. Cross-references to the relevant subsections of this seventh Canadian report are also provided.

CNS Challenges for Canada from the Sixth Review Meeting

Number	Text of challenge	Relevant article (or subsection)
C-1	Complete the implementation of the <i>CNSC Integrated Action Plan</i> in response to the Fukushima accident	8
C-2	Enhance probabilistic safety assessment (PSA) to consider multi-units and to consider irradiated fuel bays (spent fuel bays)	14(i)(d)
C-3	Establish guidelines for the return of evacuees post-accident and to confirm public acceptability of it	16.1(a)
C-4	Invite an IAEA emergency preparedness review (EPREV) mission	16.1(a)
C-5	Update emergency operational interventional guidelines and protective measures for the public during and following major and radiological events	16.1(a)
C-6	Transition to decommissioning approach	7.2(ii)(e)

C. National nuclear framework and policy

C.1 General framework

In Canada, the development and implementation of nuclear energy policy fall within federal jurisdiction. The Government of Canada has funded nuclear research and supported the development and use of nuclear energy and related applications for many decades. The first NPP in Canada began operation in 1962. Today, the Government of Canada provides \$76 million annually for nuclear research and development (R&D) activities primarily through the Federal Nuclear Science and Technology Work Plan. The nuclear industry provides, via the COG R&D program (described in subsection D.1), approximately \$40 million annually for research that supports operating NPPs. Other joint programs that are arranged through COG contribute another \$15 to \$20 million annually to R&D supporting NPPs in Canada. The national nuclear research program is summarized in appendix E.

Although the Government of Canada has important responsibilities related to nuclear energy, the decision to invest in electricity generation rests with each province. It is up to each province, in concert with the relevant provincial energy organizations and power utilities, to determine whether or not new NPPs should be built.

Nuclear energy is an emissions-free energy source that is recognized as a reliable and cost-competitive contributor to Canada's 80 percent decarbonized electricity mix, supporting climate change mitigation. The Canadian nuclear energy sector is a very important component of Canada's economy.

The following is an overview of nuclear activity in Canada:

- In 2014, nuclear energy supplied about 16 percent of Canada's electricity.
- In the province of Ontario, approximately 60 percent of electricity production comes from NPPs.
- In the province of New Brunswick, approximately 33 percent of electricity production comes from the province's NPP.
- Canada's nuclear technology sector has enabled healthcare providers to improve cancer therapy and diagnostic techniques, as Canada is a major supplier to the world market for medical isotopes.
- Canada Deuterium Uranium (CANDU) reactors have been built and operated in several countries besides Canada, including four in operation in South Korea, two in China, two in Romania and one in Argentina. In November 2015, Argentina announced it had signed an agreement for the construction of a new Enhanced CANDU 6 (EC6) reactor. Pressurized heavy water reactors based on early CANDU technology are also in operation globally, including two in India and one in Pakistan.
- Canada's entire nuclear industry, including power generation, contributes more than six billion dollars a year to the gross domestic product, directly employing more than 30,000 highly skilled workers.
- Canada is the world's second-largest producer and exporter of uranium, with about 20 percent of total world production (13,353 tonnes of uranium metal) in 2015. More than 85 percent of this production is exported, containing energy equivalent to approximately one billion barrels of oil, comparable to Canada's oil exports in 2015.

C.2 National nuclear policy

Under Canada's constitution, responsibility for nuclear energy falls within the jurisdiction of the federal government. Its role encompasses R&D, as well as the regulation of all nuclear materials and activities in Canada. The Government of Canada places high priority on health, safety, national security and the environment in relation to nuclear activities in Canada along with the implementation of Canada's international commitments on the peaceful use of nuclear energy. The Government of Canada has established a comprehensive and robust regulatory regime implemented by Canada's independent nuclear regulator: the CNSC.

Other major federal government departments involved in the Canadian nuclear sector include:

- **Natural Resources Canada (NRCan)**, which:
 - establishes policies, priorities and programs for energy science and technology
 - administers the *Nuclear Energy Act*, the *Nuclear Liability and Compensation Act* (together with the CNSC) and the *Nuclear Fuel Waste Act*
 - has overall responsibility for managing historic nuclear wastes
 - is responsible for the *Nuclear Safety and Control Act* (NSCA), which is administered by the CNSC

- **Public Safety Canada**, which is the lead authority for the all-hazards Federal Emergency Response Plan
- **Health Canada**, which:
 - establishes radiological protection guidelines and assessments
 - monitors environmental radiation as well as occupational radiological exposures
 - is responsible for the Federal Nuclear Emergency Plan, an event-specific annex to the Federal Emergency Response Plan
- **Transport Canada**, which develops and administers policies and regulations for the Canadian transportation system, including the transportation of dangerous goods
- **Environment and Climate Change Canada**, which:
 - contributes to sustainable development through pollution prevention in order to protect people and the environment from the risks associated with toxic substances
 - is responsible for administering the *Canadian Environmental Protection Act* and the recently updated *Canadian Environmental Assessment Act, 2012* (CEAA), which delegates responsibility for conducting environmental assessments of proposed nuclear projects under the NSCA to the CNSC
- **Global Affairs Canada**, which is responsible for Canada's nuclear non-proliferation policy

Various memoranda of understanding exist between the CNSC and other organizations involved in the nuclear industry, such as those organizations in the above list.

The NSCA, the *Nuclear Energy Act*, the *Nuclear Fuel Waste Act* and the *Nuclear Liability Act*, (which will be replaced by the *Nuclear Liability and Compensation Act*) are the centrepieces of Canada's legislative and regulatory framework for nuclear matters. The NSCA is the key piece of legislation for ensuring the safety of the nuclear industry in Canada. These acts are complemented by other legislation that provides emergency management, environmental protection and worker protection, such as the *Emergency Management Act*, the CEAA, the *Canadian Environmental Protection Act, 1999* and the *Canada Labour Code*.

Canada's nuclear policy framework includes the following general elements: a nuclear non-proliferation policy, transparent and independent regulation, a radioactive waste policy framework, a uranium ownership and control policy, support for nuclear science and technology, and cooperation with provincial governments and municipal jurisdictions.

AECL is a Crown corporation of the Government of Canada that reports to Parliament through the Minister of Natural Resources. Its mandate is to enable nuclear science and technology for the benefit of Canadians and industry, and to fulfill Canada's radioactive waste and decommissioning responsibilities.

Under a restructuring plan for AECL, a government-owned, contractor-operated (GoCo) model was implemented in 2015 for AECL's nuclear laboratories. This new model is similar to the one used in the United States and the United Kingdom. Under the GoCo model, a private-sector company, CNL, is now the organization responsible for the management and operation of the nuclear laboratories and it is under the ownership of Canadian National Energy Alliance, a consortium of waste management, engineering, and science and technology companies. AECL continues to function as a federal Crown corporation and continues to have the same mandate but

delivers it through contractual arrangements with CNL to provide science and technology (S&T) to meet core federal needs through the Federal S&T Work Plan (see appendix E.3 for details), and to support the nuclear industry through access to S&T facilities and expertise on a commercial basis. In addition, AECL also retains ownership of the nuclear laboratories' physical and intellectual property assets and its liabilities. AECL's infrastructure and the expertise brought by CNL are strategic elements of Canada's science and technology capabilities, bringing unique abilities that benefit Canadians and the nuclear sector.

Internationally, Canada is actively involved in IAEA-sponsored activities (such as the IAEA Nuclear Safety Action Plan) and fully supports IAEA peer review missions, including those conducted by the International Regulatory Review Service (IRRS) and International Physical Protection Advisory Service (IPPAS). In October 2015, an IPPAS mission reviewed Canada's nuclear security regime, concluding that Canada has established and maintains a strong and comprehensive nuclear security infrastructure.

Canada is actively involved with a number of other international organizations, including the International Nuclear Regulators Association, the CANDU Senior Regulators Group, the Nuclear Energy Agency (NEA) of the Organisation for Economic Co-operation and Development (OECD) and the G7's Nuclear Safety and Security Group. Involvement in these groups allows Canada to influence and enhance nuclear safety from an international regulatory perspective and to exchange information and experience among regulatory organizations. For example, by chairing the CANDU Senior Regulators' Meeting, the CNSC is able to share regulatory information that is specifically relevant to CANDU NPPs, such as, its report on Category 3 CANDU safety issues (see subsection 14(i)(g)). Canada is also a participant in the International Framework for Nuclear Energy Cooperation, the Multinational Design Evaluation Programme (MDEP; see article 18) and the Generation IV International Forum, which led to the establishment of its own national Generation IV program (see appendix E).

Canada has signed and ratified five other multilateral, nuclear-related conventions, including the:

- *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*
- *International Convention on the Physical Protection of Nuclear Material*
- *International Convention for the Suppression of Acts of Nuclear Terrorism*
- *Convention on Early Notification of a Nuclear Accident* (see subsection 16.2(b))
- *Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency* (see subsection 16.2(b))

In addition, Canada signed the IAEA *Convention on Supplementary Compensation for Nuclear Damage* in December 2013.

Canada also continued to enhance its international cooperation and assistance to improve nuclear safety worldwide, through cooperation with international partners in environmental protection and emergency preparedness and response, and by participating in international technical working groups.

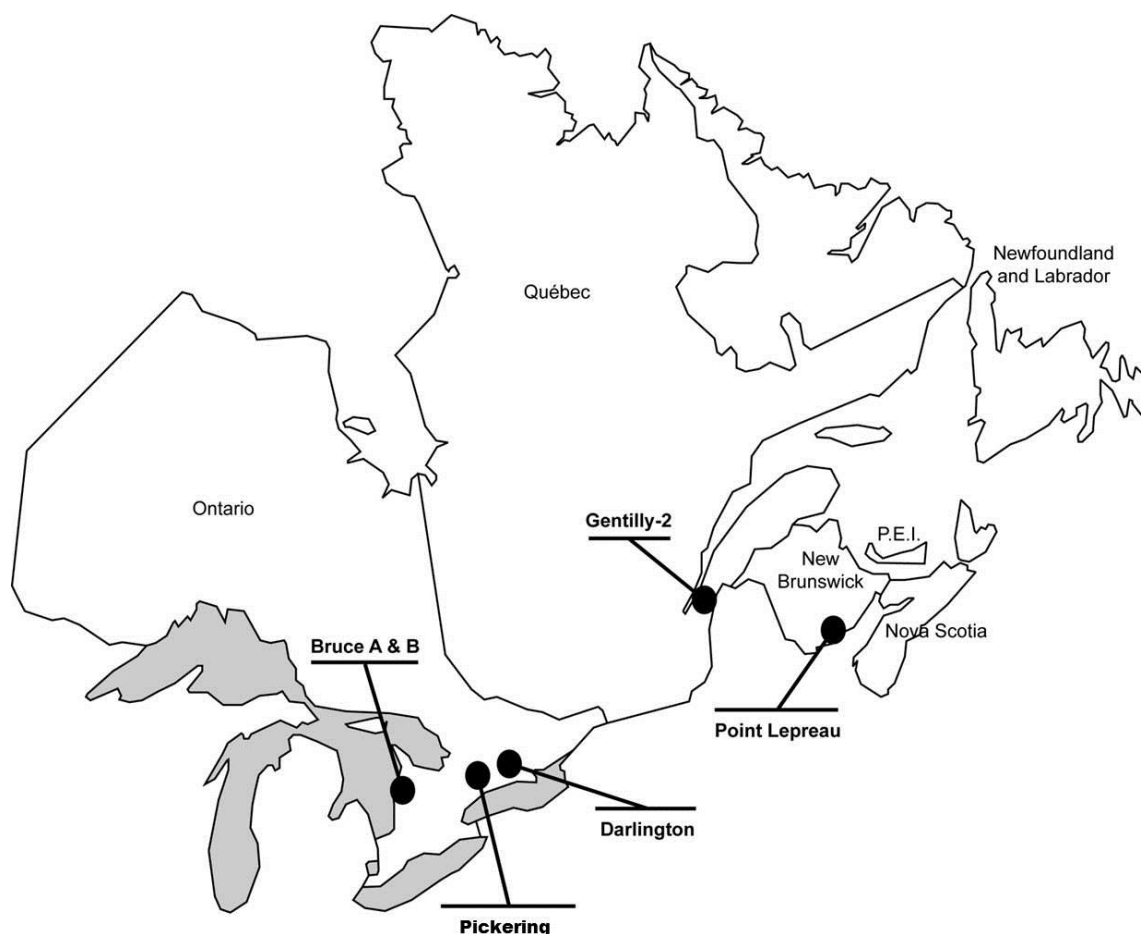
D. Nuclear power industry and recent major activities

D.1 Nuclear power industry in Canada

The locations of NPPs within Canada are shown in the partial map below. Of the 22 nuclear power reactor units in Canada, 19 are currently producing power. In addition, two units at Pickering and the one unit at Gently-2 are in a safe storage state. The Gently-2 unit has started the process toward decommissioning (see description below). The operation of these reactors is governed by five operating licences issued by the CNSC.

The Canadian NPPs are operated by four licensees:

- Ontario Power Generation Inc. (OPG), a commercial company wholly owned by the province of Ontario
- Bruce Power Inc. (Bruce Power), a private corporation
- Hydro-Québec, a Crown corporation of the province of Quebec
- NB Power, a Crown corporation of the province of New Brunswick



Partial Map of Canada Showing the Locations of NPPs

The licensees and number of reactors at each licensed site (and their status) are summarized in the following table.

Licensed NPP site	Province	Licensee	Number of reactors	Operating status of reactors
Bruce A and B	Ontario	Bruce Power	8	All operating
Darlington	Ontario	OPG	4	All operating
Gentilly-2	Quebec	Hydro-Québec	1	Safe storage state
Pickering	Ontario	OPG	8	6 operating, 2 safe storage state
Point Lepreau	New Brunswick	NB Power	1	Operating

Appendix B provides basic information on all NPP units in Canada.

The NPPs in Canada use pressurized heavy water reactors of the CANDU design (originally developed through a partnership between AECL, Ontario Hydro and GE Canada). Besides Canada, there are six other countries with CANDU reactors in operation. A full description of CANDU reactors was provided in the first and second Canadian reports.

As previously discussed in subsection C.2, the Government of Canada has taken steps to strengthen Canada's nuclear industry by restructuring AECL. In October 2011, the Government completed the sale of AECL's CANDU reactor division's assets to Candu Energy Inc., which is a wholly owned subsidiary of SNC-Lavalin Inc. In 2015, Candu Energy Inc. and SNC-Lavalin Nuclear Inc. were integrated into SNC-Lavalin Nuclear, which is a full-service provider of nuclear technology for nuclear power reactors and nuclear products and services to customers worldwide. Candu Energy acts as the original designer and vendor of the CANDU technology. Candu Energy has four reactor designs:

- **CANDU 6**: Heavy-water moderated reactor utilizing natural uranium fuel and on-power refuelling
- **Enhanced CANDU 6 (EC6)**: Generation III, 700 MWe heavy-water moderated and cooled reactor based on the successful CANDU 6 model
- **Advanced CANDU Reactor (ACR-1000)**: Generation III+, 1,200 MWe heavy-water reactor
- **Advanced Fuel CANDU Reactor**: Designed to use alternative fuel sources such as recovered uranium from the reprocessing of used light-water reactor fuel, low-enriched uranium and plutonium-mixed oxide and thorium, in addition to the conventional natural uranium (Candu Energy is currently working with China to further develop thorium as an alternative fuel source)

All CANDU operators in the world (including Canadian NPP licensees) and CNL are members of COG: a not-for-profit organization that provides programs for cooperation, mutual assistance and exchange of information for the successful support, development, operation, maintenance and economics of CANDU technology. While membership is restricted to organizations owning or operating a CANDU reactor, suppliers and engineering organizations involved in the design, construction and operation of CANDU reactors are eligible for participation in specific programs. COG also operates a Supplier Participant program that is open to all suppliers of goods and services to the Canadian nuclear industry. COG is described further in subarticle 9(c).

D.2 Life extension of existing NPPs

Several existing CANDU NPPs have undergone major life-extension projects. Currently, life extension is being pursued or considered for many of the reactor units at the Canadian NPPs and abroad. Life extension includes R&D, engineering, analysis and other fitness for service activities to support extended operation of structures, systems and components beyond their assumed design life, as well as to refurbish components. CANDU refurbishment typically involves replacement of major reactor components (e.g., fuel channels), along with replacing or upgrading other safety-significant systems. Depending on the circumstances and CNSC approval, a refurbished reactor with replaced fuel channels could operate for approximately 30 or more years. The status of each current life-extension project is briefly described below (see subsection 14(i)(f) for more details).

Bruce A and B refurbishment

In December 2015, the Government of Ontario announced that Bruce Power and the Independent Electricity System Operator entered into an amended, long-term agreement to secure 6,300 megawatts of electricity from Bruce A and B through a multi-year investment program. The amended agreement will allow Bruce Power to immediately invest in life-extension activities for Units 3–8, optimizing the operational life of the site (Units 1 and 2 were previously refurbished, returning to service in October 2012.)

Since the refurbishment of Units 3–8 was not considered during the 2015 licence renewal hearing process, Bruce Power will need to submit an application for refurbishment to be considered by the Commission in a public hearing. The life extension will entail outages to replace major critical life-limiting components (fuel channels, feeders and steam generators) and perform associated enabling work. Refurbishment will begin in 2020, starting with Unit 6.

Darlington refurbishment

OPG is proceeding with the refurbishment of the four reactors at the Darlington site to extend the life of the NPP for an additional 30 years.

By the end of the reporting period, OPG had completed all of the necessary assessments for life extension of all four units. The first refurbishment outage is scheduled to commence in October 2016 and all four units will be completed by 2026.

In preparation for refurbishment, OPG has constructed a full-scale mock-up of a Darlington reactor. The mock-up is being used to train staff prior to performing work in the field, to develop workplans and to test and commission specialized tooling required for refurbishment work. A detailed description of this refurbishment training facility, referred to as the Darlington Energy Complex, can be found in annex 11.2(a).

Pickering extended operation

Pickering Units 1–4, formerly known as Pickering A, came into service in 1971. Following refurbishment activities, Units 1 and 4 were returned to service in 2005 and 2003, respectively. In 2005, OPG decided not to return Units 2 and 3 to service, based on an economic evaluation. In 2010, Units 2 and 3 were each placed in a safe storage condition, which involved removing the fuel and heavy water from the reactors, isolating these units from the operational part of the

station (i.e., containment) and placing the units in a state that prevents start-up. Some Unit 2 and 3 systems remain operational, providing common system support to the operation of Units 1 and 4. Units 2 and 3 will be maintained in safe storage states until the entire NPP is shut down for eventual decommissioning.

Pickering Units 5–8, formerly known as Pickering B, came into service in 1983. An extensive integrated safety review (ISR) was completed in 2010 to assess the options for its ongoing service. In 2010, OPG decided that incremental life extension, rather than the options of shutdown or refurbishment, was the best option. The decision to not refurbish was based on economic factors, such as the capacity of the units, rather than on safety concerns.

In 2010, OPG developed a continued operations plan (COP) to document the technical basis actions required to support the incremental life extension of the Pickering Units 5–8 to the end of 2020. The COP is updated annually. In 2011, OPG developed a sustainable operations plan (SOP) for Pickering that contains strategic plans recognizing the unique challenges associated with the approach to the end of commercial operation. The SOP, which is also updated annually, describes the arrangements and activities required to demonstrate that Pickering's safe and reliable operation will be maintained and sustained for the period of operation until each unit is permanently shut down.

Since 2013, OPG has been conducting operation of the Pickering reactors under the COP. The incremental life extension option chosen by OPG was supported by previous work done for Pickering Units 5–8 ISR complemented by other activities linked to the end of life of the facility, such as annual updates of the COP, the start of the SOP and preparations for longer-term plans (e.g., transition to safe storage prior to decommissioning).

For the current Pickering licence to operate (granted in 2013 and expiring in August 2018), the Commission approved the operation of the Pickering Units 5–8 reactors beyond the assumed pressure tubes design life (210,000 equivalent full-power hours), based on continued demonstration of fitness for service and up to a maximum of 247,000 equivalent full-power hours.

During the reporting period, preliminary studies, including technical and economic assessments, suggest there is value in pursuing further studies to support extending the operation of the Pickering units. In 2015, the business case supporting extended operation was approved to continue operating Pickering to 2024 and subsequently in January 2016, the province of Ontario announced its support for OPG's plans to operate Pickering to 2024, subject to completion of the necessary assessments and regulatory approval. Decisions on which reactors will operate to 2024 (and which may be shutdown a year or two earlier) have not yet been made. To support this decision, CNSC required OPG to conduct a periodic safety review (PSR) update for the next licence renewal in 2018, which will cover the proposed operating period. The results of the PSR and its conclusions in the integrated implementation plan to operate until 2024 will be presented to the Commission at the next licence renewal hearing in 2018.

D.3 Transition to a safe storage state

During the reporting period, stabilization operations and activities were conducted to transition Gentilly-2 to the safe storage state. This work was completed by December 2014. All spent fuel has been placed in the irradiated fuel bay and all main NPP systems no longer in service have been drained, dried and placed in a safe layup state. Hydro-Québec foresees having all fuel in dry

storage by 2020 and dismantling the NPP between 2059 and 2064, with restoration of the site being completed by 2066.

D.4 New-build projects

As described in previous Canadian reports, in 2006 OPG submitted an application for a licence to prepare a site for future construction of NPPs within the existing boundary of the Darlington site. The project aims to create a site for up to four new nuclear reactors, with a maximum of 4,800 megawatts of electrical output, directly east of the existing Darlington NPP. An environmental assessment (EA) concluded in May 2010 that the project was not likely to cause significant adverse environmental effects. In August 2012, the joint review panel for the EA (as a panel of the Commission) granted OPG a licence to prepare the site.

Following issuance of the licence, the EA and the licence to prepare the site were challenged through an application for judicial review before the Federal Court of Canada. In May 2014, the Federal Court allowed the application in part, ordering that the licence be quashed and the matter be returned to the joint review panel (or a duly constituted panel) for further consideration and determination of the specific issues set out in the Court's decisions and reasons. The decision by the Federal Court was appealed by OPG, the Attorney General of Canada and the CNSC. Arguments before the Federal Court of Appeal were held in June 2015.

In September 2015, the Federal Court of Appeal granted the appeal, upholding the EA approval and restoring the licence to prepare the site.

In November 2015, an application for leave to appeal was filed with the Supreme Court of Canada by the parties that brought the judicial review. OPG, the other respondents and the parties that brought the initial judicial review filed their submissions in December 2015. The Supreme Court of Canada dismissed the application for leave to appeal in April 2016.

During the reporting period, OPG continued to pursue several work activities related to the joint review panel's recommendations, including:

- bank swallow monitoring and mitigation
- intake and diffuser structures siting
- support for CNSC activities to engage stakeholders in developing policy for land use around NPPs

OPG site-preparation activities will occur following selection of a reactor vendor by the province of Ontario.

Specific measures taken by CNSC and NPP licensees with respect to new-build projects are given in subsection 7.2(i)(c) and subarticle 17(ii). Other measures taken in preparation for potential new-build NPPs in Canada are described in the sixth Canadian report.

E. *Vienna Declaration on Nuclear Safety*

The *Vienna Declaration on Nuclear Safety* (VDNS) was adopted by Contracting Parties to the CNS at a Diplomatic Conference held in Vienna on February 9, 2015. The declaration provides the following three principles for implementing the objective of the CNS (to prevent accidents and mitigate radiological consequences):

- **Principle (1):** New NPPs are to be designed, sited and constructed, consistent with the objective of preventing accidents in commissioning and operation and, should an accident occur, mitigating possible releases of radionuclides causing long-term offsite contamination and avoiding early radioactive releases or radioactive releases large enough to require long-term protective measures and actions.
- **Principle (2):** Comprehensive and systematic safety assessments are to be carried out periodically and regularly for existing installations throughout their lifetime in order to identify safety improvements that are oriented to meet the above objective. Reasonably practicable or achievable safety improvements are to be implemented in a timely manner.
- **Principle (3):** National requirements and regulations for addressing this objective throughout the lifetime of NPPs are to take into account the relevant IAEA safety standards and, as appropriate, other good practices as identified *inter alia* in the Review Meetings of the CNS.

Details of how Canada fulfilled the VDNS can be found in the following articles or subsections of this report:

- subsection 7.2(i)(d): Legislative and regulatory framework – Principle (3)
- subsection 14(i)(h): Assessment and verification of safety – Principle (2)
- article 17: Siting – Principle (1)
- article 18: Design and construction – Principle (1)

Chapter II – Summary

Statement of compliance with articles of the Convention

Article 5 of the Convention requires each Contracting Party to submit a report on measures it has taken to implement each of the obligations of the Convention. This report demonstrates the measures that Canada has taken to implement its obligations under articles 6 to 19 of the Convention. Obligations under the other articles of the Convention are implemented through administrative activities and participation in relevant fora.

The measures that Canada has taken to meet the obligations of the Convention were effectively maintained and, in many cases, enhanced during the reporting period. These measures are implemented by regulatory and industry stakeholders who focus on nuclear safety, the health and safety of persons, and the protection of the environment.

General conclusions

There are 19 operating nuclear power reactors and three reactors in safe storage state in Canada; all are of the CANDU design. They are situated at five sites, each with its own operating licence issued by the CNSC. Gentilly-2 is shutdown; Hydro-Québec completed the transition to safe storage during the reporting period and will be proceeding to decommissioning the NPP. OPG plans to proceed with refurbishing Darlington starting in 2016 and intends to extend operation for Pickering beyond 2020. Bruce Power plans to refurbish six reactors commencing in 2020.

Nuclear-related activities at NPPs in Canada are governed by robust, modern legislation, with appropriate and well-defined powers to ensure that the NPPs remain safe. The legislation is complemented by regulations and other elements of the regulatory framework that are developed in consultation with stakeholders. Canada's nuclear regulator, the CNSC, is mature and well established. A system of licensing is in place to control activity related to NPPs and to maintain the associated risks to the health and safety of persons, the environment and national security at reasonable levels. The CNSC uses a comprehensive compliance program to assure the compliance of the licensees against the regulatory framework and monitor the safety performances of their NPPs. The Canadian NPP licensees fulfill their responsibilities to safety, giving it the highest priority at all levels of their organizations. Many provisions are in place that contribute to the safe operation of NPPs in Canada. Both the CNSC and the licensees make a strong commitment to nuclear safety on an ongoing basis, striving for continuous improvement.

Overall safety performance

Canada's nuclear industry has an excellent safety record spanning several decades. Any safety issues that arise are addressed by licensees, in order to keep risk at their NPPs at reasonable levels. Canadian NPP licensees also collaborate on many projects to address safety issues and share information. For example, they collaborated with the technical suppliers through COG to align severe accident management assessments and methodology for implementing actions in response to the Fukushima accident.

None of the safety-significant operational events that occurred at Canadian NPPs during the reporting period posed a significant threat to persons or the environment. For example, there were no serious process failures at any NPP during the reporting period. Furthermore, the

licensees' efforts to address these operational events were effective in correcting any deficiencies and preventing recurrence.

During the reporting period, all NPP licensees fulfilled their basic responsibilities for safety and their regulatory obligations. At all NPPs, the maximum annual worker doses were well below annual dose limits. In addition, the radiological releases from Canadian NPPs were very low, less than 1 percent of the derived release limits. The licensees' safety analyses, as described in the safety analysis reports, demonstrated adequate safety margins for all Canadian NPPs. The level of defence in depth also remained adequate during the reporting period for all operating NPPs.

Regulatory framework and improvements

During the reporting period, the CNSC continued its progress in enhancing the regulatory framework – which included various regulatory documents relevant to both existing NPPs and new-build projects – and aligning the regulatory framework with international standards (as a minimum). These changes have been introduced into the regulatory framework in a risk-informed way. Renewals of operating licences for NPPs (which occur approximately every five years) have been used to introduce new standards and requirements, with provisions for implementation of the new requirements over predefined time periods.

With the publication in 2015 of CNSC regulatory document REGDOC-2.3.3, *Periodic Safety Reviews*, and its implementation to the licensing basis of Canadian NPPs, licensees will begin to perform PSRs for future licence renewals. This closes the one remaining open recommendation from the 2009 IRRS mission to Canada.

As a result of the licence reform project that began in 2008, NPP operating licences have been streamlined to contain relatively general requirements that are common to all NPPs. These streamlined licences have led to enhanced consistency and regulatory efficiency. All NPP licensees also have licence conditions handbooks (LCHs), which state the verification criteria that CNSC staff will use to judge regulatory compliance and provide additional guidance on how to achieve compliance with the licence conditions. During the reporting period, upon renewal of NPP operating licences, the CNSC began removing references to regulatory documents and industry standards from the operating licences and including them in the LCHs.

The CNSC has a comprehensive program to assure compliance with the regulatory framework and monitor the safety performance of the NPPs. The CNSC has continued to enhance the compliance program for operating NPPs. This includes developing and updating inspection guides and establishing the compliance program elements for overseeing the various new-build licensing stages. The CNSC is optimizing its employment levels and identifying organizational and staffing requirements to support the compliance program. During the reporting period, the CNSC completed the development of the Inspector Training and Qualification Program.

A comprehensive set of graduated enforcement tools are available to the CNSC to address non-compliances. During the reporting period, the CNSC further developed a new tool that was introduced during the previous reporting period: administrative monetary penalties. This involved publishing the *Administrative Monetary Penalties Regulations (Canadian Nuclear Safety Commission)* and regulatory document REGDOC-3.5.2, *Administrative Monetary Penalties, Version 2*. This tool has been used to enhance the CNSC's effectiveness and flexibility in enforcement.

Assessments and peer reviews

Canada hosted its initial Integrated Regulatory Review Service (IRRS) mission in 2009 and a follow-up review in 2011. The results and findings of these two reviews were described in the fifth and sixth Canadian reports, respectively. The follow-up mission concluded that 13 of 14 recommendations and 17 of 18 suggestions made during the initial IRRS mission had been effectively addressed and therefore could be considered closed. The one recommendation from 2009 that remained open – to implement PSRs – has been systematically addressed by the CNSC. The one suggestion from 2009 that remained open was not directly relevant to NPPs.

The Fukushima accident component of the assessment of the 2011 follow-up IRRS mission identified two recommendations and one suggestion for follow-up. One of the recommendations pertained to the review and assessment of the offsite emergency plans for NPPs. It has been addressed through workshops that were hosted by CNSC, Health Canada, and Public Safety Canada. These workshops, which included all levels of government and industry, helped ensure that offsite emergency plans are comprehensive and that the participating organizations are capable of fulfilling their respective duties.

The second recommendation pertained to conducting, on a periodic basis, full-scale exercises of offsite emergency plans. It has been addressed through two exercises. Exercise United Response was a major joint nuclear emergency exercise held at Darlington in May 2014. It included OPG, as well as more than 50 offsite agencies, including the CNSC. The exercise lasted three days and allowed emergency response organizations the opportunity to test their response capability. Exercise Intrepid, held at Point Lepreau in November 2015, simulated an event that progressed into a severe accident with offsite implications. It was the first full-scale exercise for this NPP that used emergency mitigating equipment and other Fukushima-related modifications.

The one suggestion from the IRRS follow-up was for Canada to consider inviting an international peer review mission for emergency preparedness and review. This is being addressed through CNS Challenge C-4 and an update is given below.

The CNSC's ratings of NPP safety performance confirmed that CNSC's requirements and expectations in all 14 of its safety and control areas were met or exceeded at the NPPs for the reporting period. The integrated plant ratings were either "fully satisfactory" or "satisfactory" for all NPPs in 2013, 2014 and 2015.

Addressing the challenges for Canada from the Sixth Review Meeting

Six specific challenges for Canada were identified at the Sixth Review Meeting. The following describes the highlights of activities undertaken during the reporting period to address those challenges.

CNS Challenge C-1: Complete the implementation of the *CNSC Integrated Action Plan* in response to the Fukushima accident

The Fukushima action items (FAIs), as specified in the CNSC Action Plan and implemented by NPP licensees, address safety improvements aimed at strengthening defence in depth and enhancing onsite emergency response. The NPP licensees addressed the implementation of the 36 FAIs at their stations under aggressive timelines, with all actions completed by December 31, 2015. Verification of implementation is integrated into licensing and compliance processes.

The CNSC Action Plan also included enhancements to the CNSC's nuclear regulatory framework. Updates to regulatory documents were completed during the reporting period. Work is ongoing to amend the *Class I Nuclear Facilities Regulations* and the *Radiation Protection Regulations*.

Both the CNSC and the nuclear power industry are continuing to consider potential lessons learned from operating experience in order to make further improvements.

Canada reviewed the IAEA's *The Fukushima Daiichi Accident: Report by the Director General*, against the status of the actions taken in Canada to address the lessons learned. The review demonstrated that the Canadian nuclear industry and the CNSC and other relevant authorities have made significant progress in augmenting nuclear safety through a continuous improvement process. Canadian activities in response to the Fukushima accident aligned with and addressed the lessons learned reported in the IAEA's report.

CNS Challenge C-2: Enhance probabilistic safety assessment (PSA) to consider multi-units and to consider irradiated fuel bays (spent fuel pools)

The CNSC published regulatory document REGDOC-2.4.2, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*, in May 2014. This document introduced new requirements in light of the lessons learned from the Fukushima accident related to multi-units, irradiated fuel bays, and re-evaluation of site-specific external initiating events (e.g., seismic, flooding, and high wind). REGDOC-2.4.2 will be included in the licensing basis for NPP licensees as their operating licences are renewed. All licensees are expected to be fully compliant by 2020. Full-scope PSAs are either completed or the licensees are making acceptable progress towards completion. The licensees are developing a safety goal framework and pilot application of a whole-site PSA methodology.

CNS Challenge C-3: Establish guidelines for the return of evacuees post-accident and to confirm public acceptability of it

During the reporting period, the CNSC was involved in a number of post-accident recovery phase initiatives, including participation in the IAEA's Modelling and Data for Radiological Impact Assessments Programme.

Further, the CNSC has carried out benchmarking on recovery and, in collaboration with Health Canada, is developing a discussion paper on a proposed regulatory document that will address this matter. The main purpose of the paper is to elicit early feedback and engagement with stakeholders, including federal and provincial governments, on plans for the regulatory document to describe roles and responsibilities for recovery, as well as important considerations to be addressed before and during the recovery phase. The discussion paper is targeted for publication in the fall of 2016 and the goal is to subsequently publish the regulatory document during the next reporting period. Both the discussion paper and regulatory document will undergo an external consultation process prior to publication.

CNS Challenge C-4: Invite an IAEA emergency preparedness review (EPREV) mission

Health Canada has completed the current series of exercises to validate the Federal Nuclear Emergency Plan and worked with stakeholders to implement the lessons learned from the 2014 Exercise Unified Response. In addition, Health Canada and the CNSC continue their planning

for a future EPREV mission, which includes participating in external EPREV missions to observe best practices for hosting a peer review. An invitation for an EPREV mission is expected during the next reporting period.

CNS Challenge C-5: Update emergency operational interventional guidelines and protective measures for the public during and following major and radiological events

Health Canada is finalizing, following consultation, an update to the *Canadian Guidelines for Protective Actions during a Nuclear Emergency*, which address protective measures for the public, including evacuation, sheltering and iodine thyroid blocking, and include operational intervention levels as well as guidelines for water and food consumption. The guidelines were released in 2014 for public consultation, followed by a second round of consultation in June 2016. After consideration of the feedback and possible revisions, the guidelines will be finalized and published by the end of 2017.

CNS Challenge C-6: Transition to decommissioning approach

The CNSC has established a licensing strategy for decommissioning NPPs in the context of the 2016 licence renewal for Gentilly-2. Hydro-Québec applied in 2015 to replace its current licence with a 10-year power reactor decommissioning licence, subject to renewal. The activities to complete the transition of the reactor to the safe storage state have been completed. Transfer of irradiated fuel to dry storage modules is continuing in accordance with the existing regulatory requirements. CNSC continues to provide oversight, adapting its compliance program to the decommissioning phase.

Summary of measures that address the *Vienna Declaration on Nuclear Safety*

The 2015 *Vienna Declaration on Nuclear Safety* (VDNS) was adopted by the Contracting Parties to the CNS. It provides principles for the implementation of the objective of the CNS to prevent accidents and mitigate radiological consequences.

Canada has demonstrated its fulfillment of the principles of the VDNS through the activities of the CNSC and licensees in all aspects of NPP operation. Specifically, the principles of the VDNS have been achieved through the following means:

- The Canadian regulatory framework has been aligned with the IAEA safety standards, which themselves have been demonstrated to fulfill the principles of the VDNS. Revisions have been made to the Canadian regulations, regulatory documents and standards in response to the lessons learned from Fukushima and other operating experience.
- The designs of existing Canadian NPPs, which are all CANDU reactors, include features that prevent accidents and mitigate impacts should an accident occur. In addition, actions by the CNSC and licensees have strengthened defence in depth and enhanced emergency response. New reactors would meet the latest requirements for siting, design, and construction.
- Licensees have implemented updated safety analyses and safety analysis reports that align with the requirements in revised CNSC regulatory documents. Also, licensees are meeting the safety goals associated with PSAs. Through verification of analysis, surveillance, testing and inspection, Canadian NPPs have been shown to meet design and

safety requirements as well as the operational limits and conditions necessary for meeting the VDNS principles. Finally, considering the aging of Canada's fleet of reactors, NPP licensees have established and implemented rigorous aging programs with the objectives of preventing accidents and should one occur, mitigating possible releases of radionuclides.

- Integrated safety reviews for the refurbishment of specific NPPs have been completed. The CNSC has introduced PSRs for 10-year operating licences, which will enhance the systematic adoption of safety-related improvements of NPPs as requirements evolve.

Summary of other safety improvements during the reporting period

In addition to addressing the six challenges from the Sixth Review Meeting, numerous other safety improvements were made at the Canadian NPPs during the reporting period, including:

- verification of pressure tube fitness-for-service beyond the assumed design life of 210,000 equivalent full-power hours of operation at Darlington, Pickering, Bruce A and Bruce B
- emergency preparedness improvements following from full-scale, national emergency exercises at NPPs involving all levels of government and other institutions (Exercise Unified Response 2014, Exercise Intrepid 2015)
- distribution of potassium iodide pills to all residences, businesses and institutions within the primary zone (typically 8 to 16 km from the NPP)
- completion of the transition to safe storage for Gentilly-2
- completion of environmental assessment and integrated safety review for Darlington

Summary of planned activities to improve safety

The CNSC and NPP licensees plan to continue the initiatives and safety improvements described above and to undertake other activities to further enhance safety. The planned improvements during the next reporting period include:

- refurbishment of Darlington
- PSR update for Pickering's extended operation
- completion of PSR for Bruce A and B
- preparation of PSR basis document for next licence renewal of Darlington
- resolution of CANDU safety issues, supported by analysis and testing
- ongoing improvements to deterministic safety analysis
- completion of full-scope PSAs at all operating NPPs and methodology development for whole-site PSA
- preparations for the decommissioning of Gentilly-2
- completion of regulatory framework documents

Chapter III – Compliance with Articles of the Convention

Part A General Provisions

Part A of chapter III consists of article 6 – Existing nuclear power plants.

Article 6 – Existing nuclear power plants

Each Contracting Party shall take the appropriate steps to ensure that the safety of nuclear installations existing at the time the Convention enters into force for that Contracting Party is reviewed as soon as possible. When necessary in the context of this Convention, the Contracting Party shall ensure that all reasonably practicable improvements are made as a matter of urgency to upgrade the safety of the nuclear installation. If such upgrading cannot be achieved, plans should be implemented to shut down the nuclear installation as soon as practically possible. The timing of the shut-down may take into account the whole energy context and possible alternatives as well as the social, environmental and economic impact.

6 (a) List of existing nuclear power plants

There are 19 operating nuclear power reactors in Canada as well as three reactors in a safe storage state; all are of the Canada Deuterium Uranium (CANDU) design and all were in operation when the CNS came into force in Canada. They are situated at five sites, each with its own operating licence issued by the Canadian Nuclear Safety Commission (CNSC). Appendix B provides basic information on all the units at the Canadian nuclear power plants (NPPs).

6 (b) Justification of continued operation of Canadian nuclear power plants

General safety framework and overall description of safety evaluations

Activities related to NPPs in Canada are governed by robust, modern legislation, with appropriate and well-defined powers to ensure the NPPs remain safe. The key legislation is the *Nuclear Safety and Control Act* (NSCA), which is complemented by a system of regulations and other elements of the regulatory framework. The CNSC continues to update its regulatory framework and align it with international standards. The transparency of the regulatory process in Canada (see article 7) helps to keep the focus of regulatory decisions on the health and safety of persons and the protection of the environment. Public participation in the development of the regulatory framework and the licensing process help, to maintain this focus and keep stakeholders informed and engaged. The regulatory compliance program provides comprehensive assessments of the operating NPPs' safety performance against the regulatory framework and helps ensure all reasonable provisions are made to maintain the risk of existing NPPs at a reasonable level.

Canada's nuclear regulator, the CNSC, is mature and well established, as described in article 8. Articles 9 and 10 describe how the NPP licensees fulfill their responsibilities to safety, giving it high priority at all levels of their organizations.

The remaining articles in this report describe the many provisions that contribute to the safe operation of NPPs in Canada. Both the CNSC and the licensees make a strong commitment to nuclear safety and strive to continuously improve it. This is evidenced by a willingness to engage in third-party evaluations, such as those done by the Integrated Regulatory Review Service (IRRS) and the Operational Safety Review Team (OSART) of the International Atomic Energy Agency (IAEA) and the World Association of Nuclear Operators (WANO). The involvement of

third-party expertise and CNSC's participation in international fora and activities, such as the development of IAEA standards, strengthen these provisions.

Safety evaluations and improvements

The safety of all existing NPPs in Canada was fully reviewed during their initial licensing. Both the licensees and the CNSC have continued to conduct broad and updated assessments since then, including updates to their safety analysis reports, probabilistic safety assessments (PSAs) and licence renewal assessments. The licensees' safety analyses, as described in the safety analysis reports, demonstrate acceptable safety margins for all Canadian NPPs. Safety assessments have been conducted in response to significant events and national and international operating experience. The licensees have reassessed the safety cases of their NPPs through regular safety analysis report updates but also as part of environmental assessment follow-ups or as reviews of lessons learned in the context of special circumstances (e.g., the Fukushima accident).

As explained in subsections 14(i)(c) and 14(i)(d), licensees are also updating analyses and implementing new requirements for both deterministic safety analyses and PSAs.

The licensees and the CNSC have also conducted many detailed verification activities in support of ongoing operations. The licensees limit the life of critical components (such as CANDU fuel channels) and implement aging management plans to help ensure ongoing safe operation. The licensees also perform thousands of tests of safety and safety-related systems each year to confirm their functionality and availability to meet the safety requirements. (See subarticles 14(ii) and 19(iii) for more information on programs that verify safety and manage aging mechanisms on a continual basis.)

The CNSC renews operating licences for NPPs and oversees licensees on a regular basis throughout the lifecycle of a facility. During the reporting period, the licences for three NPPs were renewed. The CNSC has used operating licence renewals to introduce new requirements for NPPs – for example, the new requirements for deterministic safety analysis and PSA mentioned above (see subsection 7.2(ii)(d), “Licence renewals and updating the licensing basis”).

Licensees implemented safety upgrades on a continual basis to maintain safety margins and incrementally enhanced safety at their sites (see annex 18(i) for examples). Further, NPP licensees have conducted integrated safety reviews (ISRs), which are similar in scope to periodic safety reviews (PSRs), as part of the planning for potential refurbishment projects. (ISRs are described in subsection 14(i)(f).) These exercises have included comprehensive and systematic plant condition assessments and the identification of safety improvements that are reflected in integrated implementation plans – all robust mechanisms for safely extending the operating lives of NPPs. These activities have helped enhance the level of safety of refurbished NPPs as compared to their pre-refurbished conditions. With the publication in 2015 of CNSC regulatory document REGDOC-2.3.3, *Periodic Safety Reviews*, and its implementation in the licensing basis of Canadian NPPs, licensees will begin to perform PSRs for future licence renewals (see subsection 7.2(ii)(d), “Periodic safety review within the licensing framework”).

Canada has committed to fulfilling the 2015 *Vienna Declaration on Nuclear Safety* (VDNS), which provides principles for implementing the Convention's objective: to prevent accidents and mitigate radiological consequences. Details of the VDNS's principles are provided in section E of chapter I.

Principle (2) of the VDNS requires comprehensive and systematic safety assessments to be carried out periodically and regularly for existing installations throughout their lifetime in order to identify safety improvements that are oriented to meet the objective of the VDNS. Reasonably practicable or achievable safety improvements are to be implemented in a timely manner.

The measures described above illustrate that comprehensive and systematic assessments of the existing NPPs have been carried out and will continue to be carried out periodically in Canada. These have resulted in numerous safety improvements that helped meet the objective in principle (2) of the VDNS. See subsection 14(i)(h) for further discussion.

Operational safety record

Canada has a mature nuclear industry with an excellent safety record spanning several decades. None of the operational events that occurred at Canadian NPPs during the reporting period posed a significant threat to the health and safety of persons or to the environment. There were no serious process failures at any NPP during the reporting period. (A serious process failure is defined as a failure that leads to systematic fuel failure or a significant release from an NPP, or could lead to a systematic fuel failure or a significant release in the absence of action by any special safety system.) Furthermore, the licensees' efforts to address operational events were effective in correcting any deficiencies and preventing their recurrence.

During the reporting period, the CNSC did not need to engage in formal enforcement actions, including, orders, administrative monetary penalties or prosecution for resolving nuclear safety-related issues at Canadian NPPs, as described in subarticle 7.2(iv).

Conclusion

Based on the many provisions described above and its overall strong safety record, Canada is confident in the ongoing safety of the NPPs currently licensed to operate across the country.

Chapter III – Compliance with Articles of the Convention (continued)

Part B Legislation and Regulation

Part B of chapter III consists of three articles:

Article 7 – Legislative and regulatory framework

Article 8 – Regulatory body

Article 9 – Responsibility of licensees

Article 7 – Legislative and regulatory framework

1. Each Contracting Party shall establish and maintain a legislative and regulatory framework to govern the safety of nuclear installations.
2. The legislative and regulatory framework shall provide for:
 - (i) the establishment of applicable national safety requirements and regulations;
 - (ii) a system of licensing with regard to nuclear installations and the prohibition of the operation of a nuclear installation without a licence;
 - (iii) a system of regulatory inspection and assessment of nuclear installations to ascertain compliance with applicable regulations and the terms of licences;
 - (iv) the enforcement of applicable regulations and of the terms of licences, including suspension, modification and revocation.

A general description of Canada's nuclear policy is provided in subsection C.2 of chapter I.

7.1 Establishing and maintaining a legislative and regulatory framework

The Canadian Nuclear Safety Commission (CNSC) operates within a modern and robust legislative and regulatory framework. This framework consists of laws (acts) passed by the Parliament of Canada that govern the regulation of Canada's nuclear industry, as well as regulatory instruments such as regulations, licences, orders and documents that the CNSC uses to regulate the industry.

The *Nuclear Safety and Control Act* (NSCA) is the enabling legislation for the regulatory framework. Regulatory instruments set out and provide guidance on requirements. Requirements are legally binding and mandatory elements that include the regulations made under the NSCA, licences and orders. CNSC regulatory documents, as well as other standards, also become legally binding requirements if they are part of the licensing basis (as defined in subsection 7.2(ii)(a)). The NSCA, regulations, regulatory documents, licences and orders are described in more detail in the subsections below.

The Canadian nuclear legislative and regulatory framework was reviewed by the CNSC Fukushima Task Force (2011) as well as by the follow-up Integrated Regulatory Review Service (IRRS) review (2011) and the Fukushima External Advisory Committee (2012). Details on these reviews can be found in Article 8 of the sixth Canadian report. Much work to update the regulatory framework following these reviews has been completed and is ongoing.

During the reporting period, the CNSC continued to modernize its regulatory framework and library of regulatory documents, taking into consideration opportunities to improve the cataloguing and clarity of the regulatory framework. All activities were carried out with a continued focus on communicating and engaging with stakeholders, including the continued use of discussion papers, which play an important role in the selection of regulatory approaches and the development of the regulatory framework and regulatory program.

In keeping with federal policies on public consultation and regulatory fairness, the legislative and regulatory framework for nuclear regulation is open and transparent. The processes in place for the development of regulations and supporting documents, along with the issuing of licences,

provide for the involvement of interested parties and timely communications to stakeholders. (See subsection 8.1(f) for additional information on the CNSC's communications and commitment to openness and transparency.)

7.1 (a) The *Nuclear Safety and Control Act*

The original legislation in Canada governing nuclear safety was the *Atomic Energy Control Act* of 1946. As regulatory practices evolved to keep pace with the subsequent growth in Canada's nuclear industry and nuclear technology – and to focus more on health, safety, national security, environmental protection and fulfilling Canada's international obligations – updated legislation was required for more explicit and effective nuclear regulation. Thus, the Canadian Parliament passed the NSCA in 1997 and the new law came into force on May 31, 2000.

The NSCA provided a distinct identity to a new regulatory agency, the CNSC, replacing the Atomic Energy Control Board. The CNSC comprises two components: a tribunal component (hereinafter referred to as the Commission) and a staff organization.

The Commission is an independent, quasi-judicial administrative tribunal that establishes regulatory policy on matters relating to health, safety, security and the environment. (The independence of the Commission is described in subsection 8.2(a)). It also makes independent licensing decisions and legally binding regulations subject to the approval of the Governor in Council (Cabinet). It is a court of record with powers to hear witnesses, receive evidence and control its proceedings, while maintaining the flexibility to hold informal hearings.

The Commission consists of up to seven members appointed by the Governor in Council for renewable terms of up to five years. Members must have a significant scientific, engineering or business background. They are not necessarily nuclear specialists but bring strong reputations and transferrable skills to Commission proceedings.

Section 9 of the NSCA sets out the CNSC's objects (or mandate) as follows:

- to regulate the development, production and use of nuclear energy and the production, possession and use of nuclear substances, prescribed equipment and prescribed information in order to:
 - prevent unreasonable risk to the environment and to the health and safety of persons associated with that development, production, possession or use
 - prevent unreasonable risk to national security associated with that development, production, possession or use
 - achieve conformity with measures of control and international obligations to which Canada has agreed
- to disseminate objective, scientific, technical and regulatory information to the public concerning the activities of the Commission and the effects, on the environment and on the health and safety of persons, of the development, production, possession and use of nuclear substances, prescribed equipment and prescribed information

The CNSC regulates all nuclear facilities and nuclear activities in Canada, including:

- the site preparation, design, construction, operation, decommissioning and abandonment of:
 - nuclear power plants
 - non-power reactors
 - nuclear research and test facilities

- uranium mines and mills
- uranium refining and conversion facilities
- nuclear fuel fabrication facilities
- waste management facilities
- high-power particle accelerators
- heavy-water plants
- the certification and use of prescribed equipment and nuclear substances used in:
 - nuclear medicine (e.g., teletherapy machines and brachytherapy used in cancer treatment and diagnostic medicine)
 - industry (e.g., industrial radiography, oil and gas well logging, density gauges)
 - research
- the certification of persons requiring certain qualifications to carry out duties under the NSCA

The NSCA enables the regulation of facilities (such as NPPs) by establishing a system of licensing and certification and by assigning to the CNSC the power to set regulations that govern those facilities and to issue, amend, suspend and revoke licences that set out specific requirements that control licensed activities.

In addition, the NSCA provides the CNSC with other powers appropriate for a modern regulatory agency, including:

- clearly defined powers for inspectors, with powers in line with legislative practices
- a system of penalties and enforcement options for non-compliance, including the authority to issue administrative monetary penalties (AMPs)
- clear appeal provisions for orders of inspectors and officers designated by the Commission
- provision for the Commission to re-determine decisions in light of new information
- the authority to order remedial actions in hazardous situations and to require responsible parties to bear the costs of decontamination and other remedial measures
- the authority to include licence conditions (including the power to demand financial guarantees for operation, decommissioning and waste management, as a licence condition)
- recovery of the costs of regulation from entities licensed under the NSCA
- operation of the Participant Funding Program which gives the public, Aboriginal groups and other stakeholders the opportunity to request funding from the CNSC to participate in its regulatory process

The CNSC is also responsible for administering and implementing Canada's international obligations pursuant to existing bilateral and multilateral nuclear cooperation agreements, conventions and undertakings, including nuclear safeguards and the import and export of controlled nuclear equipment, material and information. The CNSC administers and implements the above obligations in collaboration with other government departments, the most important being Global Affairs Canada.

7.1 (b) Other legislation, conventions or legal instruments

Nuclear regulation is under federal jurisdiction. Subsection C.2 of chapter I describes all federal organizations in addition to the CNSC that are involved in regulating the Canadian nuclear industry.

The following legislation enacted by Parliament also applies to the nuclear industry in Canada:

- *Nuclear Energy Act*
- *Nuclear Liability Act* and the *Nuclear Liability and Compensation Act*
- *Nuclear Fuel Waste Act*
- *Radiation Emitting Devices Act*
- *Canadian Environmental Assessment Act, 2012* (CEAA)
- *Canadian Environmental Protection Act, 1999*
- *Canada Labour Code*
- *Fisheries Act*
- *Species at Risk Act*
- *Migratory Bird Convention Act, 1994*
- *Canada Water Act*
- *Navigation Protection Act*
- *Transport of Dangerous Goods Act, 1992*
- *Explosives Act*
- *Emergencies Act*
- *Emergency Management Act*

Canada signed the IAEA's *Convention on Supplementary Compensation for Nuclear Damage* in December 2013. In 2015, the Canadian Parliament passed the *Nuclear Liability and Compensation Act* to replace the *Nuclear Liability Act*. The regulations under the *Nuclear Liability and Compensation Act* were published in Canada Gazette II on May 18, 2016. When this Act comes into force on January 1, 2017, it will increase the amount of compensation available to address civil nuclear damage from \$75 million to \$1 billion, broaden the number of categories for which compensation may be sought, and improve the procedures for delivering compensation.

Under the Canadian constitution, provincial laws may also apply to nuclear facilities and activities in areas that do not relate directly to nuclear regulation and that do not conflict with federal law. Where both federal and provincial laws may apply, the CNSC tries to avoid duplicate effort by seeking cooperative arrangements with federal and provincial bodies that have regulatory responsibilities or expertise in these areas. Such arrangements are authorized by the NSCA, in order to avoid regulatory overlap.

For example, conventional health and safety is overseen at the federal and provincial levels. In Quebec and New Brunswick, the CNSC shares the regulation of conventional health and safety for NPPs with Employment and Social Development Canada, in accordance with Part II of the *Canada Labour Code*. In Ontario, under an exclusion to the *Canada Labour Code*, provincial legislation is substituted for federal legislation to protect workers at designated nuclear facilities. A memorandum of understanding exists between the CNSC and the Ontario Ministry of Labour to enable cooperation and the exchange of information/data and technical expertise related to the exercise of their respective areas of jurisdiction at designated Ontario NPPs.

As another example, environmental protection for NPPs is regulated through the CNSC, Environment Canada and at the provincial level. That is, provincial environmental legislation applies to nuclear facilities and the CNSC also shares the federal regulation of environmental protection with Environment Canada, in accordance with the *Canadian Environmental Protection Act, 1999*.

7.2 Provisions of the legislative and regulatory framework

7.2 (i) National safety requirements and regulations

The NSCA allows for a range of supporting and complementary regulatory instruments, including regulations, licences, regulatory documents and standards. The most recent update to the CNSC's long-term regulatory framework plan covers the period from 2016 to 2021 and outlines the regulations and regulatory documents the CNSC will be developing or amending during that time. This plan allows for more effective long-term planning of resources and better scheduling of projects within the regulatory framework.

The CNSC makes quarterly updates to the long-term regulatory framework plan to take into account new projects or changes in project plans. All updates are posted to the CNSC's external website.

7.2 (i) (a) Regulations under the NSCA

Under the NSCA, the CNSC has implemented regulations and by-laws with the approval of the Governor in Council. Regulations set information requirements for all types of licence applications and provide for exemptions from licensing. By-laws are in place to govern the management and conduct of the CNSC's affairs.

The following regulations and by-laws are issued under the NSCA:

- *General Nuclear Safety and Control Regulations*
- *Administrative Monetary Penalties Regulations (Canadian Nuclear Safety Commission)*
- *Radiation Protection Regulations*
- *Class I Nuclear Facilities Regulations*
- *Class II Nuclear Facilities and Prescribed Equipment Regulations*
- *Nuclear Substances and Radiation Devices Regulations*
- *Packaging and Transport of Nuclear Substances Regulations, 2015*
- *Uranium Mines and Mills Regulations*
- *Nuclear Security Regulations*
- *Nuclear Non-proliferation Import and Export Control Regulations*
- *Canadian Nuclear Safety Commission Cost Recovery Fees Regulations*
- *Canadian Nuclear Safety Commission Rules of Procedure*
- *Canadian Nuclear Safety Commission By-laws*

Generally, these regulations give licensees flexibility in how to comply with legislative requirements. With some exceptions – such as the transport packaging and licence exemption criteria for certain devices – the regulations do not specify detailed criteria used in assessing licence applications or judging compliance.

The CNSC's regulatory regime defines NPPs as Class IA nuclear facilities; the regulatory requirements for these facilities are found in the *Class I Nuclear Facilities Regulations*. Class I facilities also include research reactors (Class IA facilities) and fuel-fabrication facilities (Class IB facilities).

The *Canadian Nuclear Safety Commission Rules of Procedure* do not impose requirements for health, safety and the protection of the environment. Instead, they set out rules of procedure for public hearings held by the Commission and for certain proceedings conducted by officers designated by the Commission.

The AMP program was implemented when the *Administrative Monetary Penalties Regulations (Canadian Nuclear Safety Commission)* came into force on July 3, 2013. The regulations set out the schedule of violations that are subject to AMPs under the NSCA as well as the method by which penalty amounts are determined and notices of violation are served. See subarticle 7.2(iv) for a more detailed description of AMPs.

The CNSC's regulation-making process

When making or amending regulations, the CNSC abides by the Government of Canada's *Cabinet Directive on Regulatory Management* and follows the federal regulation process. This ensures that the potential impacts of any proposed regulations on health, safety, security, the environment and the socio-economic well-being of Canadians, as well as the costs or savings to government or business and the level of support of the proposed regulations, are systematically considered before they are created.

The CNSC's regulation-making process includes extensive consultation with both internal and external stakeholders. In developing its consultation plan, the CNSC recognizes the multiplicity of stakeholders with different levels of interest, points of view and expectations concerning the nature and content of a proposed regulatory regime. Interested parties are consulted early through discussion papers, workshops or other means to seek feedback before starting to draft the regulation. The regulation-making process is described in more detail in annex 7.2(i)(a).

Response to Fukushima – Amendments to CNSC regulations

Following the Fukushima accident, the CNSC Fukushima Task Force reviewed the regulations and found that, overall, the regulations are sound. No changes to the *General Nuclear Safety and Control Regulations* were identified as a result of the review. However, the task force recommended changes to the *Class I Nuclear Facilities Regulations* and the *Radiation Protection Regulations* (and the *Uranium Mines and Mills Regulations*) to further enhance the safety of nuclear facilities.

It is anticipated that the amendments to the *Class I Nuclear Facilities Regulations* to address lessons learned from Fukushima will be published in 2017. See subsections 7.2(ii)(d), 12(a), 13(a) and 16.1(a) for details.

It is anticipated that the amendments to the *Radiation Protection Regulations* to address lessons learned from Fukushima will be published in 2017. See subsection 16.1(a) for details. Other changes to the *Radiation Protection Regulations*, unrelated to Fukushima, are also expected to be made in 2017. See article 15 for details.

7.2 (i) (b) Regulatory framework documents

General description of CNSC regulatory documents

The CNSC uses regulatory documents to support its regulatory framework by expanding on the requirements set out in the NSCA, its regulations and legal instruments such as licences and orders. These documents provide instruction, assistance and information to the licensees.

Typically, the Canadian approach to setting requirements in regulations and regulatory documents is non-prescriptive; that is, the CNSC sets general, objective, performance-based regulatory requirements and NPP licensees develop specific provisions to meet the requirements. Specific requirements can be established where necessary.

During the reporting period, the CNSC published a number of regulatory documents that clarify requirements in the areas of accident management, aging management, security, and compliance and enforcement. The CNSC also continued to modernize its approach to documenting its requirements and expectations, moving to a single document type (referred to as a regulatory document (REGDOC)) that includes both regulatory requirements and guidance in the same document for ease of understanding and cross-referencing. The CNSC is working towards a target date of introducing all new REGDOCs and completing the revisions to current REGDOCs by 2018.

The CNSC REGDOC-development process includes significant consultation with external stakeholders. See annex 7.2(i)(b) for an outline of this process.

To organize the CNSC's library of REGDOCs in a clear and logical manner and to facilitate stakeholder access to relevant content, REGDOCs are grouped into three categories:

- **Regulated facilities and activities:** REGDOCs in this category provide guidance to applicants on the information required for licence applications and to licensees on the requirements for conducting the licensed activity. They also point to relevant expectations in the 14 safety and control areas used by the CNSC to assess, review, verify and report on performance and regulatory compliance across all regulated facilities and activities, where appropriate. They are organized according to the type of regulated facility or activity.
- **Safety and control areas:** This category covers the 14 safety and control areas in detail.
- **Other regulatory areas:** This category covers topics such as reporting requirements, public and Aboriginal engagement, financial guarantees for licensed activities, Commission proceedings and information dissemination.

The CNSC safety and control areas, which are described in detail in appendix F, are as follows:

- management system
- human performance management
- operating performance
- safety analysis
- physical design
- fitness for service
- radiation protection
- conventional health and safety
- environmental protection

- emergency management and fire protection
- waste management
- security
- safeguards and non-proliferation
- packaging and transport

The CNSC's frequency of document revision is every five years or sooner, should the need to move more quickly be identified. Documents are reviewed to determine which ones should be withdrawn and archived, retained as is for continued use or scheduled for revision. This process ensures that the CNSC's full regulatory framework continues to be current and reflects the latest developments in domestic and international operating experience and guidance.

A table listing the key CNSC documents that apply to NPP licensees is provided in annex 7.2(i)(b).

Use of other standards in the development of CNSC REGDOCs

The CNSC sets requirements by adopting (or adapting) appropriate industry, national, international or other standards. The CNSC is committed to using other standards, as appropriate, in the effective implementation of its regulatory mandate. This is in line with the Government of Canada *Cabinet Directive on Regulatory Management* and is consistent with the CNSC's vision of regulatory excellence.

IAEA standards continue to serve as references and benchmarks for the Canadian approach to nuclear safety, as they have for many years. During the reporting period, the Canadian regulatory framework related to NPPs continued to move toward better alignment with international standards. The Canadian approach recognizes that international standards may only represent minimum requirements, which may need to be augmented to suit Canadian technology, practices and regulatory approach. Annex 7.2(i)(b) provides numerous examples of where IAEA standards have been used to develop CNSC documents.

The CNSC actively contributes to the development of the IAEA's safety standards, as well as the supporting technical documents that provide more specific technical requirements and best practices for NPP siting, design, construction, operation and decommissioning. Several CNSC staff members participate in the working groups to draft these standards. CNSC representatives also sit on the IAEA Commission on Safety Standards and the five supporting safety standards committees.

Response to Fukushima – CNSC regulatory documents

A review of the CNSC's regulatory documents following the Fukushima accident found that the documents were acceptable for their purposes. However, the CNSC Fukushima Task Force did find that certain regulatory documents required updating. To address this finding, certain CNSC REGDOCs were published during the reporting period to replace older regulatory documents, as shown in the table below.

CNSC REGDOC	Superseded regulatory document	Notes regarding new REGDOC
REGDOC-2.3.2, <i>Accident Management</i>	G-306, <i>Severe Accident Management Programs for Nuclear Reactors</i>	Includes requirements and guidance for the development, implementation and validation of integrated accident management for reactor facilities.
REGDOC-2.4.1, <i>Deterministic Safety Analysis</i>	RD-308, <i>Deterministic Safety Analysis for Small Reactors</i> RD-310, <i>Safety Analysis for Nuclear Power Plants</i> GD-310, <i>Guidance on Safety Analysis for Nuclear Power Plants</i>	Includes requirements and guidance for the preparation and presentation of a safety analysis that demonstrates the safety of a nuclear facility.
REGDOC-2.4.2, <i>Probabilistic Safety Assessment</i>	S-294, <i>Probabilistic Safety Assessment for Nuclear Power Plants</i>	Provided new requirements, in light of Fukushima lessons learned, related to probabilistic safety assessment (PSA) for multi-units and irradiated fuel bays, and re-evaluation of site-specific external initiating events, such as seismic, flooding, and high winds.
REGDOC-2.9.1, <i>Environmental Protection Policies, Programs and Procedures</i>	S-296, <i>Environmental Protection Polices, Programs and Procedures at Class I Nuclear Facilities and Uranium Mines and Mills</i> G-296, <i>Developing Environmental Protection Polices, Programs and Procedures at Class I Nuclear Facilities and Uranium Mines and Mills</i>	Added guidance on station boundary monitoring.
REGDOC-2.5.2, <i>Design of Reactor Facilities: Nuclear Power Plants</i>	RD-337, <i>Design of Nuclear Power Plants</i>	Addressed key lessons learned identified in the CNSC Fukushima Task Force recommendations. Revised the description of plant states by adding design extension conditions for beyond-design-basis accidents to be addressed in design.
REGDOC- 2.10.1, <i>Nuclear Emergency</i>	Not applicable	Consolidated requirements and guidance for licensees' management of emergency preparedness in conjunction with multiple

CNSC REGDOC	Superseded regulatory document	Notes regarding new REGDOC
<i>Preparedness and Response, Version 2</i>		multi-jurisdictional governmental authorities. Includes the requirement for the pre-distribution of iodine thyroid-blocking agents (such as potassium iodide (KI) pills).

Discussion papers

Discussion papers are used to solicit early public feedback on CNSC policies or approaches, which the CNSC then analyzes and considers so that it can determine the type and nature of requirements and guidance to issue. The use of discussion papers early in the regulatory process underlines the CNSC's commitment to a transparent consultation process, giving stakeholders an early opportunity to present their positions on regulatory initiatives. The four key stages for the development of discussion papers are:

- analyze the issue
- develop the discussion paper
- consult with stakeholders
- decide on a regulatory approach

The following discussion papers were published during the reporting period:

- DIS-13-01, *Proposals to Amend the Radiation Protection Regulations*
- DIS-13-02, *Proposed Amendments Made to Regulations under the Canadian Nuclear Safety and Control Act*
- DIS-14-01, *Design Extension Conditions for Nuclear Power Plants*
- DIS-14-02, *Modernizing the CNSC's Regulations*
- DIS-15-01, *Proposal to Amend the Nuclear Non-proliferation Import and Export Control Regulation*
- DIS-15-02, *Review of CNSC Documentation on the Security of Nuclear Material*

CSA Group standards

The CSA Group (formerly the Canadian Standards Association), Canada's largest, member-based standards development organization, sets voluntary consensus standards developed by national stakeholders and public interests related to NPPs and other nuclear facilities and activities. As many CSA standards are related to NPP design, and operation, they complement the regulatory documents published by the CNSC.

During the reporting period, the nuclear industry, the CNSC and the CSA Group continued to collaborate to strengthen Canada's program for nuclear standards. A representative of CNSC senior management is a member of the CSA Nuclear Strategic Steering Committee and its Executive Committee, which are responsible for developing the suite of nuclear standards. Additionally, CNSC managers and technical staff contribute to the technical committees, subcommittees and working groups developing the CSA standards. As shown in the table in annex 7.2(i)(b), several new standards relevant to NPPs were issued during the reporting period and many others were updated or reaffirmed.

The CSA Group continued to integrate the lessons learned from the Fukushima accident into its workplan, which include proposals for new CSA standards along with revisions to several

existing ones. In May 2014, the CSA Group published a new standard on emergency management – N1600, *General requirements for emergency management for nuclear facilities* – to address lessons learned from the Fukushima accident and to align with CNSC regulatory document REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response*. A new edition has subsequently been developed and was published in March 2016. Examples of other new CSA standards include:

- N290.12, *Human factors in design for nuclear power plants* (published in 2014)
- N290.7, *Cyber-security for NPPs and small reactor facilities* (published in 2014)
- N290.16, *Requirements for beyond design-basis accidents* (published in 2016)

7.2 (i) (c) Regulatory framework for new NPPs

During the reporting period, the CNSC continued to update its regulatory framework for new NPPs. The revised framework draws upon international standards and best practices, including the IAEA's safety standards, to the extent practicable. The IAEA standards set out high-level safety goals and requirements that apply to all reactor designs; that is, they are technology-neutral.

The CNSC regulatory documents that are an important part of the suite of documents required for the licensing of new-build projects can be found in table 1 of annex 7.2 (i)(b). Additional specific information on the new-build regulatory framework and documents under development is provided in article 12 (for human and organizational factors), article 17 (for siting) and article 18 (for design and construction).

Several stakeholders have expressed interest in the possible construction of new, small reactors, including small modular reactors. A small reactor is defined as a fission reactor with a thermal power of less than 200 megawatts. Small reactors include reactors capable of producing radioactive isotopes, research reactors, steam production units and small-scale electrical power production units. The following CNSC regulatory documents related to small reactors have been published:

- RD-367, *Design of Small Reactor Facilities*
- RD-308, *Deterministic Safety Analysis for Small Reactor Facilities*
- REGDOC-2.4.1, *Deterministic Safety Analysis*

The Canadian regulatory approach to licensing small reactors is built on a long-established foundation of risk-informed regulation. Regulatory tools and decision-making processes are structured to enable a licence applicant for a reactor facility to propose alternative ways to meet regulatory objectives. Proposals must demonstrate, with suitable information, that they are equivalent to or exceed regulatory requirements.

Requirements and guidance for reactor facilities are generally articulated to be technology-neutral and, where possible, permit the use of the graded approach. The graded approach enables applicants to propose the stringency of design measures, safety analyses and provisions for conduct of their activities commensurate with the level of risk posed by the reactor facility. The factors to be considered in the graded approach are as follows:

- reactor power
- source term
- amount and enrichment of fissile and fissionable material

- spent fuel, high-pressure systems, heating systems and the storage of flammables, all of which may affect the safety of the reactor
- type of fuel elements
- type and the mass of moderator, reflector and coolant
- amount of reactivity that can be introduced (and its rate of introduction), reactivity control, and inherent and additional features
- quality of the confinement structure or other means of confinement
- utilization of the reactor
- siting, which includes proximity to population groups or extent of isolation from emergency responders

Regulatory framework activities with respect to small modular reactors are discussed in more detail in annex 7.2(i)(c).

7.2 (i) (d) Fulfilling principle (3) of the 2015 Vienna Declaration on Nuclear Safety

Principle (3) of the 2015 *Vienna Declaration on Nuclear Safety* (VDNS) states that national requirements and regulations for addressing the objective of preventing accidents and mitigating their radiological consequences throughout the lifetime of the NPP are to take into account the relevant IAEA safety standards and other good practices identified in the review meetings of the CNS. (See section E of chapter I for further details on the VDNS.)

The table in annex 7.2(i)(b) shows how IAEA safety standards continue to serve as guiding principles for the Canadian regulatory framework, for both existing NPPs and new-build. The table also shows that CNSC regulatory documents and CSA standards incorporate the content of a significant number of IAEA publications as references. The referenced IAEA publications are given in annex 7.2(i)(b) but also additional IAEA publications were considered in the development of the CNSC regulatory documents and CSA standards. Further, the revisions made to the CNSC's regulations and regulatory documents and CSA standards in response to the Fukushima accident have further aligned the national regulatory framework with the IAEA safety standards.

7.2 (ii) System of licensing

Section 26 of the NSCA prohibits any person from preparing a site, constructing, operating, decommissioning or abandoning a nuclear facility without a licence granted by the Commission. Subsection 24(4) of the NSCA states the following:

- No licence may be issued, renewed, amended or replaced – and no authorization to transfer one given – unless, in the opinion of the Commission, the applicant or, in the case of an application for an authorization to transfer the licence, the transferee
- a) is qualified to carry on the activity that the licence will authorize the licensee to carry on; and
 - 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.

Subsection 24(5) of the NSCA gives the Commission the authority to include in licences any term or condition that it deems necessary for the purposes of the NSCA.

The CNSC's licensing system is administered in cooperation with federal and provincial/territorial government departments and agencies in such areas as health, environment, Aboriginal consultation, transportation and labour. Before the CNSC issues a licence, the concerns and responsibilities of these departments and agencies are taken into account, to ensure that no conflicts exist with the provisions of the NSCA and its regulations.

The CNSC is obligated to comply with any federal legislation and therefore may make its licensing decisions in consultation with any department or agency government bodies at the federal level having independent but related responsibilities with the CNSC.

The CNSC's regulatory regime defines NPPs as Class IA nuclear facilities and the regulatory requirements for these facilities are found in the *Class I Nuclear Facilities Regulations*. These regulations require separate licences for each of the five phases in the lifecycle of a Class IA nuclear facility:

- licence to prepare a site
- licence to construct
- licence to operate
- licence to decommission
- licence to abandon

The NSCA does not have provisions for combined licences for site preparation, construction, or operation. However, applications for licences to prepare a site for, construct and operate a new nuclear facility can be assessed in parallel provided the applicant submits supporting information and evidence.

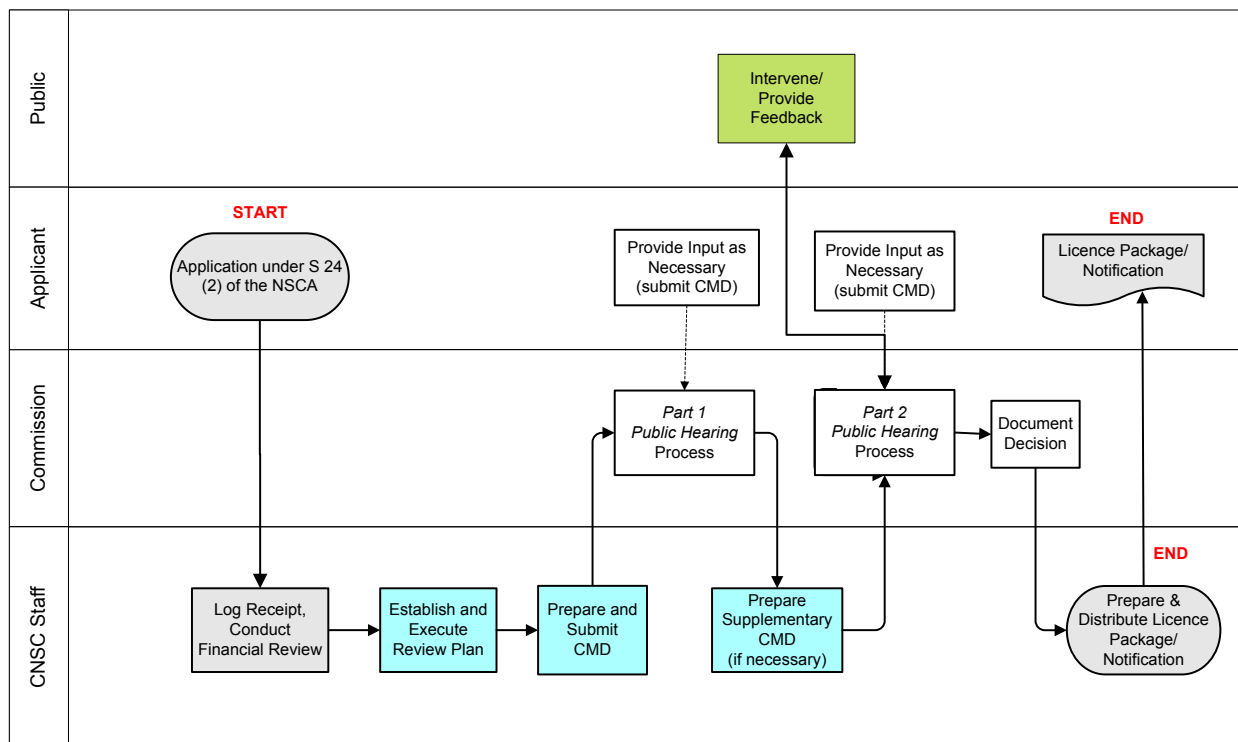
The *Class I Nuclear Facilities Regulations* and the *Uranium Mines and Mills Regulations* establish a 24-month timeline for projects requiring the CNSC's regulatory review and decision on new applications for a licence to prepare a site for a Class I nuclear facility and a licence to prepare a site and construct a uranium mine and mill. This timeline does not include the time required by proponents to respond to information requests.

7.2 (ii) (a) Licences and licensing process

CNSC REGDOC-3.5.1, *Licensing Process for Class I Nuclear Facilities and Uranium Mines and Mills*, was published in 2015 and replaced the CNSC information document INFO-0756, Rev. 1, *Licensing Process for New Nuclear Power Plants in Canada*. This document outlines the current licensing process in the context of the NSCA. The CNSC licensing process is one of the core processes in the CNSC management system, which is described in subsection 8.1(d).

Figure 7.2 depicts the CNSC licensing process and the key activities to be carried out by the licence applicant, CNSC staff and the Commission.

Figure 7.2 The Process for Obtaining an NPP Licence under the *Nuclear Safety and Control Act*



The licensing process is initiated when the proponent sends an application to the CNSC. A licence application must contain sufficient information to meet regulatory requirements and to demonstrate that the applicant is qualified to conduct the licensed activity.

The regulations under the NSCA provide licence applicants with general performance criteria and details about the information and programs they must prepare and submit to the CNSC as part of the application process. The following table highlights some of the more important information requirements identified in the *General Nuclear Safety and Control Regulations* and the *Class I Nuclear Facilities Regulations*.

Licence type	General regulations	Class I regulations
Licence to prepare a site	Section 3	Sections 3 and 4
Licence to construct	Section 3	Sections 3 and 5
Licence to operate	Section 3	Sections 3 and 6

To enhance clarity, the CNSC is preparing a supporting application guide (a REGDOC) for each licence type that provides additional details and criteria (such as references to CNSC regulatory documents, national codes and standards, or the IAEA safety standards) so applicants clearly understand what is necessary to satisfy the requirements of the applicable regulations under the NSCA. The licence application guide RD/GD-369, *Licence to Construct a Nuclear Power Plant*, was published in 2011. Application guides for the licence to prepare a site and a licence to operate an NPP are under development.

For new NPPs, information on decommissioning plans and financial guarantees is required early in the licensing process. The *Class I Nuclear Facilities Regulations* require an applicant to

provide information on its proposed plan for decommissioning a nuclear facility or site, while the *General Nuclear Safety and Control Regulations* require information on financial guarantees to accompany a licence application. Financial guarantees are used to ensure sufficient funds are available so that the facility does not pose any unnecessary risk in the event that the licensee can no longer operate the facility. To date, these have mostly been used for decommissioning an NPP at the end of its operating life and for the long-term management of spent nuclear fuel. Information on proposed financial guarantees should include any obligations for funding the decommissioning and long-term management of nuclear fuel waste, pursuant to the *Nuclear Fuel Waste Act*. Financial guarantees for decommissioning are discussed in subsection 11.1(b).

Per CEEA, before any federal authority issues a permit or licence, grants an approval, or takes any other action for the purpose of enabling a project to be carried out in whole or in part, an environmental assessment (EA) must be carried out for certain designated physical activities to identify whether the project is likely to cause significant adverse environmental effects. For all new NPPs, the EA is performed before the first licence – namely, the licence to prepare a site – is issued. An EA addresses all the phases of the project lifecycle, from site preparation through to abandonment. EAs are described in more detail in subsection 17(ii)(a).

CNSC licensing staff assessment and process documentation

The CNSC employs a risk-informed approach to define the scope of the assessments in its licensing process.

In addition to the REGDOC completion project described in subarticle 7.2(i)(b), the CNSC is implementing a comprehensive plan for the preparation of licensing process documentation, application guides and forms as part of the projects under the CNSC's *Harmonized Plan for Improvement Initiatives* (referred to herein as the Harmonized Plan, see subsection 8.1(e)). This plan includes the integration of knowledge gained from international licensing experience through organizations such as the IAEA, the Nuclear Energy Agency (NEA), the Multinational Design Evaluation Programme (MDEP) and other nuclear regulators.

Both the EA reviews and the licensing reviews are executed by CNSC staff using a project-specific assessment plan that triggers specific reviews within a project management framework per the process in figure 7.2. Public information meetings and the discussions that follow also assist in judging the acceptability of the site.

The CNSC has assessment plans and topical staff work instructions (see subsection 8.1(d)) for the following projects:

- applications for a licence to prepare a site
- application for a licence to construct
- environmental impact statements (EISs, see Article 17)
- integrated safety reviews for life extension (see subsection 14(i)(f))

Licensing recommendations, decisions and related approvals

The CNSC staff assessment of an applicant's supporting information is augmented by input from federal and provincial government departments and agencies responsible for regulating health and safety, environmental protection, emergency preparedness and the transportation of dangerous goods in relation to nuclear-related projects. The CNSC maintains memoranda of understanding with these departments and agencies. The NSCA also requires that members of

the public be invited to participate in licensing hearings of Class I facilities (NPPs, conversion facilities, research reactors) and uranium mines and mills.

CNSC staff members document the conclusions and recommendations from their reviews in Commission member documents (CMDs), submitting them to the Commission for a public hearing held in one or two parts. In the more conventional two-part hearings, the Commission considers the initial conclusions and recommendations at the Part One public hearing (refer to figure 7.2 shown previously), along with information provided by the licence applicant. At the Part Two public hearing, the Commission, in accordance with the *Canadian Nuclear Safety Commission Rules of Procedure*, invites interventions by other interested parties (e.g., members of the public, non-government organizations, labour unions, municipalities, other government departments, industry) who are then given the opportunity to present information that they feel is relevant to the licensing decision at hand.

For the licensing of NPPs, intervenors are typically allotted significant periods of time at the Part Two hearing to present their information and engage the Commission. (This usually involves a 10-minute oral presentation to summarize the key points of the written submission, followed by question period for which no time limit is ascribed.) CNSC staff and applicants may also present supplementary or revised information at the Part Two hearing as follow-up to discussion at Part One. The hearings are webcast and the video is available online for a minimum of three months following the hearing.

During and after public hearings, the Commission deliberates upon the information provided and makes the final decision on the granting of the licence. The CNSC issues news releases to inform the public of the decisions made. The records of proceedings from the hearings, along with the reasons for the Commission's decisions, are posted on the CNSC website and sent to all participants.

Content of licences - General

The licensing basis is defined as the set of requirements and documents comprising:

- (i) the regulatory requirements set out in the applicable laws and regulations
- (ii) the conditions and safety and control measures described in the facility's or activity's licence and the documents directly referenced in that licence
- (iii) the safety and control measures described in the licence application and the documents needed to support that licence application

The documents needed to support the licence application are those that demonstrate that the applicant is qualified to carry out the licensed activity and appropriate provisions are in place to protect worker and public health and safety, protect the environment, maintain national security and implement the international obligations to which Canada has agreed.

The licensing basis sets the boundary conditions for acceptable performance at a nuclear facility. As such, it establishes the basis for the CNSC's compliance program (see subarticle 7.2(iii)), which is designed to ensure licensees continue to meet requirements and conduct the licensed activity within the licensing basis.

CNSC licences for NPPs contain a general requirement to conduct the licensed activities in accordance with the licensing basis. The licensee can improve its provisions, operations or facility design during the licence period as long as the improvements are within the licensing

basis and executed according to the licensee's management system. The licensee must obtain the written approval of the Commission if it wants to make a change outside the licensing basis.

These licences also contain a general condition requiring the licensee to notify the CNSC in writing when it changes its safety and control measures. This allows CNSC staff to confirm that operations remain in accordance with the licensing basis.

If the Commission grants a licence, the information and commitments submitted with a licence application become a legal requirement for the licensee (specifically, part iii of the licensing basis). Licences may also contain other terms and conditions, including references to regulatory documents or industry standards that licensees must meet.

NPP licences may include control provisions that require approval or consent to proceed for situations or changes where the licensee could be:

- not compliant with regulatory requirements set out in applicable laws, regulations or licence conditions
- outside the licensing basis

NPP licences may also indicate if the Commission has the option of delegating the authority to grant the approval to CNSC staff (a process known as "CNSC staff consent").

A common type of approval included in an NPP licensee is a "hold point" – a specific milestone that is established in a licence to separate critical phases of a workplan and allows for regulatory review before the licensee is authorized to proceed. The licensee seeks approval of the Commission or consent of a person authorized by the Commission prior to the removal of a hold point.

Examples of Commission approval and CNSC staff consent for a hold point were included in the licence to operate Pickering issued in 2013. That licence included a hold point regarding the authorization for OPG to operate Pickering beyond the nominal fuel channel design life assumed in the original design (technical details are provided in subsection 14(ii)(b)). This hold point was exercised during the reporting period.

Licence amendments

The NSCA gives the Commission the authority to issue and amend licences (to modify existing licence conditions or to add new licensing requirements, for example). Licence amendments can be initiated by the Commission or at the request of the licensee, and can be executed relatively quickly if necessary. This ability enables the CNSC to effectively address safety-related and other issues at the licensing level.

Licence conditions handbooks

As a result of the licence reform project that began in 2008 (see the sixth Canadian report for details), NPP licences contain relatively general requirements that are common to all NPPs in Canada. This greatly reduces the detail in the licence and the need for the Commission to amend the licence during the licence period. However, each NPP site with a licence to operate has an associated licence conditions handbook (LCH), the contents of which are under the responsibility of CNSC staff.

Intended to inform both the licensee and CNSC staff, the LCH gathers in a single document all the regulatory details, explanations, expectations and associated processes for definitions,

interpretations and administrative control of the licence conditions. The LCH is read in conjunction with the licence. The LCH associates each licence condition with compliance verification criteria (CVC) that are used by CNSC staff to confirm the licensee's compliance with the licence condition. The CVC are aligned with the licensing basis and document the implementation plans, action items and transition dates required to meet specific licence conditions. They provide the latest revisions and effective dates of the CNSC regulatory documents and industry standards that form part of the licensing basis. (During the reporting period, the CNSC began removing references to regulatory documents and industry standards from renewed NPP operating licences, including this information in the LCHs instead.) The CVC also provide information on obtaining Commission approval or CNSC staff consent of specified changes (e.g., hold points).

In addition, the LCH provides recommendations and guidance for each licence condition, which include non-mandatory suggestions or advice on how the licensee can comply with the licence condition. It also provides for the management of records and documents, including the process by which the licensee notifies the CNSC of changes to its documentation comprising part iii of the licensing basis.

An NPP LCH may be revised in accordance with a CNSC process. All revisions are approved by the Director General of the Directorate of Power Reactor Regulation.

7.2 (ii) (b) Licence to prepare a site

The selection of a site for the long-term development of a new NPP is not, in itself, a regulated activity in Canada (although the activities of site characterization and evaluation, which support site selection, are regulated). The choice of site is largely a matter between the project proponent and the municipalities and provinces/territories involved. The only exception to this practice is when the Government of Canada, under Natural Resources Canada (NRCan), assumes the role of proponent if it directly sponsors a federal (i.e., government-run) NPP project. In either event, the CNSC is not involved in the site-selection process.

When applying for a licence to prepare a site, it is the applicant's responsibility to demonstrate to the CNSC that the proposed site is suitable for future development and that the activities encompassed by the licence will not pose unreasonable risks to health, safety, security and the environment for the site and its surrounding region. In addition to addressing the activities pertaining to site evaluation and site preparation, submissions for selected topics for the licence to prepare a site are expected to consider the entire lifecycle of the proposed facility. The applicant must also demonstrate that the proposed licensed activity meets all applicable regulatory requirements.

The CNSC regulatory document RD-346, *Site Evaluation for New Nuclear Power Plants*, describes the general process for evaluating an NPP site in Canada. Specifically, it:

- provides site evaluation criteria (e.g., to address the impact of the site on the environment, emergency planning and natural and human-induced external hazards)
- sets expectations for collecting site-related data
- sets expectations for quality assurance as well as public and Aboriginal consultation

Additional information on the site evaluation criteria in RD-346 and the level of certainty and detail required for the design, is provided in the preamble of article 17.

Regulatory efficiencies can be maximized if the applicant thoroughly evaluates the proposed site for the project and fully documents the site selection case before initiating the licensing and EA processes. The information needed to complete such an evaluation has been compiled in a draft regulatory document, which will update RD-346 and is expected to be released for consultation during the next reporting period. The document will include criteria for the level of facility design information needed to support the site selection case. This document is intended to supplement the related application requirements contained in the regulations under the NSCA. The draft regulatory document codifies experiences from recent assessments for potential new NPPs and addresses lessons learned.

As part of the site evaluation process, the CNSC expects the applicant to publicly announce its intention to construct the facility and initiate a robust public communication program that will continue for the life of the project. This includes public meetings, held by the applicant, where the public can express its views and question the applicant.

7.2 (ii) (c) Licence to construct

When applying for a licence to construct a new NPP, it is the applicant's responsibility to demonstrate to the CNSC that the proposed NPP design conforms to regulatory requirements and will provide for safe operation on the designated site over the proposed plant life. The information required in support of the application to construct an NPP is referred to as the "safety case" and includes, for example, the following:

- a description of the proposed design for the new NPP, taking into consideration physical and environmental characteristics of the site
- environmental baseline data on the site and surrounding area
- a preliminary safety analysis report demonstrating the adequacy of the design
- measures to mitigate the effects on the environment and health and safety of persons that may arise from the construction, operation or decommissioning of the facility
- information on the potential releases of nuclear substances and hazardous materials and proposed measures to control them
- programs and schedules for recruiting and training staff for the construction, commissioning and operation phases of the project
- programs and activities that will be undertaken by the applicant to perform the oversight of design, procurement, construction, commissioning and operation activities, in order to provide assurance that the plant will conform to regulatory requirements and the design and safety analysis, as presented in the application

During the reporting period, the CNSC published regulatory document REGDOC-2.3.1, *Conduct of Licensed Activities: Construction and Commissioning Programs*, to provide assurance to the applicant and the regulator that facilities are constructed per design and the reactor facility meets its safety requirements and will operate safely. CNSC staff will use this REGDOC to assess new applications for licences to construct reactor facilities.

In order for the applicant to demonstrate that the reactor facility can operate safely in the modes for which it has been designed, it is necessary for the design of the facility and the safety analysis to be well advanced and supported by appropriate and adequate research, including experimental tests and analysis.

The CNSC's review of an application for a licence to construct is designed to obtain reasonable assurance that the facility design meets all regulatory requirements and can be constructed, commissioned and operated safely as designed and that no new safety issues will be identified prior to reactor operation. Upon receipt of the application, the CNSC performs a comprehensive assessment of the design documentation, preliminary safety analysis report, the construction program and all other information required by the regulations. The evaluation involves rigorous engineering and scientific analysis, as well as engineering judgment, taking into consideration the CNSC's experience and knowledge of best practices in NPP design and operation gained from existing NPPs in Canada and around the world.

The scope of a licence to construct covers all facility construction and Phase A commissioning as described in REGDOC-2.3.1 (i.e., the commissioning of all structures, systems and components (SSCs) done without fuel loaded). The licensee must also build a significant portion of the operating organization such that facility operations, processes and procedures will be in place in anticipation of the licence to operate. This approach is part of an overall philosophy to facilitate the transition from construction to commissioning to commercial operation. In addition, the approach may increase regulatory certainty for an operating licence if the licensee demonstrates good regulatory performance regarding facility construction.

During the construction stage, the CNSC carries out compliance activities to verify licensee compliance with the NSCA, associated regulations and its licence. Compliance activities focus on confirming that the NPP construction is consistent with the design and the licensee is demonstrating adequate project oversight and meeting quality assurance requirements.

Regulatory oversight activities include, but are not limited to:

- inspections, surveillance, reviews, witnessing of commissioning tests and evaluations of commissioning test results
- inspections at manufacturing facilities
- assessment of the effectiveness of applicant's oversight of construction and commissioning activities
- granting of Commission approval or CNSC staff consent pertaining to commissioning hold points

Toward the latter part of construction, regulatory attention turns toward the Phase A commissioning program and its associated activities. The purpose is to verify, to the extent practicable (without fuel loaded), that all SSCs have been installed correctly and are performing according to the design intent (which includes their response to abnormal conditions, as credited in the safety analysis). Details on commissioning activities are provided in subarticle 19(i). In addition, the licensee's progress on its organizational development is considered in preparation for the anticipated application for a licence to operate.

7.2 (ii) (d) Licence to operate

When applying for a licence to operate, it is the applicant's responsibility to demonstrate to the CNSC that it has established appropriate safety management systems, plans and programs for safe and secure operation. This includes a demonstration that all Phase A commissioning has been successfully completed and all the systems important to safety are ready for the reactor core to accept first fuel.

The specific information required for an application for a licence to operate an NPP is found in sections 3 and 6 of the *Class I Nuclear Facilities Regulations*. The following list outlines some of the information required in support of a licence to operate a new NPP in accordance with CNSC regulatory document REGDOC-3.5.1, *Licensing Process for Class I Nuclear Facilities and Uranium Mines and Mills*:

- a description of the SSCs, including their design and operating conditions
- the final safety analysis report
- proposed measures, programs, policies, methods and procedures for:
 - Phase B, C and D commissioning (i.e., the commissioning of all SSCs with first fuel in the core)
 - operating and maintaining the NPP
 - handling nuclear substances and hazardous materials
 - controlling releases of nuclear substances and hazardous materials into the environment
 - preventing and mitigating the effects on the environment and health and safety of persons resulting from plant operation and decommissioning
 - assisting offsite authorities in emergency preparedness activities, including procedures to deal with an accidental, offsite release
 - developing and maintaining nuclear security
- public information and disclosure program to keep the public and target audiences informed of the anticipated effects of the NPP's operation on their health and safety and on the environment
- updated preliminary decommissioning plan
- proposed financial guarantee for the activities to be licensed

The information needed by the applicant to submit a successful application for a licence to operate will be further articulated in a CNSC regulatory document currently under development.

For a licence to operate a new NPP, in addition to assessing the information included in the initial application, the CNSC verifies that any outstanding issues from the construction licensing stage have been resolved.

The initial operating licence will enable the operator to load nuclear fuel and begin fuel-in commissioning (i.e., Phases B, C and D). These activities complete the overall commissioning program of SSCs to confirm that:

- The key operational safety characteristics match those used in the safety analyses
- The NPP has been constructed in accordance with the design
- The SSCs important to safety are functioning reliably

Commissioning is discussed in more detail in subarticle 19(i).

Licence period

The CNSC uses flexible licence periods that enable it to regulate NPPs in a more risk-informed manner (in particular, through the adjustment of the licence period according to the licensee's previous performance and the findings resulting from its compliance verification activities). The licensee may also request a specific licence period to match its planned activities or anticipated change in status (such as the beginning or end of refurbishment).

CNSC Commission member document CMD 02-M12, *New Staff Approach to Recommending Licence Periods*, compiles the factors CNSC staff members need to consider when making recommendations to the Commission regarding licence periods. These factors include:

- facility-related hazards
- presence and effective implementation of the licensee's quality management programs
- implementation of an effective compliance program from both the licensee and the CNSC
- extent of licensee experience
- demonstrated acceptable rating of licensee performance under the CNSC safety and control areas
- requirements of the *Canadian Nuclear Safety Commission Cost Recovery Fees Regulations*
- the facility's planning cycle

The imposition of a relatively short licence period by the Commission is an option where overall licensee performance is unsatisfactory or because of other considerations.

Licence renewal and updating the licensing basis

For the renewal of a licence to operate, the licensee must indicate any changes in information submitted in the previous application. Appendix C provides a summary of information required to accompany an application to renew an NPP operating licence. This type of information becomes part of the licensing basis of the NPP once a licence to operate is granted, as described in subarticle 7.2(ii). The CNSC plans and conducts a balanced assessment of the licensee programs and activities, which provides the Commission with a comprehensive review of the facility and of the licensee's activities and performance. It also supports staff recommendations for any licensing decision and guides ongoing regulatory activities. See subsection 14(i)(b) for a description of this assessment.

Licence renewal is a mechanism to implement new requirements from recently published REGDOCs or standards, thus contributing to the continuous safety improvement of NPPs. Before implementation, the CNSC consults with licensees on the need for a transition period or implementation plan to achieve full compliance. The implementation of CNSC REGDOCs or standards frequently involves a series of consultations, such as CNSC–industry workshops and CNSC staff visits to NPPs. The Commission may provide direction on the planned implementation of new REGDOCs and standards during the licence renewal process. Following the licence renewal, the implementation details of these REGDOCs and standards are recorded in the LCH. For example, the LCH contains the anticipated implementation date of the new REGDOC or standard, which may be projected to be after the start of the licence period.

During the reporting period, the licences to operate Pickering, Bruce A and B and Darlington were all renewed. The operating licences for Pickering A and Pickering B were combined into a single site licence in 2013 for a period of five years. The operating licences for Bruce A and Bruce B were similarly combined as a single site operating licence in 2015 for a period of five years. The Commission renewed the licence for Darlington in 2016 for a period of approximately 10 years. (This licence period includes the Darlington refurbishment period, which is discussed further below). All of these renewals involved the implementation of several new REGDOCs and standards, along with revised versions of existing regulatory documents and standards. The

licence to operate Gentilly-2 will expire shortly after the reporting period (see subsection 7.2(ii)(e)).

As part of continuous improvement during their licence periods, NPP licensees also implement new regulatory documents and standards (and new versions thereof) that were not considered at the time of the renewal of their licences to operate. This is done on a risk informed-basis, which considers the most effective and efficient time to adjust programs to meet evolving requirements. The LCH is used to document, on an ongoing basis, the implementation status of new regulatory documents and standards. CNSC staff informs the Commission on an annual basis of changes to the LCH, including information on progress in implementing new regulatory documents and standards. This annual reporting is described in appendix F.

Integrated safety review within the licensing framework

The CANDU reactors in Canada have a typical design life of about 30 years, after which a re-assessment is required to justify further operation. Refurbishment activities, designed to extend the life of the reactor, take years to execute. Given that the typical duration of a licence to operate in Canada has been five years, activities associated with life extension were governed in part, by the conditions in the licence to operate that are in effect before life extension, during life extension and during return to service following life extension.

In the past, CNSC regulatory requirements for life-extension projects were detailed in the regulatory document RD-360, *Life Extension of Nuclear Power Plants*. It specified the requirements for an integrated safety review (ISR), which is a one-time application of a periodic safety review (PSR). RD-360 was based on IAEA guidance for PSRs. For more information on RD-360 and recent life-extension projects, see the sixth Canadian report.

The Darlington refurbishment project, to begin in the next reporting period, was also planned using RD-360 as the base requirement. See subsection 14(i)(f) for details on the Darlington ISR and life extension. The related licence renewal of Darlington is also discussed in the next subsection in the context of PSR.

Periodic safety review within the licensing framework

In April 2015, the CNSC published REGDOC-2.3.3, *Periodic Safety Reviews*, which superseded RD-360. REGDOC-2.3.3 is consistent with the IAEA's Specific Safety Guide No. SSG-25, *Periodic Safety Review for Nuclear Power Plants*.

Like an ISR, a PSR involves an assessment of the current state of the NPP and its performance to determine the extent to which it conforms to applicable modern codes, standards and practices, and to identify any factors that would limit its safe, long-term operation. A PSR is a rigorous safety assessment that is complementary to – and does not replace – routine and non-routine regulatory reviews, inspections, event reporting and investigations, or other CNSC compliance and verification activities. It takes into account evolving international safety requirements, worldwide operating experience and, in particular, the assessment of the combined effects of plant aging on safety.

PSRs are complementary to the CNSC's existing assessments within its process to renew a licence to operate an NPP. The safety and control areas that provide the framework for the licence renewal safety assessment (and ISR/PSR) cover the IAEA PSR safety factors. The implementation of PSR at the CNSC is relatively straightforward in that it simply assigns a

regular frequency to regulatory activities that have been previously conducted in the “one-off” occasions of life-extension projects. As explained above, the imposition of requirements in new REGDOCs and standards has already been well-established in the CNSC’s licence renewal process, prior to the adoption of PSR.

Per REGDOC-2.3.3, the documentation to be submitted to the CNSC for a PSR includes:

- PSR basis document
- reports on the review of each safety factor (safety factor reports)
- global assessment report
- integrated implementation plan

The integrated implementation plan identifies corrective actions and safety improvements that address all gaps found in the PSR.

In the transition to a PSR-based regulatory regime, CNSC staff members have begun recommending 10-year operating licences for NPPs with a PSR performed every 10 years to coincide with licence renewal. During the transition to REGDOC-2.3.3, for situations where the licensee performed an ISR for life extension in accordance with RD-360, the ISR will be considered to be equivalent to the first PSR. This was the case for the recent renewal of the licence to operate Darlington. The Commission granted a 10-year licence for Darlington, which included a licence condition requiring OPG to submit a PSR basis document, along with the subsequent licence renewal application, no later than one year prior to the expiry of the new licence.

In support of the next renewal of the licence to operate Bruce A and B, the Bruce A safety factor reports were submitted to the CNSC in August 2015. CNSC staff concluded that Bruce Power has properly identified the strength and gaps presented in these reports. Bruce Power also submitted the Bruce B PSR basis document in January 2016.

The introduction of PSRs for NPPs is the lead activity in a broader CNSC initiative to consider implementing PSRs for all Class I facilities in Canada. The implementation of REGDOC-2.3.3 fulfills the 2009 IRRS recommendation R5 regarding the introduction of PSRs (see the sixth Canadian report for details). This initiative is being further supported by a proposed amendment to the *Class I Nuclear Facilities Regulations* that would require all Class I facilities to conduct a PSR at an interval as specified in their operating licence. The amended regulations are anticipated to be published in 2017.

7.2 (ii) (e) Licence to decommission

CNS Challenge C-6 for Canada from the Sixth Review Meeting “Transition to decommissioning approach”

The CNSC has established a licensing strategy for decommissioning NPPs in the context of the licence renewal for Gentilly-2. Hydro-Québec submitted a licence application in 2015, as its current operating licence will expire on June 30, 2016. The application is to replace the current licence with a 10-year power reactor decommissioning licence, subject to renewal. The activities to complete the transition of the reactor to the safe storage state have been completed and the transfer of irradiated fuel to dry storage modules is continuing in accordance with the existing

regulatory requirements. CNSC continues to provide oversight, adapting its compliance program to the decommissioning phase. In addition, during the next licensing period, Hydro-Québec is expected to continue activities related to the preparation for the decommissioning of Gentilly-2. The overall project timeline shows that dismantling of the facility will be completed by 2064 and the licensee plans to apply for a licence to abandon the site in 2066.

7.2 (iii) System of regulatory inspection and assessment

Section 30 of the NSCA authorizes CNSC inspectors to carry out inspections to verify licensee compliance with regulatory requirements, including any licence conditions. Per paragraph 24(4)(b) of the NSCA, these inspections are intended to confirm that the licensee has adequate provisions to adequately protect the environment and the health and safety of persons, maintain national security and implement Canada's international obligations. These provisions cover the areas listed in appendix C.

The CNSC and licensees take necessary and reasonable measures to maximize the level of compliance with regulatory requirements of persons or organizations regulated by the CNSC. The CNSC designs and executes a compliance program that:

- is informed by risk (to health, safety, environment and national security)
- considers the effective implementation of international agreements to which Canada has agreed
- accounts for the compliance record of the regulated person or organization

The CNSC implements a corporate-wide compliance process (one of the core processes in the CNSC management system; see subsection 8.1(d)) that integrates the following elements:

- promotion to encourage compliance
- verification activities to confirm licensees are complying with requirements and expectations
- reactive control measures to enforce compliance (see subarticle 7.2(iv))

The compliance process provides input to the initial issuance of licences and the operating licence renewal process described in subarticle 7.2(ii).

7.2 (iii) (a) Promotion of compliance

Promotion of compliance refers to all activities related to fostering conformity with legal requirements. The goal is to maximize compliance, by strengthening those factors that encourage it and by mitigating those that hinder it. Compliance promotion can take the form of consultation, acknowledgement of good performance, collaboration with other regulatory bodies, and dissemination of information to the regulated community about regulatory requirements/standards and the rationale behind them. Specific compliance promotion activities include, but may not be limited to, training, seminars, workshops and conferences.

7.2 (iii) (b) Verification of compliance

General

Verification includes all the activities related to determining and documenting whether a licensee's programs and performance comply with legal requirements and conform to acceptance criteria. Verification activities include:

- Type I inspections, which consist of audits of licensee programs or processes and their implementation
- Type II inspections, which focus on the performance or output of the programs or processes, as well as walkdowns or rounds and routine system inspections
- desktop reviews, which are reviews of documentation submitted to the CNSC by licensees (or applicants)
- surveillance and monitoring, which includes the review of NPP records; and attendance at meetings related to production, return to service and outage planning

Desktop reviews include reviewing licensee documents, such as the safety analysis reports, quarterly reports and event reports, against relevant requirements. Some specific forms of desktop review are supported by CNSC staff work instructions to ensure consistency of approach and to optimize regulatory effectiveness and efficiency. See annex 7.2(iii)(b) for a listing of systems and areas of verification activities through inspections at NPPs.

Desktop reviews are also conducted when licensees propose certain changes to their operations, documentation, etc. As indicated in subsection 7.2(ii)(a), licences require the licensees to notify the CNSC of such changes. CNSC staff members perform desktop reviews to confirm that the change, if it were to proceed, would remain in accordance with the licensing basis for the facility.

In general, acceptance criteria that can be used to assess compliance during desktop reviews or inspections may be derived from compliance verification criteria in the LCH, licensees' documents, CNSC regulatory documents and standards, and criteria that are not in the LCH such as the following:

- CNSC documents not listed in the LCH that clarify how the Commission intends to apply the legal requirements
- additional information supplied by licensees defining how they intend to meet legal requirements in performing the licensed activity
- CNSC staff's expert judgment, including knowledge of industry best practices

Important inspection improvements during the reporting period included the modernization of the CNSC laboratory, its information management system, and implementation of mobile inspection kits to enhance CNSC's capability to verify licensee compliance programs.

Inspections

Inspections typically include interviews with responsible licensee staff; reviews of documentation, data, logs and event reports; and field component line-up checks.

Some inspections monitor licensee activities as they unfold (e.g., exercises, outages). Other surveillance and monitoring activities collect real-time information about licensee performance and possible emerging issues.

The CNSC has in place a comprehensive process for conducting inspections that applies to all service lines, including NPPs. This process has been responsible for the development of procedures, templates and guides used by CNSC staff to improve the consistency and efficiency of inspections for all regulated facilities and activities. A feedback mechanism is also in place for CNSC staff to recommend revisions to inspection documents.

CNSC staff members who conduct the inspection are chosen based on the area being assessed and typically include specialists from the head office and inspectors from the site office. The site office inspectors are designated per section 29 of the NSCA and have various powers and limitations described in sections 30 to 35 of the NSCA (see subsection 8.1(b) for further details). A site office inspector generally leads the inspection team, with support from the technical specialist staff. The licensee is notified in advance of the inspection and its subject area. Entrance meetings, daily briefings of results and exit meetings are included in the inspection plans. The results are recorded in a CNSC report to the licensee and follow-up actions are documented and assigned target completion dates.

Type I inspections are used to evaluate licensee programs that address the topics listed in appendix C, and may be conducted after programmatic changes. As Canadian NPP licensees are well-established, Type I inspections are rarely conducted. Type I inspections are planned to a high degree of detail, with acceptance criteria spelled out in advance. The results from Type I inspections are transmitted by letter to licensees.

To help achieve regulatory effectiveness, efficiency, consistency and clarity, the CNSC compliance program uses a planned set of baseline inspections. It represents the minimum set of compliance activities required to verify licensee compliance with regulatory requirements. The baseline set was established by identifying a group of Type II inspections (and desktop reviews), as well as promotion activities for typical NPP operation (e.g., for those programs that address the areas listed in appendix C and for the systems and areas listed in table 1 in annex 7.2(iii)(b)). Inspections were then assigned to the CNSC safety and control areas. The baseline set was subsequently refined to represent a reasonable set of inspections for a licensee having acceptable CNSC ratings in the safety and control areas during the preceding period.

A suite of CNSC Type II inspection guides was updated during the reporting period and additional guides were developed. The guides are continuously improved to reflect the current state of the CNSC compliance program and changes to the licensing basis. The results of Type II inspections are transmitted by letter to licensees.

The baseline regulatory activities take place over a schedule of five years. For safety and control areas where the CNSC rating of licensee performance is below expectations, risk management principles are used to identify focused activities that CNSC staff will undertake in the next period to supplement the baseline inspections. Monitoring includes the quarterly review of results of all verification activities.

While most inspections are planned and scheduled with licensees, inspectors have and do use the power to conduct unscheduled inspections, in reaction to events or other findings. For example, immediately after the Fukushima accident, CNSC site staff performed walkdowns at Canadian NPPs to verify the licensees' emergency preparedness for external hazards and severe accidents. See Canada's report for the Second Extraordinary Meeting for more details.

Another CNSC program that has also helped enhance the coherency and consistency of inspections is the inspector training and qualification program (see subsection 8.1(c) for details). Results of the CNSC's compliance activities, and assessments of licensees' safety performance are provided to the Commission and stakeholders annually in the *Regulatory Oversight Report for Canadian Nuclear Power Plants* (see appendix F for details).

Licensee reporting, follow-up, recording and tracking

The CNSC published regulatory document REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*, in May 2014. It consolidates and expands upon almost all legislated reporting requirements contained in the NSCA and its associated regulations that apply to NPPs. REGDOC-3.1.1 replaced CNSC regulatory standard S-99, *Reporting Requirements for Operating Nuclear Power Plants*, as the document that sets out the timing and information that NPP licensees are required to report to the CNSC. It has been incorporated in the operating licences of all NPPs. NPP licensees began reporting in accordance with the new regulatory document in 2015.

REGDOC-3.1.1 includes requirements for scheduled (periodic) and unscheduled (e.g., event) reports. REGDOC-3.1.1 has helped improved clarity by focusing on more significant information.

Preliminary reports for the most safety-significant situations or events (as defined in the regulatory document) must be provided to the CNSC immediately. Other preliminary reports must be provided on or before the first business day after the day that the licensee determines that the situation or event is reportable. The least significant reportable events are required to be reported quarterly or annually, primarily for trending and analysis of long-term safety and regulatory issues.

CNSC staff members assess the significance of events or situations that are outside the normal operations described in the licensing basis. Significance is determined using operational procedures or expert judgment. The urgency with which follow-up to the event should be conducted is also evaluated. The CNSC reviews do not aim to duplicate the assessments already performed by licensees; their purpose is to ensure licensees have adequate processes in place to take necessary corrective actions and incorporate the lessons learned from past events into their day-to-day operations. CNSC staff will only carry out detailed reviews of those events considered particularly significant to safety. CNSC staff may also investigate events of higher safety significance to independently confirm the event causes and required corrective actions.

CNSC staff members use the Central Event Reporting and Tracking System database to record the details of reported events; to code, trend and sort events using various criteria; and to track licensee and CNSC follow-up.

Situations deemed to be of noteworthy significance with respect to the protection of health, safety and the environment, the maintenance of national security, and compliance with international obligations are reported to the Commission in an event initial report (EIR), thus making the information available to all stakeholders. CNSC Commission member document CMD 03-M68, *Criteria for Preparing Significant Development Reports (SDR)*, includes guiding criteria to be used by CNSC staff when selecting the situations and issues to include in an EIR. (Note, the CNSC replaced significant development reports with EIRs in 2013.)

REGDOC-3.1.1 requires the NPP licensees to report data for a set of 25 safety performance indicators on a quarterly basis. CNSC staff members use these safety performance indicators to:

- benchmark acceptable levels of operational safety
- allow tracking of operational trends important to safety and, in some cases, performance comparisons across NPPs
- assess, summarize and report on the performance of licensees with respect to safety in the licence renewal process, in annual/quarterly reviews of NPP performance and in the *Regulatory Oversight Report for Canadian Nuclear Power Plants*

The safety performance indicators are divided among seven categories:

- radiation and contamination
- environment, waste, and health and safety
- international benchmarking
- maintenance
- emergency response
- operations
- chemistry

REGDOC-3.1.1 also provides the CNSC's requirements for self-reporting of compliance monitoring for operating NPPs. The scheduled compliance reports are based on the 14 CNSC safety and control areas. These reports include information about the least significant reportable events discussed above that the CNSC uses for trending and analysis. The quarterly compliance reports, which include safety performance indicators, are designed to highlight areas of potential non-compliance with regulations and licence conditions. Annual reports provide information on program status and performance.

7.2 (iv) Enforcement

Enforcement includes all activities to compel a licensee into compliance and to deter non-compliance with legal requirements. The choice of enforcement tool is governed by the CNSC process to select and apply enforcement tools, which is based on a graduated approach. The process provides details on the effective application of the enforcement tools described below and outlines the responsibilities of CNSC staff and the Commission in their execution. If the initial enforcement action does not result in timely compliance, increasingly severe enforcement actions may need to be used. In the graduated approach, the severity of the enforcement measure depends on the safety significance of the non-compliance and other related factors, such as:

- the risk significance of the non-compliance with respect to health, safety, national security, the environment and Canada's international obligations
- the circumstances that lead to the non-compliance (including acts of willfulness)
- the licensee's previous compliance record
- operational and legal constraints
- industry-specific strategies, efforts and ability to return to compliance and/or rectify the situation

During the reporting period, graduated enforcement tools available to the CNSC included:

- written notices
- increased regulatory scrutiny
- request from the Commission for information

- orders
- licensing actions
- prosecution
- AMPs

The first two types of enforcement in this list – written notices and increased regulatory scrutiny – are less formal and do not require the involvement of the Commission (as they are typically handled by CNSC staff).

Written notices are the most common enforcement tools used for NPPs. There are three types of written notices: recommendations, action notices and directives.

A recommendation is a written suggestion to effect an improvement based on good industry practice. It is, technically speaking, not an enforcement tool in that it is used when the licensee is still in compliance with regulatory requirements.

An action notice is a written request that the licensee take action to correct a non-compliance that is not a direct contravention of the NSCA, the applicable regulations, or a licence condition, but that can compromise safety, the environment or national security and may lead to a direct non-compliance if not corrected. Such non-compliances include:

- a failure to satisfy acceptance criteria not directly referenced in the applicable regulations or licence conditions
- a significant, but non-systemic failure to comply with the licensee’s own policies, procedures or instructions that have been established to meet licensing requirements (including programs and internal processes submitted in support of a licence application)

A directive is a written request that the licensee or a person subject to enforcement action take action to correct:

- a non-compliance with the NSCA, the applicable regulations, or licence conditions
- a general or sustained failure to adhere to the documents, policies, procedures, instructions, programs or processes established by the licensee to meet licensing requirements

Increased regulatory scrutiny includes the focused verification activities referred to in subsection 7.2(iii)(b).

The Commission (or an authorized person) can make a formal request for more information, as stipulated in subsection 12(2) of the *General Nuclear Safety and Control Regulations*. These types of formal requests are infrequent. The licensee can be asked to explain how it plans to address a concern raised by the Commission or the authorized person. For example, such requests were issued to NPP licensees to provide information related to potential safety issues raised following the Fukushima accident in 2011.

The NSCA gives the Commission, inspectors and designated officers of the Commission the authority to issue an order without prior notice, where necessary to do so in the interests of health, safety, the environment, national security or Canada’s international obligations. The NSCA includes provisions for the review of orders by the Commission, which includes an opportunity for the affected licensee to be heard. Orders to NPP licensees are rare – there were none issued during the reporting period. In fact, no orders related to safety have been issued to NPP licensees in the history of previous Canadian reports.

Licensing action can be taken in the context of a licensing matter initiated by the licensee/applicant. The Commission could grant a licence for a shorter term – for example, so that it can reconsider a specific compliance issue in the relatively near future. Alternatively, the Commission could also grant a licence renewal for a shorter licence term to allow the licensee sufficient time to make certain improvements or provide clarifications before the licence is considered for renewal.

Examples of licensing actions initiated by the CNSC include:

- Licence amendment: CNSC staff may recommend a licence amendment to the Commission. Licence amendments cover a wide range of possibilities and are decided on a case-by-case basis. Examples of licence amendments include the following:
 - limitations to on-power operation
 - a requirement to obtain Commission approval before reactor start-up
 - a requirement to appear before the Commission on a regular basis, to provide status reports on progress in improvements to operation and maintenance programs
- Decertification of persons
- Refusal to certify or renew certification
- Licence suspension or revocation: CNSC staff may recommend to the Commission to suspend or revoke a licence. This course of action can be taken in any of the following circumstances:
 - the licensee is in serious non-compliance
 - the licensee has been successfully prosecuted
 - the licensee has a history of non-compliance
 - the CNSC has lost confidence in the licensee's ability to comply with the regulatory requirements

Notwithstanding what has been given previously regarding licensing actions initiated by CNSC, and per the NSCA, the Commission may, on its own motion, renew, suspend in whole or in part, amend, revoke or replace a licence under the prescribed conditions.

A licensee that is subject to enforcement action that involves an order or amendment, suspension or revocation of its licence, is entitled to appeal to the Commission to contest the action. For a licence amendment, suspension, or revocation, the licensee would normally receive advance notice and have an opportunity to be heard by the Commission.

Where warranted, prosecution is also an enforcement option available to the CNSC. Specific instances of non-compliance that might lead to prosecution include:

- exposures to the public or workers in excess of the dose or exposure limits
- failure to take all reasonable measures to comply with an inspector's order

During the reporting period, the CNSC introduced a new enforcement tool – administrative monetary penalties (AMPs). An AMP is a financial penalty imposed by the CNSC, without court involvement, in response to a violation of a regulatory requirement. It can be applied to any person or corporation subject to the NSCA. AMPs enhance the robustness and effectiveness of the CNSC's enforcement regime and serve as a credible deterrent, thereby achieving higher levels of compliance.

The NSCA sets the maximum AMPs for individuals and persons other than an individual (i.e., a corporation or other institution) at \$25,000 and \$100,000, respectively and addresses the rules

surrounding violations and designates who can issue AMPs and review them. The review framework is based on the current CNSC appeal process; reviews are conducted by the Commission, during which time payment is pending. The *Administrative Monetary Penalties Regulations (Canadian Nuclear Safety Commission)* set out the schedule of violations that are subject to AMPs under the NSCA, as well as the method by which the penalty amounts are determined and the way notices of violation are served.

CNSC regulatory document REGDOC-3.5.2, *Administrative Monetary Penalties, Version 2*, provides information about the AMP program. It describes how and where AMPs fit into the CNSC's approach to compliance, and provides an overview of how they are administered. REGDOC-3.5.2 was originally published in March 2014 and was revised in August 2015.

The CNSC issued a total of 20 AMPs during the reporting period. Only one AMP was issued to an NPP licensee during the reporting period, and it was related to prescribed information which is outside the scope of the *Convention on Nuclear Safety*. Specifically, this AMP was issued to promote compliance with conditions of the licence and to deter reoccurrence and was not nuclear safety-related.

The CNSC process to select and apply enforcement tools does not include follow-up and tracking of responses to enforcement action. CNSC staff members utilize an action tracking tool in order to track the follow-up to non-compliances and help ensure appropriate and timely responses.

Significant enforcement actions against NPP licensees are summarized for the Commission and stakeholders in the annual *Regulatory Oversight Report for Canadian Nuclear Power Plants* (see appendix F).

Article 8 – Regulatory body

1. Each Contracting Party shall establish or designate a regulatory body entrusted with the implementation of the legislative and regulatory framework referred to in Article 7, and provided with adequate authority, competence and financial and human resources to fulfill its assigned responsibilities.
2. Each Contracting Party shall take the appropriate steps to ensure an effective separation between the functions of the regulatory body and those of any other body or organization concerned with the promotion or utilization of nuclear energy.

Canada’s nuclear regulatory body, the CNSC, strives for regulatory excellence. Its vision, as stated in its *Management System Manual* (see subsection 8.1(d)), is “to be the best nuclear regulator in the world”. This vision is supported by a commitment to self-assessment, peer review and continual improvement. The CNSC strives to adjust to changing circumstances and learn from situations and events.

Overall CNSC response to the Fukushima accident

The CNSC’s response to the Fukushima accident included:

- Issuing a regulatory request, under subsection 12(2) of the *General Nuclear Safety and Control Regulations*, to all licensees of nuclear facilities in Canada to review the lessons learned from the event, re-examine their safety cases and report on their implementation plans to address significant gaps
- forming the CNSC Task Force to examine the response of NPPs to external events of higher magnitude than had previously been considered in the approved design bases; and to examine the licensees’ capacity to respond to external events that may cause a prolonged loss of electrical power, resulting in operators being unable to continue cooling the reactors
- publishing the *CNSC Integrated Action Plan on the Lessons Learned from the Fukushima Daiichi Nuclear Accident* (CNSC Action Plan), which included
 - 36 Fukushima actions items (FAIs) applicable to Canadian NPP licensees and prescribing well-defined deliverables and timeline for their completion
 - actions for CNSC to enhance elements of the regulatory framework

The CNSC was the subject of two, distinct, independent assessments of its response to Fukushima: the 2011 follow-up IRRS mission to Canada and the review by an external advisory committee in 2012.

Details on the CNSC response to Fukushima and the independent assessments can be found in the sixth Canadian report.

CNSC Challenge C-1 for Canada from the Sixth Review Meeting
“Complete the implementation of the *CNSC Integrated Action Plan* in response to the Fukushima accident”

Canadian NPP licensees completed all FAIs resulting from the CNSC Action Plan by December 31, 2015 and details are found throughout this report. To follow through on the closure of the FAIs, station-specific action items were raised where necessary. CNSC staff members continue to monitor the implementation of planned measures at the NPPs through the station-specific action items as part of its ongoing compliance verification program. These activities include desktop reviews or inspections of the design improvements to enhance defence in depth, and field verifications of additional emergency mitigating equipment procured (including its availability and deployment guidelines). These station-specific action items are tracked through closure under established compliance verification criteria.

The CNSC also enhanced various elements of the regulatory framework, which included regulatory documents and the regulations. The updates for regulatory documents were completed during the reporting period. See subsection 7.2(i)(b) for details. Work is ongoing to amend two regulations to address lessons learned from Fukushima: *Class I Nuclear Facilities Regulations* and the *Radiation Protection Regulations*. Details can be found in subsection 7.2(i)(a).

For more details on the CNSC’s response to the Fukushima accident, see annex 8 of the sixth Canadian report, which provides a detailed comparison of Canada’s efforts against the *IAEA Action Plan on Nuclear Safety*.

In 2015, the IAEA published *The Fukushima Daiichi Accident: Report by the Director General* (the DG-IAEA Report), which contained 45 observations and lessons learned from the accident. CNSC staff played key leadership roles in preparing this report. In consultation with Health Canada and Public Safety Canada, the CNSC reviewed the lessons learned and assessed them against the status of the actions taken in Canada to address the lessons learned. The findings of this review were tabulated in *CNSC Assessment of the IAEA Director General Report on the Fukushima Daiichi Accident*, which was posted on the CNSC website in 2016 and can be found in annex 8 of this report.

The review demonstrated that the Canadian nuclear industry, the CNSC and other relevant authorities (including Health Canada and Public Safety Canada) have made significant progress in augmenting nuclear safety through a continuous improvement process. Canadian activities in response to the Fukushima accident were in line with and addressed the lessons identified in the DG-IAEA Report, and no new gaps were identified. Additional activities continue, including the drafting of post-accident recovery guidelines that will address related elements in the DG-IAEA Report (see subsection 16.1(a) for details).

The CNSC continues to consider potential lessons learned from operational experience, both from within the nuclear industry and from other safety-conscious industries.

Preparation for new-build project

The CNSC has put in place all the necessary tools and capacity to undertake new major facility licensing and compliance activities, including conducting pre-licensing vendor design reviews.

8.1 Establishment of the regulatory body

As established by the NSCA, the CNSC is the nuclear regulatory body in Canada. The fulfillment of its mandate (see subsection 7.1(a)) is accomplished by the work of the Commission, a quasi-judicial administrative tribunal comprising a maximum of seven members. Commission members are chosen on the basis of their credentials and are independent of all political, governmental, special interest group or industry influences. Members are appointed by the Governor in Council for terms not exceeding five years and may be reappointed. One member of the Commission is designated as both the President and Chief Executive Officer of the CNSC as an organization.

Subsection 16(1) of the NSCA stipulates that the Commission can employ staff to meet the purposes of the NSCA (see subsection 8.1(b) for a detailed description of CNSC staff).

The Commission conducts its business in an open and transparent manner. The public hearings and meetings of the Commission represent the public's primary opportunity to participate in the regulatory process. For more information on openness and transparency, as well as the CNSC's efforts to engage stakeholders, see subsection 8.1(f).

Hearings and meetings are held to discuss, among other things, NPP status, licensees performance, overall industry performance, and the findings resulting from licensing and compliance activities. CNSC staff members regularly attend these public hearings and meetings to advise, report and make recommendations to the Commission.

Subsection 17(1) of the NSCA stipulates that the Commission can also retain the services of external persons having technical or specialized expertise to advise it, independently of CNSC staff. This provision is used as needed, and would be the foundation for establishing *ad hoc* or permanent committees to support the Commission.

For some technical issues, the CNSC has also jointly sponsored, with the NPP industry, independent technical panels to review certain aspects of a particular issue (such as the analysis of effects associated with the issue or the proposed methodology to address it). An example of this kind of technical panel is provided in appendix G, section G.3 of the fifth Canadian report, which describes how an independent technical panel reviewed a new neutron overpower analysis methodology. This independent panel continued its advisory work during this reporting period.

The CNSC research program provides access to independent advice, expertise, experience, information and other resources via contracts and contributions placed in the private sector and with academic institutions and other agencies/organizations across Canada and around the world. The research program helps CNSC meet its regulatory mission and is independent of the extensive R&D program conducted by the industry. Appendix E describes the research objectives of the CNSC (and the Canadian nuclear industry) during the reporting period.

8.1 (a) Position and funding of the CNSC within the government structure

Position of the CNSC in the government structure

The CNSC is independent of government and reports to the Parliament of Canada through a Minister, designated by the Governor in Council. Currently, this designate is the Minister of Natural Resources. The CNSC makes independent, fair and unbiased decisions to regulate the nuclear industry.

The Commission is accountable in the following ways:

- Accountability to Parliament: The Commission submits to Parliament its annual report as well as its *Report on Plans and Priorities* and a *Departmental Performance Report*. The President of the CNSC, as the head of the Commission, appears before parliamentary committees to elaborate on matters related to the administration of the regulatory regime.
- Legal Accountability: Regulatory decisions by the Commission can be reviewed only by the Federal Court. As a federal agency, the CNSC is subject to various laws (e.g., the *Canadian Charter of Rights and Freedoms*, the *Official Languages Act*, the *Privacy Act*, the *Access to Information Act* and the *Financial Administration Act*).

The Commission requires the involvement and support of the Minister of Natural Resources to make or amend regulations and on matters of administration. Ministerial approval is required for regulation proposals submitted to the Governor in Council for approval. In addition, the Commission requires the involvement and support of the Minister for requests for funding of activities not funded under the *Canadian Nuclear Safety Commission Cost Recovery Fees Regulations*. For example, when its workload increases for activities that have no direct benefit to individual licensees, the CNSC, with the support of its Minister, seeks incremental funding through the Government of Canada's annual budget process. While the CNSC always seeks to increase the efficiency of its operations, it can also address workload pressures associated with fee-paying licensees through an increase of its regulatory fees.

Although the CNSC is the clear regulatory authority with respect to nuclear safety in Canada, various other national organizations play important, complementary roles. Legislation is established to set the relevant requirements for other areas of jurisdiction that are also applicable to nuclear-related activities. Memoranda of understanding and working relationships are established between these organizations and the CNSC to ensure nuclear regulation is effective and consistent, safety is not compromised, all responsibilities are borne by the appropriate body and no ambiguity or overlap exists. Examples of such areas of jurisdiction are emergency preparedness, the transportation of dangerous goods, environmental protection, and conventional health and safety (see subsection 7.1(b)).

In particular, CNSC staff members communicate with management and staff of Natural Resources Canada (NRCan) in areas of mutual interest. NRCan formulates the Government of Canada's policy regarding nuclear energy and natural resources. It is also a licensee for the cleanup of certain low-level radioactive wastes on behalf of the Government of Canada and, consequently, is subject to the CNSC's licensing and regulatory oversight. Another close partner is Global Affairs Canada, with which the CNSC frequently works to ensure the fulfillment of Canada's international commitments pursuant to bilateral and multilateral treaties, conventions and understandings.

Under the *Canadian Environmental Assessment Act, 2012* (CEAA; see subsection 7.2(ii)(a)) the CNSC is identified as a responsible authority for the purpose of conducting environmental assessments. The CNSC has responsibility for both the process and decision-making under the CEAA.

In addition to federal government entities, the CNSC works with several provincial and municipal organizations, as appropriate, in fulfilling its mandate.

The CNSC issues nuclear power reactor operating licences for the nuclear operations of provincially owned electrical utilities OPG, Hydro-Québec and NB Power (as well as to Bruce Power, which is a private-sector organization). The following publicly owned institutions or agents of the federal and provincial governments also hold other types of CNSC licences:

- NRCan
- Canadian universities
- hospitals and research institutions
- federal and provincial government departments

As part of its assessment of the lessons learned from Fukushima, the post-Fukushima review evaluated the roles and responsibilities of the various federal/provincial organizations (including the CNSC) that play significant roles in nuclear safety and nuclear emergency preparedness. For more details, see the sixth Canadian report. See subsection 16.1(a) for information about the specific follow-up issues related to emergency preparedness that involve other national organizations.

Funding

The CNSC is a departmental corporation, listed in schedules II and V of the *Financial Administration Act*.

In the past, CNSC regulatory activities were fully funded through the appropriations from Parliament. In the 2013 federal budget, the CNSC received statutory authority – pursuant to subsection 21(3) of the NSCA – to spend during a fiscal year any revenues that it receives in the current or previous fiscal year through the conduct of its operations. The revenues received from regulatory fees for licences and applications are charged in accordance with the *Canadian Nuclear Safety Commission Cost Recovery Fees Regulations*. This authority to spend revenues provides a sustainable and timely funding regime to address the rapid changes in the regulatory oversight workload associated with the Canadian nuclear industry.

Revenue recovered from fee-paying applicants and licensees accounts for almost 70 percent of the CNSC's funding. CNSC activities that are not recovered through cost recovery fees are funded through annual appropriations from Parliament. This accounts for the remaining 30 percent of the CNSC's funding.

Certain organizations are exempt from cost recovery and are not charged licence fees. These include not-for-profit institutions such as schools, medical facilities and emergency services, as well as government departments or agencies that hold a licence for an abandoned, contaminated site (assuming the licensee did not create the contamination). In addition to the exempt organizations, the types of activities funded through the annual appropriations are activities that the CNSC is obliged to conduct and that have no direct benefit for individual licensees (e.g., activities related to non-proliferation, emergency preparedness, public information programs and

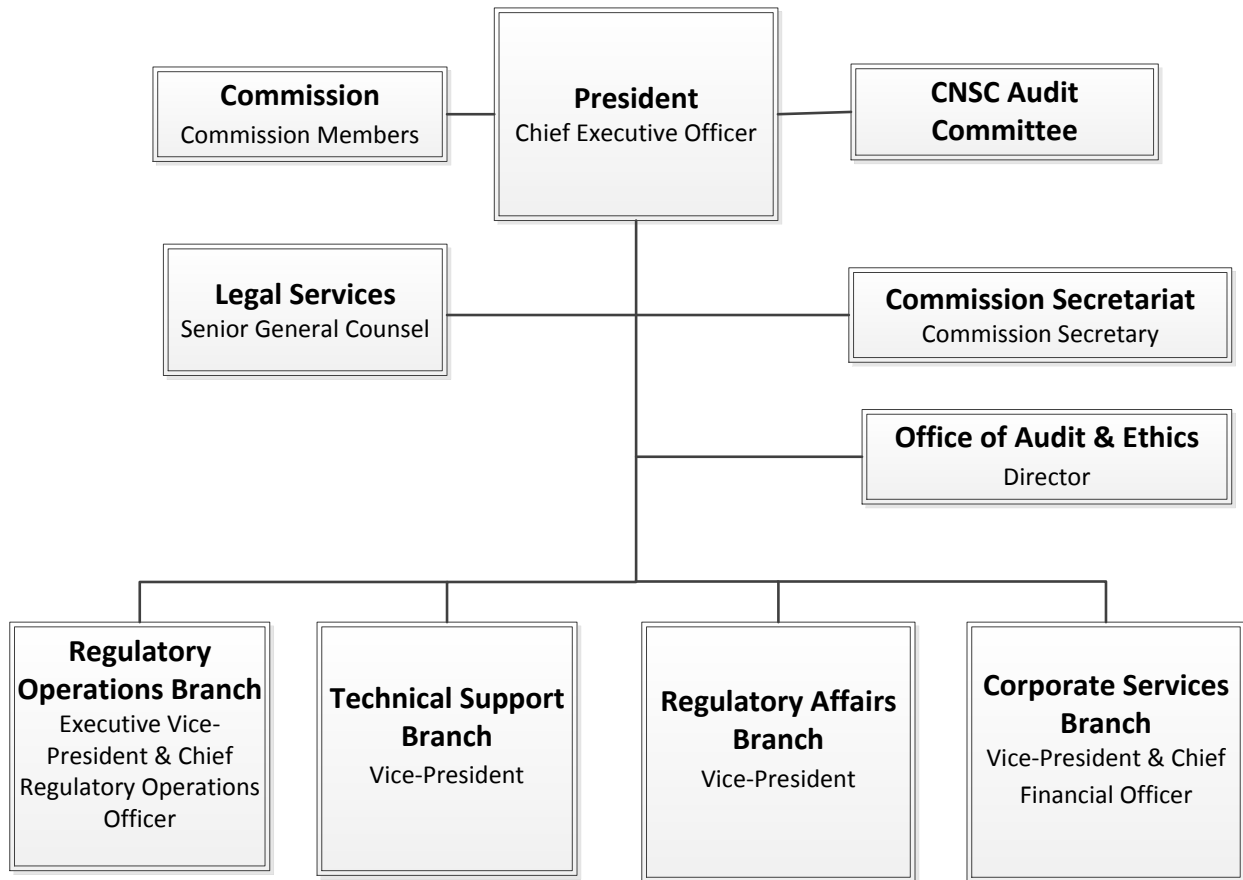
the maintenance of the NSCA and its associated regulations). For fluctuations associated with these licensees or activities, the CNSC can request additional funding from the Government of Canada (as given in the previous subsection).

8.1 (b) Organization of CNSC staff

The CNSC consists of a President, the federally appointed members of the Commission and 807 staff members (full-time equivalents), as of the end of the reporting period. Subsection 12(1) of the NSCA states that the President “has supervision over and direction of the work of the members and officers and employees of the Commission,” including professional, scientific, technical and other officers employed for the purpose of carrying on the work of the Commission.

The CNSC’s current organizational structure is described in Figure 8.1 (b) below:

Figure 8.1 (b) Organization of the CNSC



To satisfy the internal audit policy of the Government of Canada, the CNSC has an Audit Committee of five members composed of three external members, the CNSC President and the Commission Secretary. The Audit Committee provides the President with independent and objective advice and assurance on how well the CNSC’s internal audit and accountability

processes are working. Its oversight also extends to areas and processes that include values and ethics, risk management, management control and accountability reporting.

The Commission Secretariat consists of the Commission Secretary and supporting staff. It organizes all Commission hearings and meetings and provides the Commission with administrative and technical support.

The Office of Audit and Ethics, which is part of the Secretariat but whose work is also overseen and assessed by the CNSC Audit Committee, helps the CNSC achieve its objectives efficiently and in a way that demonstrates informed, ethical and accountable decision making. It is responsible for independently and objectively assessing the adequacy and effectiveness of CNSC operations and for providing advice to CNSC management on related improvement initiatives. The Office of Audit and Ethics also administers the CNSC programs for values and ethics, internal disclosure, external complaints, political activities, conflict of interest and post-employment. (See subsection 8.2(b) for additional description of the activities of the Office of Audit and Ethics.)

Legal Services acts as counsel to the Commission in its statutory roles and provides legal representation in litigation and prosecution cases. It also provides advice and legal opinions to CNSC staff members.

The CNSC as an organization consists of four branches: Regulatory Operations, Technical Support, Regulatory Affairs and Corporate Services.

Regulatory Operations Branch

The Regulatory Operations Branch is responsible for managing regulatory activities, including those related to licensing, compliance verification and enforcement. The relevant regulatory decisions may be made by designated officers, where the Commission formally assigns specific authorities to those officers in accordance with the provisions set out in the NSCA and its regulations. It is headed by the CNSC Executive Vice-President and Chief Regulatory Operations Officer and comprises the following directorates:

- Directorate of Power Reactor Regulation
- Directorate of Nuclear Cycle and Facilities Regulation
- Directorate of Nuclear Substance Regulation
- Directorate of Regulatory Improvement and Major Projects Management

The **Directorate of Power Reactor Regulation** regulates the development and operation of NPPs in Canada, in accordance with the requirements of the NSCA and its associated regulations. The directorate currently consists of the following five divisions:

- four regulatory program divisions (RPDs)
 - Pickering
 - Darlington
 - Gentilly-2/Point Lepreau
 - Bruce
- Power Reactor Licensing and Compliance Integration Division

The four RPDs are accountable for the planning, management and implementation of the power reactor regulatory program at their respective sites. Each RPD also acts as a single point of contact for internal stakeholders and licensees regarding most issues associated with the site. A

correspondence protocol is in place to govern both official communications (usually at the level of RPD Director) and unofficial communications between CNSC staff and the licensees.

In each RPD, there are permanently situated CNSC staff members who work at each NPP to lead and assist in the conduct of the CNSC compliance program activities (described in subsection 7.2(iii)(b)). Led by a site supervisor, these site inspectors inspect the premises, monitor activities and ensure compliance with the licensing basis. The inspectors are designated as such per section 29 of the NSCA.

In addition to the site inspectors at the NPP, technical staff at the CNSC's head office are also assigned to each RPD.

In 2014, given the shutdown state of the reactor at Gentilly-2 and the progress being made toward the safe storage state, the site office at Gentilly-2 was closed and the resident CNSC inspectors were re-assigned to different positions within the organization. Inspections of the Gentilly-2 site are now coordinated and conducted by CNSC staff from the head office.

The Power Reactor Licensing and Compliance Integration Division is accountable for discharging the CNSC's international obligations with respect to the NEA/IAEA Incident Reporting System (see subarticle 19(vi)) and the International Nuclear Event Scale (INES). It also ensures consistency in licensing and compliance activities across NPP sites, assists in the development of LCHs and preparations for the renewal of NPP operating licences, identifies trends in compliance information, manages performance indicator data and conducts event investigations as needed. During the reporting period, the Power Reactor Licensing and Compliance Integration Division continued to lead the development of inspection guides and corresponding performance objectives and criteria and developed various reports related to NPPs. This division also leads the management of CANDU safety issues (described in subsection 14(i)(g)).

The consistency of the implementation of the regulatory programs across the NPPs is fostered by a common approach to training (see subsection 8.1(c)). Meetings are also held regularly to foster common understanding and consistent approaches among directorate staff. This includes weekly teleconferences, divisional meetings, bi-monthly site supervisor meetings, quarterly review meetings and annual staff meetings.

The **Directorate of Nuclear Cycle and Facilities Regulation** and the **Directorate of Nuclear Substance Regulation** contribute to the regulatory program for NPPs. The Directorate of Nuclear Cycle and Facilities Regulation is responsible for, among other things, the various facilities associated with NPPs, such as uranium mines and refineries, conversion and fuel-fabrication facilities, and facilities for spent fuel storage and management of low- and intermediate-level radioactive waste. The Directorate of Nuclear Substance Regulation is responsible for some licences related to NPPs that fall outside the scope of the operating licence (e.g., licences for nuclear substances and radiation devices, transport).

The **Directorate of Regulatory Improvement and Major Projects Management** consists of three divisions:

- Internal Quality Management Division
- Regulatory Operations Coordination Division
- New Major Facilities Licensing Division

The responsibilities of the Internal Quality Management Division include strengthening the CNSC's management system, promoting a healthy safety culture, conducting and coordinating the CNSC's Harmonized Plan for improvement initiatives, and implementing self-assessments of key regulatory processes.

The responsibilities of the Regulatory Operations Coordination Division include the coordination of the annual operations planning, monitoring and reporting process, as well as the maintenance and central coordination of support activities and programs across regulatory programs. These topics are described in subsection 8.1(d).

The New Major Facilities Licensing Division is mandated to provide regulatory oversight through licensing, compliance, and other activities for potential new NPPs to be built in Canada; ensure a state of readiness for licensing any emerging technologies (such as small modular reactors); and manage new major projects and their related regulatory framework improvement projects. This division manages the CNSC's pre-project vendor design reviews, which provide vendors with regulatory guidance in regards to their NPP designs. It also participates in international activities that have a bearing on new-build projects, including those of the Multinational Design Evaluation Programme (MDEP). See the preamble to article 18 for more details on pre-project vendor design reviews and MDEP.

Technical Support Branch

The Technical Support Branch consists of a large number of employees with particular knowledge and skills who provide technical support to the activities of the Regulatory Operations Branch (including the Directorate of Power Reactor Regulation) and the Regulatory Affairs Branch. This is accomplished by providing specialist advice for regulatory programs, reviewing NPP licensee submissions, participating in inspections and helping to develop regulatory framework documents. Collaborations frequently include contributions involving several disciplines from across the Technical Support Branch and the Regulatory Operations Branch, requiring an integrated approach to resolving issues. The staff of the Technical Support Branch also share scientific and technical information and experience with stakeholders in Canada and other countries and undertake special projects within their expertise and mandate.

The Technical Support Branch comprises four directorates:

- Directorate of Assessment and Analysis
- Directorate of Safety Management
- Directorate of Environmental and Radiation Protection and Assessment
- Directorate of Security and Safeguards

The **Directorate of Assessment and Analysis** has expertise in the areas of chemistry, nuclear fuel, reactor physics, engineering (electrical, materials, mechanical, metallurgical, nuclear, civil/structural, and systems), design, aging management, maintenance, and equipment qualification, as well as fire protection, robustness, vulnerability design engineering and safety analysis, including deterministic safety analysis, probabilistic safety assessment and hazards analysis. The Directorate of Assessment and Analysis consists of eight divisions:

- Engineering Design Assessment Division
- Operational Engineering Assessment Division
- Probabilistic Safety Assessment and Reliability Division
- Systems Engineering Division

- Physics and Fuel Division
- Reactor Behaviour Division
- Reactor Thermalhydraulics Division
- Assessment Integration Division

The **Directorate of Safety Management** has expertise in the areas of human and organizational safety management, human factors, safety culture, management systems, examination, certification and training. It consists of four divisions:

- Management Systems Division
- Personnel Certification Division
- Human and Organizational Performance Division
- Training Program Evaluation Division

The **Directorate of Environmental and Radiation Protection and Assessment** has expertise in the areas of environmental assessment (EA), environmental risk assessment, environmental monitoring and environmental management systems, as well as radiation protection, dosimetry and health sciences. It consists of five divisions:

- Environmental Risk Assessment Division
- Environmental Assessment Division
- Environmental Compliance and Laboratory Services Division
- Radiation Protection Division
- Radiation and Health Sciences Division

The **Directorate of Security and Safeguards** has expertise in the area of emergency management and response. It is responsible for the CNSC's Nuclear Emergency Management Program, including its implementation and the planning of activities with other federal/provincial agencies and international organizations (see article 16). It also has expertise in nuclear security; import and export of nuclear substances, equipment and devices; safeguards; and non-proliferation. It consists of four divisions:

- Nuclear Security Division
- Emergency Management Programs Division
- Non-proliferation and Export Control Division
- International Safeguards Division

Regulatory Affairs Branch

The Regulatory Affairs Branch plays a central role in managing the regulatory framework in addition to communications and stakeholder relations. It encompasses the Regulatory Policy Directorate, the Strategic Planning Directorate and the Strategic Communications Directorate. The Regulatory Policy Directorate is charged with managing the regulatory framework, which includes reviewing the adequacy of regulatory instruments, managing their revision, and producing new instruments (including new regulatory documents). The Strategic Planning Directorate is responsible for planning and reporting at the organizational level (e.g., reporting to Parliament), and for evaluating the CNSC's effectiveness and efficiency in relation to its regulatory mandate. The Strategic Communications Directorate is responsible for both internal and external communications and hence contributes to measures related to openness and transparency.

Corporate Services Branch

The Corporate Services Branch manages organizational-wide services, activities and resources that are administered to support the needs of programs and other corporate obligations of the organization. These include management and oversight, human resources management, financial management, information and technology management, acquisition services, and other administrative services. It provides services and resources that apply across the organization.

8.1 (c) Maintaining competent staff

Workforce management

Maintaining a competent, agile and engaged workforce is critical to the CNSC's success and its goal of being "an employer of choice." As a result of uncertainty in the nuclear industry and anticipated attrition of the CNSC's workforce, an initiative to significantly increase the rigour of workforce planning was launched during this reporting period. Its aim was to strengthen CNSC's capacity for continuous forecasting of industry trends, including their workforce implications, so that proactive measures could be taken to build and protect the organizational capabilities needed to deliver on its mandate. The CNSC also focused on employee retention and fostering high levels of employee engagement.

Increasing the rigour of workforce planning included:

- development of a framework to catalogue the CNSC's current capabilities and associated workforce competencies
- segmentation of positions into categories to support the development of targeted recruitment strategies
- establishment of forecasts of future workforce requirements using scenario planning
- review of the anticipated supply of labour (internal and external to the CNSC) and the analysis of anticipated gaps
- development of a framework to engage all managers across directorates in the examination of workforce requirements and potential risk areas
- development and implementation of workforce strategies to address anticipated gaps and risks

The development and implementation of strategies to address workforce needs was supported by an organizational review to understand the degree to which CNSC's organizational structure supported on-the-job growth and development and the effective progression of employees from junior to senior roles. Consequentially, CNSC launched a significant New Graduate Recruitment Initiative that resulted in the hiring of 61 new employees – representing almost 8 percent of the CNSC's overall workforce. This was supported by redistribution, as necessary, of some senior roles (upon retirement) to create entry-level job opportunities or mid-level positions that support progression to senior levels.

Professional development

Each CNSC staff member has an individual learning plan that contributes to the CNSC's strong learning culture by ensuring immediate and future learning needs are identified and by helping the CNSC meet its evolving business priorities and objectives. The CNSC offers a variety of technical and non-technical training to its staff directly in support of its mandate.

The CNSC's Management Excellence Initiative supports leadership capacity building at all levels. During the reporting period, several learning activities were provided to CNSC leaders including courses on topics such as, leadership fundamentals, emotional intelligence, influence and persuasion (without authority), and critical thinking. A new initiative on exploring leadership was also offered to employees during the reporting period, providing them the opportunity to do a series of assessments to identify their leadership strengths and areas for development.

During the reporting period, the development of the Inspector Training and Qualification Program (ITQP) was completed. This program, which is composed of a combination of core training, service-line specific training and on-the-job training, establishes a consistent approach to train, assess and qualify CNSC inspectors-in-training across all service lines.

As part of the ITQP, the Directorate of Power Reactor Regulation uses a systematic approach for NPP-related knowledge and on-the-job-training for NPP site inspectors. This program includes a training plan that identifies the common inspector and specific training required by NPP site inspectors, on-the-job training and evaluation manuals and a training qualification record that documents the inspector's progress. Each inspector is required to take courses related to the regulatory process, CANDU design, non-technical topics (such as technical writing and effective interviewing), radiation protection and conventional health and safety. An inspector certificate is issued only when the site supervisor at the NPP determines that the inspector-in-training has achieved all the training requirements. From the time a new inspector enters into the program, it takes approximately 18 months to obtain an inspector's certificate.

To support senior inspectors who are coaching inspectors-in-training, a course on effective knowledge transfer was developed and delivered during the reporting period. The CNSC also began developing a Regulatory Operations Training Program for all regulatory operations staff and their supervisors to promote consistent application of CNSC licensing, certification and compliance processes.

The CNSC has a well-established 15-month co-op student rotation program with the University of Ontario Institute of Technology (UOIT), McMaster University and the University of Saskatchewan, and is actively looking to expand this program to other universities.

8.1 (d) Management system

The management system links the people, processes and resources within the CNSC's overarching regulatory framework. It reflects an integrated, fit-for-purpose approach to managing the performance of mandated functions, allowing for differences in implementation across CNSC programs and sub-programs. The CNSC management system is based on principles and requirements found within international quality standards and internationally recognized frameworks for organizational excellence. It also aligns to the IAEA safety standard GS-R-3, *The Management System for Facilities and Activities*, and other related safety standards. Additional CNSC-specific elements, such as its regulatory philosophy, internal safety culture, strategic priorities, its goal to become "an employer of choice" and its vision of being "the best nuclear regulator in the world," are all incorporated into the management system to ensure it meets the needs of the CNSC.

The CNSC management system was the subject of extensive review during the IRRS missions in 2009 and 2011 and during the reporting period the CNSC continued to build upon the feedback received. Ongoing development and strengthening of the management system has focused on

continuing to move the organization from an expert-based system to a more process-based system.

Management System Manual

The CNSC *Management System Manual* is the top-level document in the management system's document hierarchy. It applies to all CNSC staff. While it applies to the relationship and process interfaces with the Commission, the tenets of the manual do not apply to the Commission itself. The manual was last updated in December 2014 and is scheduled to be reviewed in 2016 in accordance with its two-year review cycle.

The purpose of the *Management System Manual* is to describe for CNSC employees and contractors how the management system integrates people, processes and resources within the CNSC's overarching regulatory framework to manage all work across the organization and ensure consistent, high-quality results. The manual identifies the high-level policies, principles and processes and mechanisms by which the CNSC achieves its goals and objectives. The manual is supported at lower levels by process documentation, detailed work instructions and other tools developed as needed that guide staff and collectively provide direction on how work is to be conducted at the CNSC.

The *Management System Manual* identifies the CNSC's key processes as follows:

- management processes
- core processes (manage the regulatory framework, manage licensing and certification and assure compliance)
- enabling processes

The *Management System Manual* also identifies the CNSC governance structure and describes the role of process owners who are responsible for the development, implementation and maintenance of the key processes. Each key process has a single process owner, appointed by senior CNSC management.

The CNSC staff work instructions are also found in the *Management System Manual* under processes. These important process-related documents provide more detailed guidance to staff.

Planning process for regulatory activities

The overall plan for the CNSC is summarized in its annual *Report on Plans and Priorities*, which is presented to Parliament.

At the working level, integral with its annual planning exercise, the CNSC organizes its inspections, reviews and other regulatory activities for NPPs by creating, implementing, monitoring and adjusting regulatory workplans for each NPP. Workplans are reviewed to ensure they cover specific goals, are risk-informed, and are consistent among NPPs. Activities in each NPP workplan are also consolidated into a summary – the Regulatory Activity Plan – which is costed to establish an estimate of the annual licence fee for each NPP (see subsection 8.1(a)). The Regulatory Activity Plan, along with a notification containing the licence fee estimate, is sent to each licensee at the beginning of each fiscal year.

During the reporting period, the CNSC formally documented its operations planning process within the management system.

8.1 (e) Assessment and improvement mechanisms

Follow-up IRRS mission to Canada

Canada hosted its initial IRRS mission in 2009. The results, findings and the CNSC's planned follow-up were described in the fifth Canadian report.

Canada hosted a follow-up IRRS mission in 2011 to review the measures taken to address the recommendations and suggestions from the initial mission and to review two new review areas – the Fukushima accident and the regulation of the transport of radioactive material. The results, findings and follow-up were described in the sixth Canadian report.

The follow-up mission concluded that 13 of 14 recommendations and 17 of 18 suggestions made during the initial IRRS mission had been effectively addressed and therefore could be considered closed. The one IRRS recommendation from 2009 that remained open – to implement PSR – has been systematically addressed by the CNSC (see subsection 7.2(ii)(d)). The one IRRS suggestion from 2009 that remained open was not directly relevant to NPPs.

The responses to findings from the follow-up IRRS mission that resulted from the Fukushima review were related to emergency preparedness and are described in article 16. The findings from the follow-up IRRS mission that resulted from the transport review are outside the scope of the CNS.

Harmonized Plan for Improvement Initiatives

Many of the improvement initiatives needed to address employee suggestions, the findings of peer reviews, and audits and evaluations of the CNSC are addressed through the CNSC's Harmonized Plan for Improvement Initiatives: a continuous improvement mechanism that develops and strengthens the CNSC's management system through the integration and alignment of all corporate-wide improvement initiatives into a single prioritized plan. The Harmonized Plan leverages commonalities between the different improvement initiatives and helps to streamline business processes, prioritize work and distribute resources to maximize horizontal collaboration and coordination for greater effectiveness and efficiency. It makes planning easier and helps CNSC managers work together to reduce duplication and redundancy. The Harmonized Plan is refreshed regularly to ensure it remains aligned with corporate priorities. The executive authority for the Harmonized Plan is the CNSC's Executive Vice-President and Chief Regulatory Operations Officer (see subsection 8.1(b)).

Many Harmonized Plan initiatives have helped improve the effectiveness and efficiency of regulatory oversight of NPPs and the overall NPP regulatory program by:

- establishing levels of regulatory activities that are founded on formal, well-articulated risk-informed approaches
- developing, establishing and implementing documented processes and procedures that define how the many contributors work together in a coordinated and well-managed manner
- improving information management in support of the regulatory program
- ensuring a consistent regulatory approach is applied for all licensees in a graded manner

CNSC assessments

CNSC self-assessments are championed by the manager responsible for the process or program being assessed.

Internal audits and program evaluations are conducted per the schedules approved by senior management and in accordance with established Government of Canada policies and procedures. Final reports are posted on the internal website for staff review and are shared with the public on the CNSC website. Each assessment and/or review of elements of the CNSC management system results in action plans that are approved and then monitored by senior management.

During the reporting period, formal audits were conducted on the following:

- CNSC Action Plan
- the process for the certification of personnel working at NPPs
- the import-export licensing program
- the CNSC's oversight of emergency measures at Class I nuclear facilities and uranium mines and mills
- the CNSC Participant Funding Program
- the CNSC travel, hospitality, conference and event expenditures

In addition, formal program evaluations were conducted on the CNSC Nuclear Emergency Management Program, the compliance verification program for the Directorate of Nuclear Substance Regulation, the CNSC grants and contributions program, and CNSC contributions to the Organisation for Economic Co-operation and Development (OECD).

An evaluation of the CNSC Harmonized Plan is scheduled for the next reporting period. The goal of the evaluation will be to ensure that the Harmonized Plan remains as effective as possible.

In August 2015, the Commissioner of the Environment and Sustainable Development of the Office of the Auditor General of Canada (OAG) began a performance audit of the CNSC's oversight of the nuclear sector for the period 2013–2015. An OAG performance audit is an independent, objective and systematic assessment of how well the Government of Canada is managing its activities, responsibilities and resources. The audit of the CNSC is examining management practices, controls, and reporting systems. The objective of the audit is to determine whether the CNSC adequately oversees the management of NPPs so that the health, safety, and security of Canadians and of the environment are protected. The audit is focusing on the CNSC's processes for planning and completing compliance inspections at NPPs, allocating resources to support the inspection program, and applying enforcement measures to correct and deter non-compliance.

The OAG audit is expected to be tabled in Parliament in October 2016.

During the reporting period, the CNSC hosted its first IAEA International Physical Protection Advisory Service (IPPAS) mission, an international peer review of Canada's nuclear security regime and its effectiveness in protecting against the unauthorized removal of nuclear material and the sabotage of nuclear facilities and material. Following 12 months of preparation, including a comprehensive self-assessment, the mission was conducted in October 2015. The IPPAS mission concluded that Canada has established and maintains a strong and comprehensive nuclear security infrastructure. As with other assessments of elements of the CNSC management

system, an action plan was developed alongside a commitment to track, through to implementation, improvement opportunities identified during the mission.

CNSC staff members also actively participate in international conferences, workshops and peer reviews to gain useful insights and lessons learned that can be leveraged to strengthen the CNSC management system. CNSC attendees/participants are required to complete trip reports that are shared within the organization and where relevant, are asked to participate in CNSC improvements stemming from the insights gained. Interactions with IAEA Member States and other Government of Canada agencies take place on many technical and non-technical topics on a regular basis.

8.1 (f) Openness and transparency

Dissemination of information – General

Disseminating objective scientific, technical and regulatory information is a part of the CNSC's mandate (see subsection 7.1(a)). The CNSC is taking advantage of new means of communicating to maximize the dissemination of information and engagement with stakeholders, which benefits both stakeholders and the CNSC.

During this reporting period, the CNSC approved a new approach for outreach and engagement. The CNSC identified many outreach opportunities focusing on youth, municipal governments in the areas where major facilities are located, medical communities, professional associations and non-governmental organizations. To reach target audiences, the CNSC uses many tools such as its website, Facebook, Twitter, YouTube, webinars, interactive online modules, email updates to subscribers and attendance at third-party events and conferences. CNSC staff members also host information sessions to explain to stakeholders how the nuclear industry is regulated and how to participate in the regulatory process.

The CNSC is equally committed to helping licensees and the nuclear industry to understand and comply with its regulatory framework. It has undertaken a variety of engagement activities, including the following:

- offering information sessions on draft regulatory documents
- participating in the Certification and Training Advisory group (co-chaired by CNSC and the industry), involving policy-level discussions about the training and certification of NPP personnel
- participating in COG Nuclear Safety Committee meetings, as well as meetings of the Chief Nuclear Officer/CNSC Executive Forum (see subsection 8.1(g)) to promote common understanding of generic safety and licensing issues

Response to Fukushima – Dissemination of information

The CNSC includes a section on its response to the Fukushima accident in its annual *Regulatory Oversight Report of Canadian Nuclear Power Plants*, which is described in appendix F. The public has the opportunity to provide written comments on that report's content and these are addressed when the report is presented to the Commission in a public meeting.

During this reporting period, the CNSC published the *Study of Consequences of a Hypothetical Severe Nuclear Accident and Effectiveness of Mitigation Measure*. Written in plain language, it assesses the consequences and possible preventative mitigation of a hypothetical severe nuclear

accident in Canada. It addresses concerns raised during public hearings in 2012 on the EA for the Darlington refurbishment project and in response to the Fukushima accident.

In June 2014, the draft study was released for public consultation and presented to the Commission. The CNSC addressed and incorporated Commission feedback and comments from more than 500 submissions from the public, government and other organizations. Certain study assumptions and language were clarified, and information was added on a number of topics such as reactor behaviour, emergency response decisions, risk acceptability, and comparisons to effects from the Fukushima accident. In some cases, dose and risk results were updated, using a statistical approach more consistent with how dose modelling would be done in an actual emergency. These changes did not alter the conclusions of the report.

A subsequent update was presented to the Commission and published on the CNSC website in September 2015. See subsection 15(b) for details.

In 2015, a new interactive online module was launched on the CNSC website highlighting the most significant post-Fukushima safety improvements in Canada.

Open and transparent processes

In keeping with federal policies on public consultation and regulatory fairness, the legislative and regulatory framework for nuclear regulation is open and transparent. The CNSC is fully committed to maximizing the openness and transparency of its affairs and the undertakings of the Commission.

The CNSC takes all stakeholder feedback into account when finalizing its regulatory approach. In cases where diverse viewpoints are presented to the CNSC, additional consultations or meetings may be used to explore the issue. However, in all cases, the CNSC sets requirements in accordance with the best available science and other information, to deliver on its mandate.

Before the Commission makes decisions about whether to license nuclear-related activities, it considers applicants' proposals, recommendations from CNSC staff and stakeholder views. Each decision to license is based on information demonstrating that the activity or the operation of a given facility can be carried out safely and that the environment will be protected. To promote openness and transparency, the Commission conducts its business where possible in public hearings and meetings and, where appropriate, in the communities where activities arise. Members of the public can participate in hearings via written submissions and oral presentations. Commission hearings and meetings can also be viewed online as webcasts on the CNSC website, and transcripts of public hearings and meetings are also made available.

During the reporting period, public hearings associated with the licence renewal of the Pickering, Darlington and Bruce A and B NPPs were held in the respective host communities. Public participation for these hearings was promoted through advertising in local community newspapers, notices sent to CNSC email subscribers, and through the CNSC's Facebook, Twitter and YouTube channels. CNSC information sessions were also held in the communities well in advance of the hearings. The Commission considered more than 560 public submissions during these hearings.

In anticipation of refurbishment at Bruce A and B and Darlington, the CNSC launched two communications products in early 2015 to help explain how it regulates during these significant undertakings. One was a new online interactive module on refurbishing a virtual NPP; the other

was a video giving an explanation of the role of the regulator in the refurbishment of NPPs in Canada.

The CNSC's commitment to effective and well-managed Aboriginal consultation processes is guided by *Aboriginal Consultation and Accommodation – Updated Guidelines for Federal Officials to Fulfill the Duty to Consult – March 2011*. The CNSC's *Codification of Current Practice: CNSC Commitment to Aboriginal Consultation* outlines the organization's approach to fulfilling its legal obligations as an agent of the Government of Canada and as a regulatory body for Aboriginal consultation on CNSC-regulated projects.

In February 2016, the CNSC published regulatory document REGDOC-3.2.2, *Aboriginal Engagement*, which sets out requirements and guidance for licensees whose proposed projects may raise the Crown's duty to consult Aboriginal peoples. The implementation of REGDOC-3.2.2 is expected to lead to more effective and efficient Aboriginal engagement practices, strengthen relationships with Aboriginal communities, assist the CNSC in meeting its duty to consult obligations, and reduce the risk of delays in the regulatory review processes.

To assist in its decision-making process, the CNSC offers a Participant Funding Program to give members of the public, Aboriginal groups and other stakeholders the opportunity to request funding to support their participation in and submissions to the CNSC's regulatory decision-making process. This allows eligible stakeholders to participate in aspects of EAs and licensing actions for major nuclear facilities. Funding may also be made available for other CNSC proceedings that are of significant interest to the public or to Aboriginal peoples. An independent Funding Review Committee, composed of three external members, reviews all funding applications and makes recommendations to the CNSC on potential funding recipients, individual amounts and deliverables. The CNSC approves the overall fund release. For the above-mentioned licence renewal hearings for Pickering, Darlington and Bruce A and B, \$198,000 in funding was provided to 23 recipients.

The CNSC also has significant opportunities for public involvement in its regulation making process (see subsection 7.2(i)(a)) and its regulatory document writing process (see subsection 7.2(i)(b)). The use of CNSC discussion papers and the analysis and publication of the feedback they generate have also enhanced the degree and interactive nature of engagement possible.

The CNSC takes every opportunity to encourage other national nuclear regulators and international organizations involved in nuclear safety to share information with the public.

8.1 (g) Collaborative approach to the resolution of safety issues

The Chief Nuclear Officers/CNSC Executive Forum provides an effective channel of high-level communication between the NPP licensees and the CNSC. The participants discuss strategic issues that involve both the licensees and the CNSC, thereby promoting a mutual understanding of and helping to focus action on various safety issues related to NPPs. It is used to identify strategic challenges and opportunities that may influence the Canadian nuclear power industry and the CNSC. The forum continued to evolve and help focus efforts to address various safety issues during the reporting period. Although the forum is not a mechanism for decision making, it has facilitated dialogue on the following:

- existing and emerging issues pertaining to the CNSC's mandate for health, safety, security and the environment

- new industry developments, major projects and planned (emergency) exercises
- respective focus areas and strategic plans and priorities where practical and appropriate
- IAEA missions and other third-party audits planned at Canadian NPPs, such as those conducted by the IPPAS, Operational Safety Review Team (OSART), etc., and their outcomes

The CNSC and the nuclear power industry created a strategic forum called the CANDU Industry Integration Team (CIIT) during the previous reporting period to discuss, on a quarterly basis, the progress in completing the CNSC Action Plan. During this reporting period, the CIIT transitioned to a working group where updates or further discussions on the status of actions derived from the CNSC Action Plan would be accomplished, as necessary.

The CNSC also participates, with industry members, in the standard-setting work of the CSA Group, as described in subsection 7.2(i)(b).

8.2 Status of the regulatory body

8.2 (a) Separation of the CNSC and organizations that promote and utilize nuclear energy

The passage of the NSCA created distinct, enabling legislation for the regulation of nuclear activities and the separation of functions of the regulatory body from organizations that promote or use nuclear energy. The mandate of the CNSC (see subsection 7.1(a)) focuses clearly on the health, safety and security of persons, the preservation of national security and the protection of the environment, and the implementation of Canada's international obligations. The mandate does not extend to economic matters (such as the promotion of nuclear power).

The Commission (described in subsection 7.1(a)) is defined as a court of record in the NSCA, which allows it to conduct its matters in an independent manner. Commission members are subject to guidelines on conflict of interest and ethics that assure separation between them and the various stakeholders. Commission members hold office "during good behaviour" rather than being appointed "at pleasure." This means they can only be removed for cause (such as fraud). No member of the Commission has ever been removed for cause.

The Commission's decisions are not subject to review by any minister or other parts of the government executive. The NSCA provides that only the Governor in Council may issue directives to the Commission and these must be broad and not directed at any particular licensee. In addition, such an order would be published in the *Canada Gazette* and laid before each House of Parliament. An example is the *Directive to the Canadian Nuclear Safety Commission Regarding the Health of Canadians*, which is described in subsection 8.2(b).

To safeguard the integrity of the Commission's role as an independent decision maker, contact between the Commission and CNSC staff occurs through the Secretariat. With the exception of the Secretariat and the President, CNSC staff members have limited interaction with the Commission.

The CNSC, as an organization, is also independent of other organizations in the government, as described in subsection 8.1(a). As stated there, the CNSC does not report to a minister, but rather to Parliament through the Minister of Natural Resources.

8.2 (b) Other mechanisms that facilitate regulatory independence

The CNSC fosters open interaction and communication with its stakeholders, thereby continuously gathering input from all parties with an interest in Canada's nuclear industry. Transparent regulatory processes make the consideration of that input more systematic and fair (see subsection 8.1(f) for more information). These provisions help prevent undue influence from any one party or concern. Other mechanisms that help maintain the independence of the CNSC include a risk-informed framework for decision making as well as a strong framework for ethical and responsible action.

Guidance and structure for decision making

Nuclear regulatory independence is facilitated by a strong framework for decision making that is aligned with the CNSC's mandate and based on a rational, balanced consideration of risk.

For important decisions involving different types of risks, general guidance was provided to the CNSC in 2007 through the *Directive to the Canadian Nuclear Safety Commission Regarding the Health of Canadians*, which states the following:

In regulating the production, possession and use of nuclear substances in order to prevent unreasonable risk to the health of persons, the Canadian Nuclear Safety Commission shall take into account the health of Canadians who, for medical purposes, depend on nuclear substances produced by nuclear reactors.

The explanatory notes of the directive indicated that it is necessary to protect the health of Canadians if a serious shortage of medical isotopes in Canada and around the world puts the health of Canadians at risk.

The CNSC also has a formalized process in which risk is considered systematically. The use of risk-informed decision making was described in detail in the sixth Canadian report.

Office of Audit and Ethics

The Office of Audit and Ethics administers three ethics-related programs. The Values and Ethics Program provides employees with guidance and techniques for strengthening relationships in the workplace and with stakeholders, as well as practical tools for ethical decision-making. The Internal Disclosure Program is designed to help employees safely and constructively disclose wrongdoing and to protect them from reprisal. The Conflict of Interest and Post-employment Program gives CNSC employees tools to prevent and avoid situations that could create the appearance of conflicts of interest or result in potential or actual conflict of interest.

In 2014, the CNSC conducted a benchmarking exercise to compare the implementation of these programs with similar programs found in 17 other federal departments and agencies. The CNSC has implemented the recommendations coming out of the post-exercise report.

In addition, beginning in 2016, the Office of Audit and Ethics will manage complaints made by external entities to the CNSC to ensure a neutral body is overseeing the investigation and resolution processes.

Article 9 – Responsibility of the licence holder

Each Contracting Party shall ensure that prime responsibility for the safety of a nuclear installation rests with the holder of the relevant licence and shall take the appropriate steps to ensure that each such licence holder meets its responsibility.

9 (a) Legislation assigning responsibility to the licence holder

Paragraph 26(e) of the NSCA prohibits any person from preparing a site, constructing, operating, modifying, decommissioning or abandoning a nuclear facility without a licence granted by the Commission. As stated in subarticle 7.2(ii), the Commission can only issue licences only to applicants that are qualified to operate the NPP and that will adequately provide for the health and safety of persons and the protection of the environment.

Subsection 12(1) of the *General Nuclear Safety and Control Regulations* assigns various responsibilities to the licensees related to nuclear safety. Paragraph 12(1)(c) requires the licensee to take all reasonable precautions to protect the environment and the health and safety of persons and to maintain the security of nuclear facilities and of nuclear substances. Other paragraphs assign responsibility to the licensee to:

- provide and adequately train a sufficient number of qualified workers
- provide and maintain the required devices
- require that all people on site properly use equipment, devices, clothing and procedures
- take all reasonable precautions to control the release of nuclear or hazardous substances to the environment
- take measures to instruct its staff on security provisions and to alert itself in the event of illegal activities or sabotage

9 (b) Means by which licence holders discharge safety responsibility

For the most part, Canada has a relatively non-prescriptive nuclear regulatory regime for NPPs that sets general requirements and performance standards, thereby allowing the licensees some flexibility to meet them in a manner that best meets their needs. The licensees are responsible for addressing the requirements in their systems, programs, processes and designs. Descriptions of these provisions are submitted to the CNSC at the time of licence application (see appendix C). If accepted by the CNSC, these provisions become part of the licensing basis for the NPP (defined in subsection 7.2(ii)(a)) and dictate future regulatory activities.

Licensees must demonstrate that NPP operations satisfy performance standards and that the NPP continues to meet applicable criteria throughout its licence period and the designated operating life.

During operations, licensees fulfill their responsibilities through the following activities that are described elsewhere in this report:

- complying with the regulatory requirements set out in applicable laws and regulations
- operating in accordance with the licensing basis (see article 19)
- defining and following operating policies and principles (OP&Ps; see “Specific organizational provisions” below)

- defining safe operating limits and working within them (see subarticle 19(ii))
- developing safety policies and an organizational culture committed to ensuring safe NPP operation (see article 10)
- monitoring both employee and facility performance to ensure expectations are met (see subsection 14(ii)(a) and subarticle 19(vii))
- ensuring adequate financial resources are available to support the safety of each NPP throughout its life (see subarticle 11.1)
- ensuring adequate qualified resources are always available to respond to planned activities and contingencies (see subsection 11.2(b))
- implementing managed systems to control risks associated with NPP operations to govern the above activities (see article 13)

As explained in subsection 13(a), all licensees implement and maintain a management system. An NPP management system is expected to establish safety as the paramount objective, foster the safe operation of the NPP during all phases of its life-cycle, and implement practices that contribute to excellence in worker performance. Licensees have various provisions that help ensure safe operation, such as ensuring worker competence, sharing and using operating experience, verifying the correctness of work, identifying and resolving problems and controlling changes. The licensees' processes also require independent assessments to confirm the effectiveness of the management systems in achieving the expected results. These measures help ensure that the licensees' responsibility to safety is fulfilled.

Each licensee structures its organization so that the safety of the nuclear facilities under its responsibility is optimized. Each licensee has appointed a key management leader who is responsible for the operation and safety of the NPP. These nuclear executives or nuclear officers participate in the Chief Nuclear Officers Forum (see subsection 9(c)).

Specific organizational provisions

Many of the specific provisions used by each licensee to discharge its responsibility for safety are described in its OP&P document. This document is submitted in support of a licence application and is enforceable as part of the licensing basis of the NPP. The OP&P document provides direction for operating the NPP safely and reflects the safety analysis submitted to the CNSC as part of the licence application. For each NPP, the OP&P document explains, at a high level, how licensees operate, maintain and modify systems to maximize nuclear safety and keep consequential public risk acceptably low. (More detailed information on this area is contained within the management system documentation of the NPP.) Each licensee is required to define the bounds and limits for safe operation that are derived from the safety analysis that is also part of the facility's licensing basis. Operation in states not considered in or bounded by the safety analysis is not permitted.

9 (c) Other mechanisms that facilitate the licence holder's execution of responsibility

Peer and other reviews

The licensees host independent reviews that help confirm that their responsibilities for safety are being met. For example, the NPP licensees are members of the World Association of Nuclear Operators (WANO) and host WANO reviews on a regular basis (see subsection 14(i)(e)). As

another example, Bruce Power, OPG and NB Power initiate regular, independent, external nuclear safety assessments through a Nuclear Safety Review Board (NSRB) to provide assurance that the requirements of their respective nuclear safety policies and nuclear management systems are being fulfilled. The NSRB is a team of external industry experts that performs annual assessments (typically one week in duration) of NPP activities that might affect nuclear safety and performance. It reports directly to the Chief Nuclear Officer.

An IAEA OSART mission was conducted at the Bruce B facility during 2015 (see subsection 14(i)(e)). Canada has invited the IAEA to conduct OSART missions at several Canadian facilities over the next few years.

Collective measures

Although the regulatory framework and licensee governance are in place to ensure each licensee fulfills its responsibility to safety, the licensees in Canada also act collectively to help fulfill that responsibility. The purpose of this collective effort is to pool understanding and expertise (when appropriate), coordinate and prioritize the resolution of issues and improvement initiatives and enhance overall adherence to regulatory requirements.

In addition to membership in WANO and the CSA Group, all NPP licensees in Canada and Canadian Nuclear Laboratories (CNL) are members of the CANDU Owners Group (COG): a not-for-profit organization dedicated to providing programs for cooperation, mutual assistance and exchange of information for the successful support, development, operation, maintenance and economics of CANDU technology. COG has provided the mechanism for many projects to improve the safety of CANDU reactors, several of which are described throughout this report. In addition to its R&D program (described in appendix E.2), COG facilitates the execution of licensee responsibility by:

- sharing operating experience and providing support to resolve technical and operating problems for all COG members
- initiating and managing jointly funded projects and services
- adopting common strategies and plans for the resolution of regulatory issues related to nuclear safety
- sharing best practices, delivering jointly developed training programs and developing knowledge-retention tools such as the CANDU textbook (described in subsection 11.2(b))

In addition to ongoing COG programs, the members form working groups to address specific issues that arise.

The Chief Nuclear Officers Forum, which includes senior representatives from all licensees and CNL, facilitates a coordinated approach to resolving significant technical and regulatory issues. It provides high-level direction to, and oversight of, the work done by functional groups to better understand and resolve safety issues. The benefits include consistency of licensing positions, alignment of strategic directions and pooling of resources. COG facilitates the meetings of the Chief Nuclear Officers Forum, which helps ensure the alignment of the high-level direction with ongoing COG programs and projects.

The chief nuclear officers also engage in high-level communications with CNSC executives (see subsection 8.1(g)).

In addition, Chief Executive Officers from more than 30 companies in the Canadian nuclear industry created in 2012 the Nuclear Leadership Forum, which examines the strengths, challenges and prospects in Canada for the complete nuclear cycle (e.g., uranium mining and milling, fuel fabrication, nuclear power, nuclear medicine, suppliers).

Proactive disclosure and public communications

CNSC regulatory document RD/GD-99.3, *Public Information and Disclosure*, requires all major licensees, including NPPs, to maintain active public information and disclosure programs. Programs must be supported by robust disclosure protocols regarding events and developments involving their facilities or activities. Program requirements are derived from the objectives of the Commission in the NSCA and paragraph 3(j) of the *Class I Nuclear Facilities Regulations*, which requires licensees “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.”

The public disclosure protocols must describe the type of information or reports to be made public, the criteria for determining when such information and reports are to be published and the medium of disclosure. To define what information and reports are of interest to the different audiences, the licensees and applicants must consult with stakeholders and interest groups. The protocols must be posted on the Internet and any revisions sent to the CNSC.

The elements of the licensees’ public information and disclosure program, along with specific examples of NPP licensee outreach activities conducted during the reporting period are, provided in annex 9(c).

9 (d) CNSC verification and oversight of licensees’ responsibilities

To assure compliance of the licensees with the various regulatory requirements, the CNSC:

- sets and documents clear requirements using a process that includes consultation
- cooperates with other organizations and jurisdictions to foster the development of consistent regulatory requirements
- indicates acceptable ways to meet regulatory requirements, but allows licensees to propose alternative methods that take into account risk and cost-benefit
- promotes compliance with regulatory expectations
- verifies that processes and programs satisfy regulatory requirements
- enforces requirements using an escalating, consistent regulatory approach based on the level of risk
- uses appropriate industry, national, international or other standards

These regulatory activities are described in more detail in subarticle 7.2, covering all operational states, including accidents.

The licensing basis for each NPP is established through the process to renew each licence to operate, reaffirming the responsibility of the licensees. Licensees implement new regulatory documents and standards, on a regular basis, both at licence renewal and during the licence period.

The licensing basis dictates CNSC regulatory activities during the licence period, such as inspections and change approvals. Between licence renewals, the CNSC compliance program

ensures that licensees meet their defined responsibilities. The CNSC maintains trained, experienced inspectors at all NPP sites with operating reactors on a permanent basis. They provide a high degree of day-to-day interaction with the licensees and scrutiny of their activities (see subsection 8.1(b) for more details).

Reporting requirements are an important aspect of the CNSC's assurance that licensees continue to meet their responsibilities. Operating licences refer to CNSC regulatory document REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*, which establishes reporting requirements for safety-significant developments and non-compliances with legal requirements (see subsection 7.2(iii)(b)).

The transparency of the Canadian nuclear regulatory framework and the licensing process also helps ensure that the licensees' execution of their responsibility to safety is apparent to all stakeholders.

9 (e) Summary of fulfillment of safety responsibilities during reporting period

During the reporting period, NPP licensees fulfilled the fundamental responsibilities for safety as required by the NSCA and its regulations. The licensees' fulfillment of this responsibility was manifested by the strong safety record of the Canadian NPPs during the reporting period, as described throughout this report. The use of regulatory enforcement action such as orders, licensing action or prosecution (as described in subarticle 7.2(iv)) by the CNSC was not required to resolve safety-related issues at Canadian NPPs. The CNSC's regulatory activities involving promotion and verification of compliance were sufficient to address and resolve safety-related issues and the regulatory tools were adequate to maximize conformance with regulatory requirements by all NPP licensees.

Immediately after the Fukushima accident, each NPP licensee commenced a thorough review of the lessons learned and, during the reporting period, completed the improvements to address these lessons learned.

The licensees further fulfilled their responsibility to safety during the reporting period by executing numerous improvements to safety. Since original construction, the NPP licensees in Canada have made many safety improvements based on CNSC requirements, industry research, national and international operational experience, and heightened public expectations.

Chapter III – Compliance with Articles of the Convention (continued)

Part C General Safety Considerations

Part C of chapter III consists of seven articles:

- Article 10 – Priority to safety
- Article 11 – Financial and human resources
- Article 12 – Human factors
- Article 13 – Quality assurance
- Article 14 – Assessment and verification of safety
- Article 15 – Radiation protection
- Article 16 – Emergency preparedness

Article 10 – Priority to safety

Each Contracting Party shall take the appropriate steps to ensure that all organizations engaged in activities directly related to nuclear installations shall establish policies that give due priority to nuclear safety.

The collective priority to safety by organizations engaged in activities related to nuclear facilities is, in part, demonstrated by the commitment to peer review and continuous improvement. For example, the Canadian NPP licensees regularly participate in World Association of Nuclear Operators (WANO) assessments (see subsection 14(i)(e)). The licensees also demonstrate an ongoing commitment to safety through their sponsorship of, and involvement in, safety-related research and development activities (see appendix E for details). The CNSC has demonstrated a commitment to peer review and improvement, including the hosting of Integrated Regulatory Review Service (IRRS) missions (see the sixth Canadian report). In addition, the CNSC has an active research program that focuses on regulatory issues (see subarticle 8.1).

10 (a) Establishment of policies and supporting processes for NPPs that give due priority to safety

To make safety an overriding priority, the executive and management of an organization must state and demonstrate safety as a core value. Its management system must consistently uphold and restate this priority at all levels of the management structure. The management system (see article 13) provides assurance that policies, principles and high-level safety requirements are adequately carried through to licensee activities.

All NPP licensees have established policies that give due priority to nuclear safety. All licensees have also embedded in their management systems the principle that “safety is the paramount consideration, guiding decisions and actions”. The implementation of the principles found in these policies differs by licensee, as described in annex 10(a).

NPP licensees’ management system processes ensure that conditions adverse to safety are systematically evaluated and resolved. Corrective action programs are formalized to ensure issues affecting safety are addressed properly and promptly. These processes continue to mature each time they are used and the lessons learned are shared with the other licensees.

Operability evaluations are completed when the ability of systems and components to carry out their safety-related function is uncertain. Decision-making processes are used to resolve significant problems that require prompt, coordinated response to indeterminate or known degraded conditions that affect safety. Other practices, such as management presence in the field and oversight committees, also help maintain the priority on safety.

CSA standard N286-12, *Management System Requirements for Nuclear Facilities*, has been implemented, or is being implemented by the NPP licensees (see subsection 13(a) for details). This standard builds upon the principal that safety is the paramount consideration guiding decisions and actions by including a requirement on safety culture that states:

Management shall use the management system to understand and promote a safety culture by:

- (a) issuing a statement committing workers to adhere to the management system;
- (b) defining and implementing practices that contribute to excellence in worker performance;
- (c) providing the means by which the business supports workers in carrying out their tasks safely and successfully, by taking into account the interactions between individuals, technology, and the organization; and
- (d) monitoring to understand and improve the culture.

10 (b) Safety culture at NPPs

General approach

The safety culture at Canadian NPPs is based on a collective belief among all employees and management that safety is the first priority when making decisions and performing work. This is accomplished by considering risks and maintaining adequate safety margins, maintaining respect and a sense of responsibility for the reactor core and reactor safety and confirming that a task can be performed safely before executing it. The foundation of safety culture is further established by constantly examining nuclear safety, cultivating a “what if?” approach to safety planning and preparation, embracing organizational learning, and promoting a “just culture” that aims to learn as much as possible from events or near misses without removing the possibility of holding persons responsible for their actions.

Clear lines of authority and communication are established, so that individuals throughout the organization are aware of their responsibilities toward nuclear safety. Senior management is ultimately responsible for the safety of the NPP and is, therefore, expected to develop processes to encourage and track the effectiveness of safety programs and to demonstrate through action that safety is of overriding concern. Supervisors’ behaviour must also show that they expect their workers to follow safety processes while, at the same time, encouraging a questioning attitude. At the individual level, the emphasis is on personal dedication and accountability for each individual engaged in an activity that affects the safety of the NPP. All employees are expected to be aware of and adhere to all procedures. This assures that rules, policies and regulations related to reactor safety, radiation safety, environmental protection, industrial safety, security, fire protection and other relevant areas addressed in the procedures are followed. These expectations are promoted through training and leading by example; monitored through field observations, oversight committees and self-assessments; and assured by means of coaching and mechanisms to encourage problem identification and effective corrective action.

Safety culture self-assessments

NPP licensees conduct safety culture self-assessments, conduct follow-ups to assess safety culture issues, develop appropriate corrective actions and complete post-assessments.

The benefits of a safety culture assessment are the learning and improvement opportunities created. However, in a safety culture self-assessment there is the potential for licensees to overlook key topics or circumstances due to complacency and over-familiarity with internal ways of conducting business. As such, the industry has taken several approaches to try to overcome the potential for “organizational blindness,” including:

- the development of common safety culture assessment guidance and information exchange among Canadian NPP licensees through the COG Human Performance Working Group
- the implementation of safety culture monitoring processes between safety culture assessments to identify possible, subtle changes in safety culture
- the inclusion of safety culture as part of regular, third-party assessments by other industry organizations

The licensees use guidance from WANO, the Institute of Nuclear Power Operations (INPO) and the Nuclear Energy Institute as their primary source of self-assessment requirements.

The nuclear safety culture monitoring panel (NSCMP) process discussed in the sixth Canadian report is now fully established for all NPP licensees. The panels monitor process inputs that are indicative of the health of the organization’s nuclear safety culture (internal events, trends, and organizational changes), and identify areas of strengths and potential concern that merit additional attention by the organization. They also monitor the actions from safety culture assessments on a periodic basis. Executive management considers the insights produced by the NSCMP process.

The results of safety culture self-assessments and other safety culture activities during the reporting period are summarized here for Canadian NPP licensees.

Ontario Power Generation

OPG conducts a comprehensive nuclear safety culture self-assessment once every three years at each of its NPPs. The assessment has two phases: a detailed safety culture survey that is sent to all employees and resident contractors; and an onsite assessment by an assessment team involving interviews, focus groups, document review and observations. The assessment focuses on perceptions, attitudes and behaviours of the organization.

The assessment process continues to be refined based on the lessons learned from each preceding assessment. Enhancements to both the staff survey tool and the onsite assessment process have been made to facilitate the collection and consistency of assessment inputs, and to allow OPG to benchmark its results with other utilities that use the INPO safety culture survey.

OPG completed nuclear safety culture assessments at both Darlington and Pickering in 2015. Overall, the assessments determined that each NPP has a healthy nuclear safety culture and respect for nuclear safety and that nuclear safety is not compromised by production priorities. Personnel feel they can challenge any decision if needed without fear of professional or personal implications. OPG also identified a strength in the way both NPPs foster an environment in which employees feel comfortable raising safety concerns.

At Pickering, one focus area was noted in reducing maintenance backlogs and addressing some equipment issues. Both these issues are receiving focus as part of the NPP and fleet improvement programs.

At Darlington, one focus area has been to continue to strengthen the interface between the staff of the NPP, projects and contract partners. As the NPP is beginning a large-scale refurbishment project, the organization has recognized the need to foster strong relationships and a healthy nuclear safety culture with all organizations involved. To this end, OPG carried out in April 2016 (after the reporting period) a first-of-a-kind comprehensive nuclear safety culture assessment within the nuclear projects area and involving all of its major contract partners.

Hydro-Québec

The most recent self-assessment at Gentilly-2 was an evaluation by peers in 2012. See the sixth Canadian report for details.

Bruce Power

A nuclear safety culture self-assessment was performed at Bruce Power in 2013, covering Bruce A, Bruce B and the licensee's corporate functions. An electronic survey was delivered to all staff and interviews and focus groups were held.

The purpose of the self-assessment was to gather a wide input of people's perceptions about safety. This type of assessment cannot rate safety performance in absolute terms, but instead is designed to provide an overview of people's concerns, behaviour patterns and other insights to help management improve the safety culture.

Some of the assessment areas that received the most positive ratings were:

- employees' comfort in raising concerns and ability to recognize unusual conditions and stop in the face of uncertainty
- employees' strong sense of ownership of their work
- how training reinforces safe behaviours and establishes high expectations
- senior leadership's frequent communications on the importance of nuclear safety
- the respect given to the roles of the regulators

Among the most frequently raised issues were:

- employees concerns about equipment reliability (although employees have faith that nuclear safety is not being jeopardized)
- the lack of awareness of the value of the corrective action program, including effectiveness, trends and actions taken on issues raised
- management communications to staff
- the need to ensure nuclear knowledge and experience is maintained

After evaluating the results of the nuclear safety culture self-assessment, Bruce Power decided to concentrate on three main new focus areas to address the findings related to:

- management communications to staff
- the lack of awareness of the value of the corrective action plan
- the employees' concern about equipment reliability

NB Power

NB Power conducted a comprehensive nuclear safety culture self-assessment in November 2014. The assessment was carried out in two parts: a survey of NB Power employees; and an interview process to validate the survey responses and gain additional insights. The assessment is required

at a minimum every three years per the licensee's process documentation; however, a two-year cycle is currently being used with a brief employee "pulse" survey being deployed in the years between full assessments.

The 2014 assessment revealed there is a healthy nuclear safety culture that values nuclear safety over other competing priorities such as production. NB Power utilizes 10 nuclear safety culture "action statements" derived from the INPO document, *Traits of a Healthy Nuclear Safety Culture*. The action statements provide information on what the traits mean to all employees at NB Power.

The 2014 assessment results showed significant improvements in all 10 action statements in comparison to the 2011 assessment. Although nuclear safety culture cannot be measured by statistical data alone, the assessment noted, an overall 10 percent improvement in the action statements. The improvement was driven by:

- the strong level of support for the direction set out in the *Navigating for Excellence Plan*, which identifies the goals, objectives and strategies for the NPP
- employees' level of pride in moving forward toward industry excellence
- a sense of togetherness (as indicated by the phrase: "One Team, One Plan")
- the performance metrics in place to track progress and motivate the workforce

Some of the assessment areas that were identified as focus areas included:

- equipment reliability
- leadership commitment to deliver key messages face to face
- investing in developing NPP licensee staff

Actions taken by NB Power to address the focus areas include:

- scheduling WANO technical support missions for the areas of leadership and equipment reliability
- scheduling an equipment reliability process implementation strategy
- producing a plan for developing staff through training and seminars, formalizing a leadership training and development program, and enhancing the performance management programs

NB Power completed a pulse survey in December 2015 and plans to conduct another safety culture assessment in 2016.

SNC-Lavalin Nuclear

SNC-Lavalin Nuclear has made safety both in the workplace and within technical activities a key commitment at all levels of the organization. In 2015, the two organizations comprising SNC-Lavalin Nuclear (Candu Energy Inc. and SNC-Lavalin Nuclear Inc.) joined INPO as supplier members. This membership enables SNC-Lavalin Nuclear to incorporate many of the INPO principles, including the Principles for Excellence in Nuclear Supplier performance, in its business approach. These INPO principles are important elements of the SNC-Lavalin Nuclear safety culture.

10 (c) CNSC framework for assessing safety culture at NPPs

As stated in CNSC discussion paper DIS-12-07, *Safety Culture for Nuclear Licensees*, the CNSC defines safety culture as:

the characteristics of the work environment, such as the values, rules and common understandings that influence employees' perceptions and attitudes about the importance that the organization places on safety.

This definition includes the degree to which a critical, questioning attitude exists that is directed toward facility improvement. The CNSC maintains regulatory oversight of the organizational processes (such as roles and responsibilities, communications and training) that influence safety performance at Canadian nuclear facilities in order to determine whether the licensees possess the characteristics of safety culture that support the safe conduct of nuclear activities. (See article 12 for more discussion on human factors technical review areas.) The CNSC evaluates the NPP licensees according to the following characteristics:

- Safety is a clearly recognized value in the organization.
- Accountability for safety in the organization is clear.
- Safety is integrated into all activities in the organization.
- A safety leadership process exists in the organization.
- Safety culture is learning-driven in the organization.

Safety performance can be influenced by the ways in which responsibilities are assigned within the organization, from the senior management team to the personnel in the field where operational activities are carried out. It can also be influenced by the ways in which organizational changes are made and communicated to staff, and by the effectiveness of its training programs.

When reviewing NPP management systems, the CNSC pays particular attention to the way nuclear, radiological and conventional safety; environmental protection; and the security of the facility are all managed and integrated within the general management system. Canadian management system requirements introduce the promotion of safety culture (as discussed in subsection 10(a)) and include several measures related to organizational changes.

CNSC staff members use an organization and management review method to evaluate organizational influences on licensees' safety performance. The review method is a long-established, objective and systematic approach that has been used extensively to conduct baseline assessments of all operating NPPs in Canada. The review method uses a multi-trait, multi-method approach to determine the presence or absence of the organizational processes (or behaviours) that are important to safety. There are 17 behaviours that can be measured. Multiple data collection methods are used (e.g., surveys, interviews, work task observations) to measure each process. The results are then used to determine whether the licensee's organization possesses the characteristics of a culture where safety is its most important focus.

CNSC staff members review events related to personnel safety and security against expected organizational behaviours to observe emerging trends in the licensee's safety culture.

CNSC staff members also check for other indicators of a healthy safety culture at NPPs, such as whether:

- documentation exists that describes the importance and role of safety in the operation of organization, such as a safety management program

- good housekeeping, material condition and working conditions are maintained
- the use of continuous self-assessment is evident

Organizational performance is monitored and assessed through a number of activities, such as desktop reviews, regulatory inspections and the review of licensee self-assessments.

CNSC staff members examine the self-assessment approach proposed by each licensee and review licensees' plans to conduct specific assessments. They also provide licensees with feedback on planned corrective actions that may arise from licensees' self-assessments, and examine how licensees evaluate security culture in the context of safety culture.

Safety culture draft regulatory document

The CNSC is developing a regulatory document on safety culture, based on the feedback received from its 2012 discussion paper DIS-12-07, *Safety Culture for Nuclear Licensees*. The regulatory document is anticipated to:

- formalize the CNSC's commitment to promoting a healthy safety culture in the nuclear industry by providing a clear definition and describing the characteristics of a healthy safety culture, ensuring a shared understanding of these concepts between the CNSC and its stakeholders
- formalize requirements and expectations for licensees regarding safety culture at NPPs
- clarify and implement the CNSC's oversight role and strategy to verify that NPP licensees are conducting and implementing appropriate safety culture self-assessments and that corrective actions arising from these assessments are effectively implemented

10 (d) Priority to safety at the CNSC

The CNSC makes nuclear safety the priority in all of its activities. The CNSC *Management System Manual* (see subsection 8.2(d)) has clear statements on the consideration of safety in every decision made by the CNSC and on the expectation of a strong culture of safety where organizational and individual behaviour continuously demonstrate this consideration. In support of this, all regulatory processes within the CNSC management system are developed respecting the CNSC's focus on the safety of staff (both its own and the licensees'), the environment and the Canadian public.

The regulatory independence of the CNSC (as described in subarticle 8.2) helps CNSC staff members maintain their focus on nuclear safety while addressing all organizational priorities.

During the reporting period, an internal safety culture working group facilitated a series of town hall sessions within the CNSC to showcase the mechanisms and commitments being used to address recent survey results and the attributes of being a world-class regulator.

Article 11 – Financial and human resources

1. Each Contracting Party shall take the appropriate steps to ensure that adequate financial resources are available to support the safety of each nuclear installation throughout its life.
2. Each Contracting Party shall take the appropriate steps to ensure that sufficient numbers of qualified staff with appropriate education, training and retraining are available for all safety-related activities in or for each nuclear installation, throughout its life.

11.1 Adequacy of financial resources

Each NPP licensee in Canada has the prime responsibility for the safety of its facility per article 9 of the CNS. This responsibility includes providing adequate financial resources to support the safety of each NPP throughout its life.

Paragraph 3(1)(l) of the *General Nuclear Safety and Control Regulations* requires all licence applicants to provide a description of any proposed financial guarantee relating to the activity to be licensed. In addition, NPP licensees in Canada are required by licence conditions, imposed pursuant to a specific reference in subsection 24(5) of the NSCA, to provide financial guarantees acceptable to the CNSC for the costs of decommissioning NPPs.

11.1 (a) Financing of operations and safety improvements made to nuclear power plants during their operating life

Canadian NPP licensees maintain budgets for operation, maintenance and capital improvements. For large-scale improvements, an item is costed for financing over the estimated remaining effective lifetime of the NPP. Expenditures are dictated by the licensee's financial position, current and planned performance, service obligations (electrical load forecast) and financial and business strategies. These inputs are used to develop the envelopes for ongoing operating expenditures and capital investments.

Canadian NPP licensees place a high priority on safety-related programs and projects. This ensures adequate financial resources will be applied to safety improvement programs and projects throughout the life of each NPP.

11.1 (b) Financial resources for decommissioning

Canada's four NPP licensees have opted for different methods of supplying decommissioning financial guarantees, as allowed by CNSC regulatory guide G-206, *Financial Guarantees for the Decommissioning of Licensed Activities*. In each case, the financial guarantee arrangements include legal agreements that grant the CNSC access to the guaranteed funds in the event of default by the licensee. The licensees maintain preliminary decommissioning plans, cost estimates and financial guarantees and report periodically to the CNSC that the estimates and plans remain valid, in effect and sufficient to meet the decommissioning needs. The preliminary decommissioning plans and financial guarantees are kept up to date in response to events such as changes to NPP operating plans, changes in financial conditions and the development of plans

for the long-term management of spent fuel under the *Nuclear Fuel Waste Act*. The financial guarantees encompass not only the operation of the NPP but also the safe storage of nuclear waste and spent fuel produced by the plant. Therefore, the financial guarantees are significant. NPP licensees submit to the Commission annual reports on the status of their financial guarantees and CNSC staff members review the financial guarantees plan for each NPP licensee every five years.

Acceptable financial guarantees include cash, letters of credit, surety bonds, insurance and legally binding commitments from a government (either federal or provincial). The acceptability of the guarantees is assessed by the CNSC according to the following general criteria:

- **Liquidity:** The proposed funding measures should be such that the financial vehicle can be drawn upon only with the approval of the CNSC and that payout for decommissioning purposes is not prevented, unduly delayed or compromised for any reason.
- **Certainty of value:** Licensees should select funding, security instruments and arrangements that provide full assurance of their value.
- **Adequacy of value:** Funding measures should be sufficient, at all or predetermined points in time, to fund the decommissioning plans for which they are intended.
- **Continuity:** The required funding measures for decommissioning should be maintained on a continuing basis. This may require periodic renewals, revisions and replacements of securities provided or issued for fixed terms. For example, during a licence renewal the preliminary decommissioning plan may be revised and the financial guarantee updated accordingly. Where necessary and in order to ensure that there is continuity of coverage, funding measures should include provisions for advance notice of termination or intent not to renew.

The decommissioning financial guarantees required from Hydro-Québec, NB Power and OPG cover the full breadth of decommissioning, including the initial steps to place the facilities in a safe storage state. Under the lease conditions of the Bruce site to Bruce Power, the owner (OPG) maintains the decommissioning financial guarantees for the Bruce reactors.

All licensees issue a preliminary decommissioning plan every five years. The preliminary decommissioning plan provides the long-term vision for the storage and surveillance period (approximately 30 years) prior to demolition and site restoration. In the preliminary decommissioning plan, the estimated costs associated with decommissioning are presented that support the decommissioning financial guarantees.

Further details on financial guarantees and decommissioning can be found in Canada's *National Report for the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*.

In addition to financial guarantees for decommissioning, the CNSC may also require financial guarantees for other costs where it considers that financial and safety risks warrant such a requirement.

Financing of the Pickering safe storage project

The financing of the placement of Pickering Units 2 and 3 into safe storage and the isolation of interfaces to the operating NPP was provided primarily from OPG's Nuclear Decommissioning Fund.

The project scope and cost estimate for the placement of Pickering Units 1, 4, 5, 6, 7 and 8 into safe storage at the end of their operating lives are in development. OPG is working on plans to transition the NPP into safe storage beginning in early 2023 with completion by approximately late 2027. Under these plans, partial shutdown would begin at the end of 2022, followed by full NPP shutdown at the end of 2024. Some preliminary plans for the activities associated with the transition of Pickering into safe storage were provided in the stabilization activity plan which was submitted to the CNSC in December 2015.

11.1 (c) Requirements under the Nuclear Liability Act and Nuclear Liability and Compensation Act

Canada's nuclear liability regime is currently under revision. In 2015, the Canadian Parliament passed the *Nuclear Liability and Compensation Act*. This new legislation will come into force on January 1, 2017, once the key regulations and financial security mechanisms are in place. It is intended to replace the current *Nuclear Liability Act*, providing a stronger legislative framework that will better address liability and compensation after a nuclear incident.

The civil liability regime provided by the *Nuclear Liability and Compensation Act* – like the current *Nuclear Liability Act* – establishes the absolute, exclusive and limited liability of the operator for civil damages. It is designed to provide certainty on the treatment of legal liability for nuclear damage resulting from a nuclear incident (including losses resulting from a preventive measure) and to provide prompt compensation with minimal litigation.

The *Nuclear Liability and Compensation Act* will include the following changes from the existing legislation:

- It increases the absolute liability limit of an NPP operator to \$1 billion from the \$75 million specified in the current legislation. The \$1 billion limit will apply in the fourth year, progressively increasing from \$650 million when the new legislation comes into force. Operators of nuclear installations other than NPPs will have lower liability limits, commensurate with their risk, as established in regulations.
- It expands the definition of compensable damage to include, in addition to bodily injury and property damage under the current legislation, some forms of psychological trauma, economic loss, losses resulting from preventive measures and environmental damage.
- It introduces a longer limitation period – 30 years from the current 10 years – for submitting compensation claims for bodily injury and loss of life. Through an indemnity agreement with operators, the Government of Canada will provide coverage for claims occurring between 10 and 30 years. The limitation period for other forms of damage will remain at 10 years as in the current legislation.
- Operators will be required to maintain financial security to cover their full liability limit. This financial security must be in the form of insurance obtained from an insurer approved by the Minister of Natural Resources. Subject to the approval of the Minister, operators will be permitted to cover up to 50 percent of their liability with alternate forms of financial security such as provincial government guarantees or letters of credit.
- It establishes a quasi-judicial claims tribunal to replace the courts if necessary, to accelerate claims payments and provide an efficient and equitable forum.

Once the *Nuclear Liability and Compensation Act* comes into force, Canada will be able to ratify the *Convention on Supplementary Compensation for Nuclear Damage*, which it signed in 2013.

11.2 Adequacy of human resources

Paragraph 12(1)(a) of the *General Nuclear Safety and Control Regulations* require licensees to “ensure the presence of a sufficient number of qualified workers to carry on the licensed activity safely and in accordance with the Act, the regulations made under the Act and the licence.”

Adequate human resources means the employment of enough qualified staff to carry out all normal activities and to respond to the most resource-intensive conditions under all operating states, including normal operations, anticipated operational occurrences, design-basis accidents, and emergencies.

As described in the following subsections, the licensees have extensive and effective programs related to training, staffing, examination, workforce capacity evaluation, hiring, knowledge retention and research and development (R&D). These programs, in conjunction with the above developments, have contributed to the effective management of human resources, in general, across the industry.

11.2 (a) Requirements and measures related to staffing levels, qualifications, training and certification of workers

Licensees are responsible for the safe operation of their respective NPPs. As such they are held fully responsible for both training and testing their workers to ensure they are fully qualified to perform the duties of their positions.

Licensee training programs

In August 2014, the CNSC published regulatory document REGDOC-2.2.2, *Personnel Training*, which sets out the requirements and guidance for the analysis, design, development, implementation, evaluation, documentation and management of training at nuclear facilities, including the principles and elements essential to an effective training system. NPP licensees are in the process of implementing the requirements of REGDOC-2.2.2.

Licensee training programs are established in accordance with the principles of the systematic approach to training, which ensures licensee staff members receive training pertinent to their positions. Departmental programs are routinely reviewed and training needs analytically identified to allow training courses to be revised or developed as necessary to guarantee that the training replicates the procedures and equipment used in the NPPs. Furthermore, training program evaluation processes and procedures are regularly applied to assess the effectiveness of the training programs. Licensees use objectives and criteria for accreditation of training programs (such as those developed by INPO). All key training performance areas are evaluated and assessed against these objectives quarterly. OPG, for example, uses them as the basis for a number of training performance indicators.

All NPP licensees have internal training programs that focus on training in CANDU technology and on the development of soft skills (such as behaviour competencies). Operations and maintenance training is provided to create and maintain job performance capability. This training normally includes classroom instruction, workshops, full-scope simulator exercises, on-the-job instruction, supervisory coaching and informal briefings. The majority of staff members are also trained to a radiation protection level that qualifies them to be responsible for their own protection and able to sponsor supplemental staff and provide radiation protection oversight. In

addition, SNC-Lavalin Nuclear provides internal training in CANDU technology as well as training in other nuclear technologies that support its products and services for NPPs.

A number of enhancements have been made to the training programs at Canadian NPPs during the reporting period. (OPG, for example, built a reactor mock-up at Darlington for training in preparation for refurbishment.) Annex 11.2(a) provides examples from Bruce Power, OPG and NB Power.

The CNSC regularly evaluates licensees' training programs for certified and non-certified staff. It also verifies that all workers, including temporary staff and contractors, are qualified and competent to perform the tasks assigned to them. Regulatory activities include the assessment of processes and procedures in the context of the systematic approach to training, review of training programs and onsite evaluation and inspections of the training program's products and material.

The number of staff working in the regulatory field is too small for a single Canadian NPP licensee to maintain and deliver an in-house training program on regulatory affairs. Therefore, an industry working group coordinates a joint regulatory affairs training program. It includes courses on the following topics, developed by individual licensees, the CNSC and CNL:

- NPP operating licences
- REGDOC-3.1.1, *Reporting Requirements for Operating Nuclear Power Plants*
- the NSCA and its regulations
- introduction to safety analysis
- regulatory issues management
- regulatory communications and technical writing
- International Nuclear Event Scale (INES) training

The use of supplemental staff is important to licensees' performance of critical work on safety and safety-related systems during maintenance outages. While supplemental workers are typically recruited to augment outages, they can also be involved in engineering or design work.

Training programs consider the requirements for supplemental personnel (e.g., electrical, hoisting and rigging, pressure boundary) as well as personnel performing a contract management role. The training programs consider previous training and experience through the use of standard task evaluations based on Electric Power Research Institute (EPRI) methodology or apprentice-related certificates of qualification. The training and qualification of supplemental workers ensures familiarity with nuclear-related practices such as human performance tools and corrective action programs. Specialized training is provided in areas such as environmental qualification, foreign material exclusion, respiratory protection, human performance and radiation protection, all of which include industry-related operating experience. The programs to assess the competencies of the supplemental staff include the evaluation of the knowledge and skills necessary to conduct specific work at the NPPs.

Qualification and numbers of workers

The CNSC defines and establishes regulatory requirements and criteria for the qualification, examination, and numbers of licensee personnel, including certified staff at NPPs.

Annex 11.2(a) provides specific details on the hierarchy of these requirements and guidance. Some of the more pertinent documents are discussed in detail in the following.

CNSC regulatory document RD-204, *Certification of Persons Working at Nuclear Power Plants*, sets the requirements for persons in certified positions at NPPs (the actual positions are described in annex 11.2 (a)). It also sets requirements for processes by which the licensees train and examine their candidates for certified positions. The NPP licensees independently administer the examinations of their candidates for certified positions. The CNSC provides oversight of the training and examination programs.

Minimum shift complement refers to the minimum number of workers with specific qualifications that must be present at the NPP at all times to carry out the licensed activity safely and in accordance with the NSCA, the regulations and the licence. It is specific to each nuclear facility due to factors such as plant design, organizational structure and procedures. It must be adequate to respond to the most resource-intensive conditions under all design-basis operating states, including normal operations, anticipated operational occurrences, design-basis accidents, and emergencies.

The CNSC guidance document G-323, *Ensuring the Presence of Sufficient Qualified Staff at Class I Nuclear Facilities – Minimum Staff Complement*, describes CNSC staff's expectations as they relate to the key factors that must be considered for ensuring the presence of a sufficient number of qualified staff at Class I nuclear facilities. G-323 also describes the expectation to ensure that at any given time, the minimum shift complement is present at the nuclear facility. Considerations include shift turn over, scheduling vacation and training and short term absences due to sick leave.

Licensees conduct a systematic analysis to determine the specific numbers and qualifications of staff required in the minimum shift complement. This analysis considers all work groups essential to ensuring the safe operation of the nuclear facility and adequate emergency response capability, such as certified and non-certified staff, maintenance, emergency response, and fuel handling. It also considers the response necessary to mitigate the consequence of all design-basis events including common mode events and multi-unit facilities. The adequacy of the minimum shift complement is demonstrated by an integrated validation exercise that is observed by CNSC staff. During the reporting period, OPG completed the document analysis and validation of minimum shift complement for its operating units at Pickering and Darlington. The remaining NPP licensees continued the systematic analysis and validation of the minimum shift complement requirements. This work is expected to be completed during the next reporting period.

As noted above, the minimum shift complement is in place to ensure safe operation during any design-basis condition. As part of the CNSC Action Plan, NPPs were required to evaluate existing emergency plans and take steps to enhance their emergency response capability to various conditions that extend beyond the previously postulated design-basis accidents (e.g., an extended loss of all AC power). Among other things, licensees were required to evaluate the roles and functions of staff that would be required beyond minimum shift complement. These roles and functions were tested in various emergency exercises which were also observed by CNSC staff.

The FAIs pertaining to the evaluation of plans and measures to enhance the emergency response capability were closed for all NPP licensees during the previous reporting period.

11.2 (b) Capability maintenance at NPP sites

The nuclear industry in Canada has robust workforce-development and worker-replacement programs in place to meet future needs. Changes in workforce demographics and anticipation of increasing industry human resources requirements (e.g., due to refurbishments and possible new construction that may compete for resources with other large energy-related projects) have led to initiatives in four related areas:

- workforce capability analyses
- hiring programs
- external training programs
- knowledge-retention programs

Workforce capability analyses

NPP licensees regularly conduct detailed workforce capability analyses to predict gaps between forecasted supply and planned resource levels in operator, maintenance and engineering job-families. These analyses focus on assessing critical gaps in skills that need to be retained, replaced and resourced. Training requirements are also identified. Annex 11.2(b) provides, as an example, a detailed description of the workforce planning process used by Bruce Power.

Succession-planning processes are also in place at the NPPs to predict, plan and prepare for the replacement of senior-level personnel. Leadership positions down to the level of department manager are identified and assessments of employee readiness to assume a position (from “ready now” to “ready in one to two years” to “ready in three to five years”) are conducted.

Development plans prepare potential candidates to assume critical positions as employees retire. To address anticipated readiness gaps at senior levels, OPG initiated a program to accelerate the development of high-potential engineers through focused development and targeted learning events.

SNC-Lavalin Nuclear addresses this issue through a comprehensive resource-management system that focuses on the delivery of engineering products and services to nuclear facilities around the world, the refurbishment of existing reactors and the construction of new reactors. This functionally managed system covers various groups in SNC-Lavalin Nuclear and takes an optimal approach to dealing with volatility of business, balancing customer needs and ensuring a consistent approach, while complying with its collective agreements and using best practices. System elements are grouped on the basis of supply, demand, resource planning, development of resources and performance management. Skills of individual technical staff are identified and maintained with succession plans established to meet commercial demands. The attrition risks of these employees are actively managed by a dedicated functional resource management team that continually assesses worker skills, knowledge and qualification to identify gaps and utilize a combination of targeted and on-the-job commercial training opportunities to close the gaps.

Hiring programs

NPP licensees continued to replenish their workforces through hiring programs to recruit workers into the operator, maintenance and engineering job-families. Recruitment of mechanical and control maintenance workers and operators is largely conducted through community colleges; the NPP licensees have established partnerships with colleges in their regions, often advising on curriculum and career opportunities. Recruitment of engineers includes both

experienced workers and new graduates from Canadian universities, some of which offer nuclear engineering programs.

To further promote the industry and increase the pool of potential applicants, the NPP licensees are active in programs such as campus outreach and robotics competitions, as well as in organizations such as Women in Nuclear (WiN) and North American Young Generation in Nuclear (NAYGN).

WiN-Canada emphasizes and supports the role of women in addressing the general public's concerns about nuclear energy and applying radiation and nuclear technology. WiN-Canada also works to provide an opportunity for women to succeed in the industry through initiatives such as mentoring, networking and personal development opportunities. The industry has collaborated on a number of joint initiatives in partnership with WiN, including the production of a video to encourage young women in high school to pursue a career in the nuclear industry and an initiative to provide the human resources community with recommendations for developing more robust strategies to have women pursue trades careers in the electricity sector.

A number of new graduate engineering trainees in the licensee organizations are part of the NAYGN. This organization provides opportunities for a young generation of nuclear enthusiasts to develop leadership and professional skills, create life-long connections and engage and inform the public.

At SNC-Lavalin Nuclear, the supply of personnel in the needed skills is maintained by internal postings and external hiring, including that of experienced personnel on contract (such as retirees from Candu Energy or the licensee organizations). Further, recruitment by SNC-Lavalin Nuclear utilizes social media and innovative partnerships with Canadian universities and Mitacs (a non-profit organization that manages and funds research and training programs).

External training programs

In addition to the partnerships mentioned above, there are a number of specific programs in Canada to develop new workers for the nuclear industry.

The University of Ontario Institute of Technology (UOIT) has shaped a nuclear engineering program specifically to meet industry needs. Its Faculty of Energy Systems and Nuclear Science offers undergraduate (bachelor's), post-graduate (master's) and doctorate (PhD) degrees, graduate courses and diploma programs that focus on nuclear engineering, radiation science and related areas to support continuing-education needs.

More than 450 undergraduate students, over 90 master's students and four PhD students have graduated from the degree programs offered by the Faculty of Energy Systems and Nuclear Science since 2007. A close interface with industry members, the CSA Group and the CNSC is used to formulate advice on the curriculum and make available thesis and research topics at the university. UOIT is strongly committed to promoting educational and career opportunities for women in science and engineering. The nuclear programs focus on reactor kinetics, reactor design, plant design and simulation, radiation detection and measurement, radiation biophysics and dosimetry, radiation protection, environmental radioactivity, nuclear security, production and utilization of radioisotopes, waste management, fuel cycle, radiation chemistry and material analysis with radiation techniques.

The University Network of Excellence in Nuclear Engineering (UNENE) is an alliance of Canadian universities (including UOIT and others) and NPP licensees, with support from research and regulatory agencies. UNENE was created to provide a sustainable supply of qualified nuclear engineers and scientists to meet the current and future needs of the Canadian nuclear industry through university-based training. Through UNENE, nuclear professorships in participating universities have been sustained. The five universities currently participating in UNENE offer a common course-based master of engineering (M.Eng.) program aimed at professionals already working in the nuclear industry. To date, 106 students have graduated from the UNENE M.Eng. program. A new, shorter diploma program was introduced by UNENE in April 2015 to enable young industry professionals to acquire focussed knowledge in their current areas of responsibility. UNENE also supports M.Sc. and Ph.D. research; currently there are 120 students participating.

Mitacs is a not-for-profit, government-supported training organization to connect highly skilled graduate students and postdoctoral fellow interns (and their supervising professors) with CANDU technology projects aimed at addressing a clearly identified industry knowledge gap.

CANTEACH is a web-based knowledge repository that provides high-quality technical documentation relating to the CANDU nuclear energy system. The CANTEACH program was established by AECL, OPG, COG, Bruce Power, McMaster University, l'École Polytechnique de Montréal and the Canadian Nuclear Society. Its aim is to develop and maintain a comprehensive set of web-accessible documents for use in various aspects of education, training, design and operation. The CANTEACH program continues to accumulate information contributed by the Canadian nuclear industry, universities and the CNSC.

In 2015, UNENE announced the publication of a CANDU textbook titled “The Essential CANDU”, which meets the long-standing need for a peer-reviewed textbook on CANDU technology, suitable for senior undergraduate and graduate students, educators, trainers and working professionals. It enables those new to CANDU technology to learn about the overall system and pursue specialized topics in depth. As such, it prepares undergraduates for a career in the nuclear industry, facilitates the technical training of new employees, and supports knowledge enhancement of experienced employees. It also supports university level nuclear education curricula. It is available at the UNENE website and is intended to be a living document.

Knowledge-retention programs

Knowledge management and retention continue to be important focus areas for the NPP licensees. Various knowledge management and mitigations plans exist for critical and “at-risk” roles due to the departure of a significant portion of the nuclear industry’s knowledge workers.

For example, OPG uses both internal and external approaches to knowledge management. The internal approach uses internal tools and resources to assess the risk of knowledge loss by determining a total attrition factor that includes a rating based on the estimated time until retirement or departure and the position criticality. This information is then utilized in developing an approach to manage the key issues. The external approach involves engaging a vendor to capture knowledge through specialized knowledge mapping software. Both approaches are integrated into OPG’s succession-planning cycle when critical and “at-risk” roles are reviewed and identified, with specific focus placed on critical positions where knowledge loss is the greatest threat.

Managers periodically review knowledge-retention plans to assess the overall criticality of the roles and the availability of knowledge to the organization. OPG's leadership team fully supports the program and regularly reviews the knowledge risk areas through the succession-planning process.

Some of the initiatives implemented by NPP licensees in Canada to mitigate knowledge retention risks include:

- knowledge repositories that use common documentation
- a high-potential development program for emerging leaders and middle managers that accelerate the development of high-potential employees for future leadership roles
- a recruitment and resourcing strategy to achieve a mix of new graduates, experienced hires, on-the-job developmental opportunities and rotations, and contract staff
- partnerships with selected external service providers to provide a new means of implementing projects
- ongoing mentoring and coaching of employees
- on-the-job and classroom-based training communities for sharing best practices and discussing solutions to common issues and challenges
- centres of excellences, which establish a critical mass of expertise and a consistent enterprise-wide approach in key areas important to the business

To support the knowledge management and retention initiatives of CANDU NPPs, SNC-Lavalin Nuclear provides the following engineering support services:

- attachment of experienced SNC-Lavalin Nuclear staff to CANDU NPPs
- provision of common nuclear products and services to multiple CANDU 6 NPPs

Maintaining research and development capability

In addition to the human resource challenges noted above, there has been some concern that available funds for nuclear power R&D may be insufficient to sustain the core R&D elements of people and facilities. Canada recognizes that it is important to retain adequate core R&D capability, preserve expert knowledge and train future experts.

Every three years, COG produces a report on the R&D capability of the Canadian nuclear industry. This report examines and documents Canadian R&D capability in order to ensure adequate financial resources for R&D, with the view of supporting continued safe and reliable operation of NPPs. The 2015 report assessed the R&D funding stream during the previous three years (2012–14) and the resources anticipated for the following three years (2015–17). The 2015 report noted that sustained R&D funding in recent years has allowed the industry to adequately maintain the infrastructure (both facilities and expert staff) needed to support safe and efficient operation of nuclear facilities as they age. Initiatives such as knowledge retention through the production of state-of-the-art reports, software quality assurance documentation, consolidated databases and operational guidelines, along with higher-level initiatives related to the management of knowledge retention and the elimination of singleton expertise, are expected to produce positive results in the short and medium terms.

During the reporting period, COG funded a formal capability maintenance program aimed at supporting the R&D facilities and resources located at CNL during the period of AECL's restructuring. This program focused on several facilities that were potentially at risk during the transition period. With the formation of the government-owned, contractor-operated (GoCo)

model and the restructuring and operation of CNL, the formal program came to an end in March 2016.

The CNSC monitors both the capability of the Canadian nuclear industry to sustain R&D and the results of the R&D programs themselves. The licensees are required to report to the CNSC significant findings generated by R&D that reveals a hazard different than previously represented to the CNSC according to CNSC REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*.

Appendix E describes the R&D programs for Canadian NPPs during the reporting period.

Article 12 – Human factors

Each Contracting Party shall take the appropriate steps to ensure that the capabilities and limitations of human performance are taken into account throughout the life of a nuclear installation.

“Human factors” are those that influence human performance and thereby influence the safety of a nuclear facility or activity during any (or all) phases, including specification, design, construction, commissioning, operation, maintenance and decommissioning. These factors may include the characteristics of the person, the task, the equipment or tools used, the organizations to which he/she belongs, the work environment and the training received. The application of human-factors knowledge and methods, in areas such as interface design, procedures, training and organization and job design, improves the reliability of humans performing tasks under various conditions.

The CNSC regulatory approach is to consider human factors during its licensing, compliance and standards-development activities. During licensing, the CNSC evaluates the extent to which the applicant has considered human factors and applied that knowledge in its proposed programs.

The CNSC has issued several regulatory documents and guides to assist licensees and licence applicants in the planning and implementation of human factors activities. In addition, a number of CNSC regulatory documents include specific requirements for the consideration of human factors during new-build and life-extension projects. Relevant documents include:

- G-276, *Human Factors Engineering Program Plans*
- G-278, *Human Factors Verification and Validation Plans*
- G-323, *Ensuring the Presence of Sufficient Qualified Staff at Class I Nuclear Facilities – Minimum Staff Complement*
- RD/GD-210, *Maintenance Programs for Nuclear Power Plants*
- REGDOC-2.3.2, *Accident Management, Version 2*
- REGDOC-2.3.3, *Periodic Safety Reviews*
- REGDOC-2.4.1, *Deterministic Safety Analysis*
- REGDOC-2.4.2, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*
- REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants*
- REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response, Version 2*

Also, CNSC regulatory document RD/GD-369, *Licence Application Guide: Licence to Construct a Nuclear Power Plant*, addresses human and organizational factors throughout its guidance. It stresses the necessity for the applicant to demonstrate the knowledge, skills and abilities of its workers and those of the major contractors and their subcontractors, as well as an overall commitment to fostering a healthy safety culture.

Additionally, the CSA Group has published the following standards relevant to human factors activities:

- N286-12, *Management system requirements for nuclear facilities*
- N290.6, *Requirements for monitoring and display of nuclear power plant safety functions in the event of an accident*

- N290.12, *Human factors in design for nuclear power plants*

In the next reporting period, CNSC staff will continue its work developing and improving the regulatory framework in support of human factors. Such work includes initiatives on human performance, fitness for duty (including fatigue management), safety culture and minimum shift complement. These improvements will reflect the lessons learned from the Fukushima accident.

The CNSC Action Plan identified a number of specific actions that have implications for human and organizational performance. In short, licensees were required to evaluate the habitability of emergency control facilities, the roles and functions of staffing requirements beyond minimum shift complement (see subsection 11.2(a)), and the emergency procedures and equipment that would be used to mitigate any beyond-design-basis accident (BDBA). Given the nature of the potential enhancements, human performance was considered in the assessment of the response to BDBA. In the reporting period, CNSC staff reviewed the licensees' plan to address FAIs for the use of human and organizational tools, including task analysis, verification and validation, usability requirements, procedure development, operating experience and lessons learned, habitability, severe accident management guideline (SAMG) development and validation, training needs analysis, and more. CNSC conducted a series of Fukushima-related inspections at the NPPs focussing on human and organizational factors. Specifically, these verified that the licensees are adequately developing and modifying procedures, and taking human factors in design into account, as they relate to Fukushima lessons learned. CNSC also witnessed the testing of various human and organizational factors during emergency exercises. The FAIs for all NPPs were closed by the end of the reporting period but improvements related to human and organizational factors, and CNSC's monitoring thereof, are continuing.

The CNSC subdivides its assessment of human factors into the following technical review areas as shown in the table below. The subarticle/subsection number in the table indicates where the factor is described.

Technical review area	Subarticle/Subsection
Reporting and trending	7.2(ii), 19(vii)
Safety culture	10(b)
Minimum shift complement	11.2(a)
Human performance program	12(a)
Fitness for duty	12(b)
Procedures	12(c)
Human actions in safety analysis	12(d)
Human factors engineering (Human factors in design)	12(e)
Organizational performance	12(f)
Work organization and job design	12(g)
Accident management and recovery	19(iv)

12 (a) Human performance programs

Human performance is the outcome of human behaviours, functions and actions in a specified environment, reflecting the ability of workers and management to meet the system's defined performance requirements under the conditions in which the system is employed. Human performance programs aim to minimize the potential for human error by addressing the range of factors that affect human performance. An effective human performance program integrates the

full range of human factors considerations – not just the people but also the tools, equipment, tasks and environments in which they work – to ensure people are fully supported in carrying out their work safely. The desired human performance is supported by hardware and software design that considers the users, high-quality procedures, good procedural adherence, effective work organization and careful job design. It is also necessary to ensure workers are fit for duty and are supported by appropriate organizational mechanisms, continuous monitoring and an organizational commitment to improvement. (These review areas are discussed in subsequent subsections.)

The requirement for a licensee to have a documented human performance program is a licence condition in NPP operating licences. An NPP licensee's human performance program should be developed, reviewed for effectiveness and updated continually (or at frequent intervals) and at all phases of the plant lifecycle, from design through to decommissioning. CNSC staff members are drafting a discussion paper that considers the approach to human performance at an organizational level, to develop stronger links between the human performance program and the range of human factors topics, leading to a strong, integrated consideration of human performance.

CNSC has also proposed an amendment to the *Class I Nuclear Facilities Regulations* that would require all Class I facilities to have a human performance program for the activity to be licensed, including measures in place to ensure workers' fitness for duty (discussed further below). The amended regulations are anticipated to be published in 2017.

All Canadian NPPs have implemented human performance programs that emphasize detection and correction of human error with a focus on monitoring individuals' behaviours. Licensees' human performance improvement programs encourage assessment of internal and external events and operating experience as opportunities to address problems before errors occur. All licensees conduct detailed reviews of operational conditions, activities, incidents and events (e.g., review of station condition records), as well as apparent-cause evaluation or root-cause analyses to facilitate the detection and correction of human performance and other human factors-related issues. Licensees have developed coding schemes to effectively identify and track the causes of adverse conditions (see subarticle 19(vii) for more information).

In this learning environment, licensees strive to operate in a blame-free environment, which increases the willingness of staff to identify errors in their work.

The mechanisms by which NPP licensees assign responsibilities and accountabilities for human performance are described in annex 12(a).

More recently, some licensees have broadened the focus of their human performance programs to consider managing defences against human error and supporting workers to achieve the desired safety performance. Defence methods, which are identified through risk assessment, include elimination, engineering controls, administrative controls and personal protective equipment. The CNSC recognizes the benefit of licensees encouraging employees to get more involved in devising methods to improve the quality, reliability and safety of their work, and more fully appreciating their roles in nuclear safety. An example of this is the Human Performance Advocates Network implemented by Bruce Power.

CNSC staff's review of human performance programs assesses the organization's ability to create, integrate and implement defences that prevent or mitigate the consequences of human

error in work activities, and to support its workers to achieve the desired human performance. This includes a review of programs for performance monitoring that detect latent organizational conditions and weaknesses, the consideration of human and organizational factors in organizational processes, strategies for improvement and the licensee's overall commitment to fostering a healthy safety culture.

The CNSC review of performance monitoring and improvement focuses on ensuring that there is a systematic, objective and comprehensive process for monitoring and improving safety. The CNSC event reviews ensure that corrective action plans are systematically developed, comprehensive and effective for addressing the causes of an event.

12 (b) Fitness for duty

Fitness for duty is a broad topic that touches on occupational health, physical and mental ability, the use of potentially physio- and psycho-active substances and occupational fitness. It is defined as a condition in which workers are physically, physiologically and psychologically capable of competently and safely performing their tasks.

CNSC regulatory document RD-204, *Certification of Persons Working at Nuclear Power Plants*, requires licensees to have a documented fitness-for-duty program for certified workers. In addition, CNSC regulatory document RD-363, *Nuclear Security Officer Medical, Physical and Psychological Fitness*, sets out the fitness-for-duty requirements for nuclear security officers.

During the reporting period CNSC issued draft regulatory document REGDOC-2.2.4, *Fitness for Duty*, for public consultation. This document will be applicable to all workers who could pose a risk to nuclear safety or security at high-security sites and has been developed considering the full breadth of fitness for duty requirements, including alcohol and drug testing. REGDOC-2.2.4 will amalgamate requirements from RD-363.

As part of the process to ensure workers possess the minimum qualifications to perform their jobs safely and to minimize the risks to NPP safety, the environment, and themselves or others, NPP licensees conduct various fitness-for-duty assessments across various workgroups. Depending on the risks associated with a position, these may include medical evaluations, alcohol and drug testing, and occupational or physical fitness. These evaluations are conducted in various circumstances, including pre-placement, periodic and return-to-work, or are based on referral from the employee health assistance program or the outcome of behavioural observation.

With respect to fatigue-related fitness for duty, the CNSC has expectations for limits on hours of work and mandatory rest periods between blocks of 12-hour shifts. These expectations are currently implemented by NPPs with some exceptions (e.g., application to casual construction trades and contractors, outages). The CNSC monitors hours-of-work violations, which are reported quarterly by the licensees. During the reporting period the CNSC issued draft regulatory document REGDOC-2.2.4, *Managing Worker Fatigue*, for public consultation. This regulatory document will provide requirements and guidance with respect to managing worker fatigue at high-security sites.

12 (c) Procedures

NPP licensees have processes for producing and maintaining procedures used for testing, maintenance and operations (both normal and abnormal). In addition, most licensees have a guide that addresses relevant human factors.

CNSC staff's review of procedures focuses on ensuring there is an adequate process for the development, validation, implementation, modification and use of procedures that account for human performance. CNSC staff members also focus on ensuring that the process is implemented effectively and there are demonstrated mechanisms for managing procedural adherence.

12 (d) Human actions in safety analysis

Human actions are considered in probabilistic and deterministic safety analyses to examine the possible contribution of human error and human reliability to hazards and risks.

Human reliability analysis is an integral component of probabilistic safety assessment (PSA) in situations where humans are involved in system performance. (More information on PSA is provided in subsection 14(i)(d).) It is a method for estimating the probability that a system-required human action, task or job necessary for safety will not be completed successfully within the required time period. It can also consider the probability that extraneous tasks or actions detrimental to system reliability or availability will be performed. Other safety analyses that consider human actions include hazard and operability studies, failure modes and effects analyses and hazard analyses.

Licensees use industry-accepted human reliability assessment methods within their PSAs to incorporate the probability of human errors in risk-important sequences. While the CNSC does not require its licensees to use any particular method for human reliability analysis, it verifies that the method chosen meets industry good practices and is carried out in a systematic way. One commonly used method is the Technique for Human Error Rate Prediction.

The CNSC is conducting research into the Standardized Plant Analysis Risk – Human Reliability Analysis method with regard to adapting the factors that shape human performance. This could eventually assist licensees with developing their Level 2 PSAs, including consideration of the use of emergency mitigating equipment and severe accident management guides.

CNSC staff's review of human actions focuses on the execution of components of emergency operating procedures in the control room and field.

12 (e) Human factors engineering (human factors in design)

The consideration of human factors engineering (HFE) (also referred to as human factors in design) applies to the design of new facilities and to the modification and decommissioning of existing facilities. The concept of HFE is concerned with ensuring that the design or modification of facilities, systems and equipment integrates information about human characteristics, performance and limitations so as to ensure safe and reliable task and system performance and to minimize the potential for human error. The concept considers the cognitive, physical and sensory characteristics of people who operate, maintain or support the system, ensuring that the system and equipment are designed to support human performance.

HFE effort increases with higher levels of interface complexity or criticality; greater HFE effort is typically required for reactor operator tasks.

The CNSC regulatory document REGDOC-2.5.2, *Physical Design – Design of Reactor Facilities: Nuclear Power Plants*, includes requirements for addressing human factors in the design of new NPPs (see subarticle 18 (iii) for details). In addition, CNSC regulatory document

RD/GD-210, *Maintenance Programs for Nuclear Power Plants* includes requirements for addressing human factors in maintenance.

The CSA standard N290.12-14, *Human factors in design for nuclear power plants*, was published in December 2014. NPP licensees are currently implementing this standard.

As part of an integrated safety review (ISR) for a life-extension project, licensees must determine the extent to which the current NPP and plant performance conform to modern standards and practices and identify any gaps between those standards and actual performance (see subsection 14(i)(f) for details). The CNSC expects that modern HFE principles and standards using best practices will be consulted when plant modifications are being considered, although it is recognized that the existing technologies, space limitations and control room practices may limit their application to older NPPs. CNSC staff members continue to work with licensees undergoing life-extension projects to ensure the reviews against modern standards address expectations related to human factors that could limit safe long-term operation. In addition, modifications in response to the Fukushima accident have included human factors in design considerations.

A description of how the Canadian nuclear industry considers human factors through its application of HFE is provided in annex 12(e).

CNSC staff's review of HFE assures that there is a systematic process for effectively incorporating human factors considerations into system requirements, definition, analysis, design and verification and validation activities. CNSC staff members also focus on ensuring that the process of incorporating HFE is implemented effectively by suitably trained, qualified and competent human-factors specialists.

12 (f) Organizational performance

CNSC staff members review the management processes related to organizational performance (e.g., business planning, the establishment of the organization, change management of roles and responsibilities, communications, resourcing) and consider the influence of such processes on safety performance at Canadian nuclear facilities. For example, safety performance at NPPs can be influenced by the ways in which organizational changes are made and communicated, how contractors are managed, how the organization conveys its vision and mission, and how responsibilities are assigned within the organization — from the senior management team to the field where the work is carried out. All of these processes are established in the licensees' management systems according to the requirements of CSA standard N286-12, *Management system requirements for nuclear facilities*, and are regularly assessed by both the licensees and CNSC for their effectiveness.

The CNSC's review of licensees' organizational processes and performance is described further in subsection 10(c).

12 (g) Work organization and job design

Work organization and job design relate to the organization and provision of a sufficient number of qualified staff and the organization and allocation of work assigned to staff to ensure that work-related goals are achieved in a safe manner. They include, but may not be limited to,

staffing levels and minimum shift complement, which are discussed in more detail in subsection 11.2(a).

Article 13 – Quality assurance

Each Contracting Party shall take the appropriate steps to ensure that quality assurance programs are established and implemented with a view to providing confidence that specified requirements for all activities important to nuclear safety are satisfied throughout the life of a nuclear installation.

13 (a) General management system requirements

Safe and reliable operation requires a commitment and adherence to a set of management system principles and, consistent with those principles, the establishment and implementation of a planned and systematic pattern of actions that achieve the expected results.

Currently, the *Class I Nuclear Facilities Regulations* require licence applicants to propose quality assurance programs for the following activities to be licensed:

- site preparation
- construction
- operation
- decommissioning

The *Class I Nuclear Facilities Regulations* and the *Uranium Mines and Mills Regulations* will be amended to require licence applicants to propose a management system for the activities listed above, including measures to promote and support safety culture. The amended regulations are expected to be published in 2017. This represents a significant step for the CNSC in evolving the regulatory framework for management systems. CNSC licensing requirements refer to “management systems” and specify CSA standard N286 as the principal safety management requirement.

The current CSA N286 standard, N286-12, *Management system requirements for nuclear facilities*, is being cited as the management system requirement for all new licence applications and licence renewals. This standard promotes the integration of management systems and requires that safety be the paramount consideration guiding decisions and actions. It follows and builds on the model provided in the IAEA general safety requirements document GS-R-3, *The Management System for Facilities and Activities*.

NPP licensees have implemented (or are in the process of implementing) CSA standard N286-12. For a description of the existing management systems that are currently implementing N286-12, see the sixth Canadian report (annex 13(a) of that report provides an example of an existing management system for one NPP licensee). For licensees who are in the process of implementing N286-12, their existing management system is in accordance with CSA standard N286-05, *Management system requirements for nuclear power plants*.

The N286 standard applies to the top management with overall accountability for the facility, through its life cycle including design, supply chain, construction, commissioning, operation and decommissioning and integrates the management system requirements for health, safety, environment, security, economics and quality. N286 applies to all 14 CNSC safety and control areas.

Management systems based on N286-12 include processes to define, plan and control the licensed activities by identifying relevant requirements to be met; establishing objectives that achieve the requirements; identifying and controlling risks; establishing plans, measures and targets, monitoring that results are achieved and taking appropriate corrective measures if they are not. As part of the management system, these processes are subject to regular monitoring and reporting to assess effectiveness and identify opportunities for improvement. See subsection 9(b) for additional details of management systems in this context.

Specifically, N286-12 is based on the following 12 principles for management system:

- Safety is the paramount consideration, guiding decisions and actions.
- The business is defined, planned and controlled.
- The organization is defined and understood.
- Resources are managed.
- Communication is effective.
- Information is managed.
- Work is managed.
- Problems are identified and resolved.
- Changes are controlled.
- Assessments are performed.
- Experience is sought, shared and used.
- The management system is continually improved.

These principles are supported by the following generic requirements for management systems as outlined in N286-12:

- **Safety culture:** The management system is used to understand and promote a safety culture.
- **Business planning:** Requirements are identified, risks to objectives are identified and controlled, and results are monitored to ensure planned results are achieved.
- **Organization:** The organizational structure, authorities, accountabilities, responsibilities, and decision-making process are defined.
- **Resources:** Resources required to carry out the business plan with a focus on competent human resources, and the means to achieve this requirement, are identified.
- **Communication:** Processes exist to ensure effective communications and to make workers aware of the relevance and significance of their work.
- **Information management:** The management system is documented, information is provided to those who need it in a timely manner, and document control and records are managed.
- **Work management:** Work is planned, controlled and independently verified.
- **Problem identification and resolution:** Problems are identified, evaluated, documented, and resolved, and the effectiveness of the resolution confirmed.
- **Change:** Required changes are identified, justified, reviewed, approved, implemented and assessed.
- **Assessment:** Self-assessments and independent assessments are conducted.
- **Use of experience:** Experience gained within the industry and from other industries is reviewed for relevance and used to initiate improvement.

- **Continual improvement:** Management continually improves the management system and periodically assesses its effectiveness to achieve planned results.

The CNSC expects licensees' management systems and performance to demonstrate adherence to these principles by implementing processes, aligned with the generic requirements that apply to all of their licensed activities.

It is of particular importance that licensees conduct self- and independent assessments of their core processes and programs to evaluate the effectiveness of the management system in ensuring requirements are met. Licensees routinely conduct self-assessments, sometimes referred to as functional area self-assessments, on their core processes to provide objective information to senior management for their overall management review activity. This is supplemented with information from independent assessments and other important metrics and indicators.

CNSC staff members routinely review the licensees' assessment information to ensure the processes are properly implemented and that licensees' senior management are receiving objective feedback on the organization's performance.

The following quality assurance/management system standards are also relevant to NPP operations:

- CSA standard N286.7-16, *Quality Assurance of Analytical, Scientific and Design Computer Programs for Nuclear Power Plants*
- International Organization for Standardization (ISO) document 14001-2004, *Environmental management systems – Requirements with guidance for use*

Applicants for site preparation and construction licences also require the proposed quality assurance program for the design of the nuclear facility. Applicants are required to provide descriptions of measures, policies, methods and procedures for worker health and safety protection, environmental protection, and for operating and maintaining the nuclear facility.

13 (b) Addressing the issue of suspect material

Incidents involving the purchase and use of valves, which may have had suspect material used in their manufacture, was discovered by NPP licensees during the reporting period. Canadian licensees had purchased and installed valves containing suspect material at Bruce A and B, Darlington, Pickering and Point Lepreau. This issue had no impact on safety at Gentilly-2.

The potential non-conforming material in the suspect valves was supplied by a third party supplier. These valves had been received as early as 2001 and some had been installed since that time. In March 2015, Canadian NPP licensees were notified by a valve supplier that materials contained in valve assemblies and components may not conform to accepted standards, specifications or technical requirements. Licensees immediately notified the CNSC about this event, per the requirements of the regulatory document REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*.

The affected NPP licensees determined the extent of condition and submitted related reports to the CNSC. Licensees determined that there were no operability or safety concerns with the supplied valves and components and that none of the safety-related components in service has had a pressure boundary failure. Moreover, they quarantined all suspect components in storage to prevent installation and identified affected system(s).

Licensees performed a root-cause analysis and identified the root cause and have taken corrective actions to prevent re-occurrence of a similar event.

The CNSC staff concluded that the engineering assessments and reviews conducted by licensees, suppliers and authorized inspection agencies have been performed thoroughly and in a robust manner. The CNSC also concluded that the licensees implemented appropriate corrective actions.

The discovery and reporting of these incidents demonstrated the effectiveness of the NPP licensees' supply chain management and procurement quality assurance program for discovering and mitigating the intrusion of counterfeit, fraudulent and suspect items (CFSIs) into their operations as well as the overall robustness of their supply chain processes. To further improve the effectiveness of their programs, the licensees implemented a variety of enhancements to increase surveillance of sub-suppliers' quality programs and to enhance awareness and training of supply chain staff with respect to CFSI issues.

CSA standard N299, *Quality assurance program requirements for the supply of items and services for nuclear power plants*, is an update to the former Z299 series of standards into which requirements for measures to address CFSIs has been introduced. It is expected to be published in 2016 and NPP licensees are planning to implement it.

For further details, see appendix D.

Article 14 – Assessment and verification of safety

Each Contracting Party shall take the appropriate steps to ensure that:

- (i) comprehensive and systematic safety assessments are carried out before the construction and commissioning of a nuclear installation and throughout its life. Such assessments shall be well documented, subsequently updated in the light of operating experience and significant new safety information, and reviewed under the authority of the regulatory body;
- (ii) verification by analysis, surveillance, testing and inspection is carried out to ensure that the physical state and the operation of a nuclear installation continue to be in accordance with its design, applicable national safety requirements, and operational limits and conditions.

14 (i) Assessment of safety

14 (i) (a) General safety assessment in response to the Fukushima accident

As reported in the sixth Canadian report, Canada's post-Fukushima safety assessment confirmed that operating procedures and equipment are in place at all CANDU reactors to ensure key safety functions are carried out for extended durations and to bring a reactor to a safe, stable state following an accident.

The post-Fukushima safety review also found that the licensees' assessments of the progression of beyond-design-basis accidents (BDBA) were adequate. The assessment also confirmed the general adequacy of the licensees' safety cases for external events.

The CNSC Action Plan assigned an action to licensees to complete the review of the basis of each external event to which the NPP may be susceptible using modern, state-of-the-art practices. Most of this work was described in the sixth Canadian report.

The licensees' remaining work to address this action is described in the following subarticles/subsections:

- reviews of the bases of external events – subarticle 17(iii)
- updates to PSAs – subsection 14(i)(d)
- deterministic analyses for representative severe core damage accidents to confirm that consequences of events triggered by external hazards are within applicable limits - subsection 14(i)(c)

14 (i) (b) Assessment of licence applications

CNSC staff members perform detailed assessments of safety in relation to NPP licence applications. Subarticle 7.2(ii) describes the general CNSC licensing process for both new-build projects and currently operating NPPs and provides specific information related to CNSC licences to prepare the site for, construct and operate an NPP. The CNSC's assessment of safety for a licence application is conducted against the application requirements set out in the *General Nuclear Safety and Control Regulations*, the *Class I Nuclear Facilities Regulations*, and other relevant regulations. Licence application guides have been written (or are in production) to

supplement the regulations. They are written in the context of the 14 CNSC safety and control areas as well as the other matters of regulatory interest described in appendix F. CNSC staff members use assessment plans, along with staff work instructions, to coordinate the assessment of licence applications related to NPPs. During the reporting period, the CNSC continued to develop a comprehensive set of technical assessment criteria to aid these assessments. See subarticle 7.2(ii) for more details on these topics.

The rest of this subsection describes the CNSC's assessment of an application to renew a licence to operate an NPP. These assessments have typically recurred every five years for currently operating NPPs in Canada, corresponding to the typical duration of licences to operate that were in effect during the reporting period. In 2015, an NPP operating licence for a period greater than five years was issued to OPG for the operation of Darlington (see below).

In accordance with the regulations and CNSC guidance, an application to renew a licence to operate an NPP typically addresses the programs and plans listed in appendix C, which are aligned with the CNSC safety and control areas. The CNSC conducts a balanced assessment of the licensee's programs and activities, with priority placed on certain areas based on performance history, risk and expert judgment. In their assessments, CNSC staff members focus on:

- the performance of the licensee and the NPP over the previous licence period
- the licensee's plans for operation and safety improvement over the next licence period
- significant activities envisaged by the licensee for an extensive period beyond the next licence period

To help summarize the overall assessment of an application to renew a licence to operate, CNSC staff members assess and rate the applicant's performance under the CNSC safety and control areas, as described in appendix F.¹

As explained in subsection 7.2(ii)(d), the periodic safety review (PSR) process is being integrated into the overall CNSC licence renewal process. This is illustrated in the following description of the recent Darlington licence to operate, where the integrated safety review for refurbishment will serve as the initial PSR.

OPG was issued an operating licence in 2015 for Darlington for a licence period from January 1, 2016 until November 30, 2025. The assessment of the application to renew this licence to operate produced the following major results:

- The assessments for the refurbishment and life extension of Darlington met the requirements of CNSC regulatory document RD-360, *Life Extension of Nuclear Power Plants*. RD-360 was used because the project started prior to publication of the CNSC regulatory document REGDOC-2.3.3, *Periodic Safety Reviews*.
- The safety and control areas for Darlington were all rated as "satisfactory" or "fully satisfactory" during the licensing period.
- The PSA results showed that the safety goal limits were met.

¹ These ratings are, in fact, produced for all licensees and all safety and control areas on an annual basis, as described in appendix F.

- CNSC staff verified that OPG has demonstrated pressure tube (which contain the fuel) fitness for service beyond 210,000 equivalent full-power hours (EFPH), up to the planned pre-refurbishment service life of 235,000 EFPH. (See subsection 14(ii)(b) for details.)
- The distribution and pre-stocking of potassium iodide (KI) pills was completed in accordance with regulatory requirements. (This is discussed further in subsection 16.1(d).)
- All CNSC Fukushima action items (FAIs) were closed.
- OPG was required to complete the refurbishment integrated implementation plan (IIP).
- OPG was required to submit the PSR basis document, along with the subsequent licence renewal application, no later than one year prior to the expiry of the new licence.

14 (i) (c) Deterministic safety analysis

Response to Fukushima – Deterministic safety analysis

The licensees and CNSC post-Fukushima review of the deterministic safety analyses for each NPP confirmed that the safety analysis of each NPP adequately considered design-basis accidents and meets or exceeds the original design intent. The safety report of each NPP shows that the predicted consequences, with conservative safety analysis assumptions, met the CNSC's prescribed acceptance criteria. The review found that the licensees' assessment of beyond-design-basis events were adequate. Further details were provided in the sixth Canadian report.

General requirements and approach

General requirements for safety analysis are found in the *Class I Nuclear Facilities Regulations*. In particular, paragraph 5(f) requires an applicant for a construction licence to submit a preliminary safety analysis report. The regulations also specify supporting design information that must be submitted in an application for a licence to construct a Class I nuclear facility. This includes:

- a description of the proposed design of the nuclear facility, including the manner in which the physical and environmental characteristics of the site are taken into account in the design (paragraph 5(a))
- a description of the environmental baseline characteristics of the site and the surrounding area (paragraph 5(b))
- a description of the structures proposed to be built as part of the nuclear facility, including their design and their design characteristics (paragraph 5(d))
- a description of the systems and equipment proposed to be installed at the nuclear facility, including their design and their design operating conditions (paragraph 5(e))
- the proposed quality assurance program for the design of the nuclear facility (paragraph 5(g))

For new-build projects, CNSC regulatory document REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants*, published in May 2014 and replacing CNSC regulatory document RD-337, *Design of New Nuclear Power Plants*, stipulates that the preliminary safety analysis report shall assist in the establishment of the design-basis requirements for items important to safety and demonstrate whether the NPP design meets applicable requirements. The *Class I Nuclear Facilities Regulations* also stipulate requirements for an application to operate a Class I nuclear facility. Per paragraphs 6(a) and 6(b), an application for a licence to operate shall

contain descriptions of the systems, structures and equipment of the facility, including their design and design operating conditions. Paragraph 6(c) further requires the application to contain a final safety analysis report demonstrating the adequacy of the design of the facility. Details on the content of a typical safety analysis report for a currently operating NPP are provided in annex 14(i)(c).

REDGDOC-2.5.2 further states that the final safety analysis report shall:

- reflect the as-built NPP
- account for postulated aging effects on structures, systems and components important to safety
- demonstrate that the design can withstand and effectively respond to identified postulated initiating events
- demonstrate the effectiveness of the safety systems and safety support systems
- derive the operational limits and conditions for the plant, including:
 - operational limits and set points important to safety
 - allowable operating configurations, and constraints for operational procedures
- establish requirements for emergency response and accident management
- determine post-accident environmental conditions, including radiation fields and worker doses, to confirm that operators are able to carry out the actions credited in the analysis
- demonstrate that the design incorporates sufficient safety margins
- confirm that the dose and derived acceptance criteria are met for all anticipated operational occurrences and design-basis accidents
- demonstrate that all safety goals have been met

The licensees use integral mechanistic models in sophisticated computer codes to simulate accident progression and consequences. The tools and methodologies used in licensees' safety analysis reports are supported by national and international experience and are validated against relevant test data and benchmark solutions. In addition to the quality assurance requirements for safety analysis specified in paragraph 5(g) of the *Class I Nuclear Facilities Regulations* noted above, the licensees follow CSA standard N286.7, *Quality assurance of analytical, scientific and design computer programs for nuclear power plants*, which is part of the licensing basis for all operating NPPs. The NPP licensees have established specific validation programs in accordance with N286.7 for industry standard tool (safety analysis) codes to provide the necessary confidence in the analytical results. During the reporting period, the industry continued to extend the validation of these codes to align with expanded applications.

In accordance with CNSC regulatory document REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*, the NPP licensees, within five years of the date of the last submission of their NPP description and final safety analysis report (or when requested by the CNSC), must submit an updated NPP description and an updated final safety analysis providing:

- a description of the changes made to the site and the NPP's structures, systems and components (SSCs), including any changes to the design and design operating conditions of the SSCs
- safety analyses that have been appropriately reviewed and revised and that take into account the most up-to-date and relevant information and methods, including the experience gained and lessons learned from the situations, events, problems or other information reported pursuant to REGDOC-3.1.1

Updates to safety analysis reports for existing NPPs are ongoing continuously to include the effects of aging of the primary heat transport system. See annex 14(i)(c) for details.

During the reporting period, CNSC staff reviews of the safety analysis reports confirmed that the safety margins for all Canadian NPPs remained acceptable.

In addition to the analysis of design-basis accidents, licensees perform analyses of design extension conditions accidents (a subset of BDBAs), including severe accidents. In this context, a design extension conditions accident is a BDBA that is not included in the NPP design basis but is nevertheless considered in the design.

An example of a design extension conditions accident resulting in fuel damage but maintaining intact core geometry is a large-break loss of coolant accident (LBLOCA) coincident with a loss of emergency core cooling where the moderator serves as an ultimate heat sink. This event was formerly considered as a design-basis accident and its analysis continues to (typically) be included as part of safety reports. Other BDBAs, such as a prolonged station blackout, are analyzed using PSA, which is discussed in subsection 14(i)(d).

If the safety consequences of an event are significant (e.g., severe core and fuel damage and the potential to exceed the regulatory dose limits), it is referred to as a severe accident. To address lessons learned from Fukushima, the NPP licensees are continuing to perform further deterministic analyses for representative severe core damage accidents. Such safety analysis has already been conducted as part of the integrated safety reviews (ISRs) to help decide on the scope of refurbishment activity for NPPs undergoing life extension. The licensees are also evaluating the existing models for BDBA analyses to specifically address multi-unit events.

Further, NPP licensees use deterministic severe accident analyses to:

- develop computational aids, guidelines and procedures
- identify potential strategies for mitigating severe accident consequences
- assess instrumentation and equipment survivability and facilities habitability in severe accidents
- train staff and conduct validation exercises

Updating safety analysis requirements, methods and acceptance criteria

A set of siting criteria for assessing the acceptability of NPPs was developed in the mid-1960s. The criteria specify offsite dose limits to be used in safety analyses of any serious process failure (i.e., a single failure) and any combination of a serious process failure and failure of a special safety system (i.e., a dual failure).

These criteria continue to be used as part of the licensing basis for all Canadian NPPs, except for Darlington. For the initial licensing of Darlington, the CNSC consultative regulatory document C-006, *Requirements for the Safety Analysis of CANDU Nuclear Power Plants*, was used on a trial basis. This document addressed deficiencies in the basic single/dual-failure safety analysis requirements, reflecting Canadian experience in applying the single/dual-failure analysis approach. The safety report for Darlington continues to reflect the requirements of C-006.

Details on the above criteria can be found in subsection 14(i)(c) of the sixth Canadian report.

During the reporting period, the CNSC continued to update the regulatory framework for NPPs, as described in subsections 7.2(i)(b) and 7.2(i)(c). CNSC regulatory documents that contain updated requirements related to safety analysis include:

- RD-346, *Site Evaluation for New Nuclear Power Plants* (see article 17)
- REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants*
- REGDOC-2.3.3, *Periodic Safety Reviews*
- REGDOC-2.4.1, *Deterministic Safety Analysis*

The implementation of these and other documents will enable the CNSC and stakeholders to take into account:

- modern practices in safety analysis
- aging of equipment
- refurbishment and PSR
- evolving requirements for new-build projects and their adaptation to existing NPPs

The licensees' work to update their safety analyses and safety analysis reports (such that they will be aligned with the new documents) is ongoing. The implementation of modern requirements for operating NPPs consists of a gap assessment with subsequent prioritization of analysis activities to address any identified gaps and shortcomings. The most significant issues are addressed on a priority basis. In the longer term, compliance with these documents, to the extent practicable, will be achieved as part of PSRs. CNSC regulatory document REGDOC-2.3.3, *Periodic Safety Reviews*, requires the safety analysis update to be completed according to modern standards.

The key new document related to safety analysis is REGDOC-2.4.1, which was published in 2014 and supersedes RD-310, *Safety Analysis for Nuclear Power Plants*. Aligned with the IAEA standards on safety analysis, its purpose is to modernize and improve transparency and consistency of safety analysis activities supporting the safe operation of Canadian NPPs. REGDOC-2.4.1 identifies high-level regulatory requirements for an NPP licence applicant's preparation and presentation of deterministic safety analysis in the evaluation of event consequences. REGDOC-2.4.1 prescribes a systematic process for event identification and classification of the events into categories based on event frequency. It requires BDBAs to be addressed.

All future new-build projects will be expected to be fully compliant with REGDOC-2.4.1. Although it is recognized that the existing safety cases are not in question, Canadian NPP licensees will update certain analyses through the implementation of REGDOC-2.4.1, which will continue into the next reporting period. Assessments of the gaps between the requirements of REGDOC-2.4.1 and the existing safety reports are being used to prioritize the safety report updates. The safety margins and degree of conservatism in the analyses will continue to be re-assessed in light of operating experience and new knowledge. To facilitate this, the NPP industry and the CNSC participate in a working group to address specific safety analysis shortcomings identified by the CNSC as well as other safety analysis issues important to the industry.

To better coordinate safety report updates across the industry, the NPP licensees established a safety analysis improvement program through COG. One of the purposes of the COG safety analysis improvement program is to facilitate the implementation of REGDOC-2.4.1. Specific areas of focus for the program include assessing the impact of aging on the heat transport system

and evaluating the conservatism of, and correcting inconsistencies in, the safety analyses. The main activities of the program have included:

- performance of pilot studies for specific analyses
- production of a guideline for application of derived acceptance criteria to safety analysis
- performance of pilot studies of Darlington loss-of-reactivity control, Bruce A loss of flow and Point Lepreau safety report dose assessment
- gap assessments for the set of analyses in the safety analysis report, followed by the necessary actions to address such gaps
- overall improvement of the safety analysis report

The lessons learned from the pilot studies are being used to update a COG document that provides guidance for deterministic safety analysis and, in particular, for the implementation of REGDOC-2.4.1.

The activities undertaken as part of the safety analysis improvement program are chosen, in part, to address the CANDU safety issues described in subsection 14(i)(g). For example, the pilot study of the Darlington loss-of-reactivity control addressed one of the Category 3 CANDU safety issues related to non-large-break loss-of-coolant accident (non-LBLOCA). In that work, OPG integrated modern and validated coupled thermal hydraulic and reactor physics tools and classified events into the categories of anticipated operational occurrences, design-basis accidents and BDBAs.

Details on the work each licensee is undertaking to implement REGDOC-2.4.1 are provided in annex 14(i)(c).

Fire safety assessment

Each facility has revised its fire safety assessment (which involves a fire hazard assessment and fire safe shutdown analysis) in accordance with the CSA standard N293-07, *Fire Protection for CANDU Nuclear Power Plants*, which is part of the licensing basis for all NPPs. CNSC staff members have reviewed and accepted the revised fire safety assessments. NPP licensees have implemented modifications or provided corrective action plans to address recommendations arising from the revised assessments. The recommendations identified in the fire safety assessments are not considered to be risk significant. The implemented and proposed modifications will enhance fire protection at Canada's NPPs.

The CSA Group issued a new edition of the standard N293 standard during the reporting period. The updated standard, N293-12, *Fire Protection for CANDU Nuclear Power Plants*, provides clarifications to content and additional guidance on achieving compliance in the case of performance-based designs. It does not include any new requirements that would negate or requires revisions to the approved fire safety assessments.

14 (i) (d) Probabilistic safety assessments

A PSA is a comprehensive and integrated assessment of the safety of an NPP that considers the probability, progression and consequences of equipment failures or transient conditions to derive numerical estimates that provide a consistent measure of safety. There are three levels of PSAs:

- A **Level 1 PSA** identifies and quantifies the sequences of events that may lead to the loss of core structural integrity and massive fuel failures.
- A **Level 2 PSA** starts from the Level 1 results and analyzes the containment behaviour, evaluates the radionuclides released from the failed fuel and quantifies the releases to the environment.
- A **Level 3 PSA** starts from the Level 2 results and analyzes the distribution of radionuclides in the environment, evaluating the resulting effect on public health.

The main objectives of the PSA are to:

- provide a systematic analysis that gives confidence that the design will comply with the fundamental safety objectives
- demonstrate that a balanced design has been achieved
- provide confidence that small changes of conditions that may lead to a catastrophic increase in the severity of consequences (i.e., cliff-edge effects) will be prevented
- assess the probabilities of occurrence for severe core damage states and the risks of major radioactive releases to the environment
- assess the probabilities of occurrence and the consequences of site-specific external hazards
- identify NPP vulnerabilities and systems for which design improvements or modifications to operational procedures could reduce the probabilities of severe accidents or mitigate their consequences
- assess the adequacy of emergency procedures
- provide insights into the severe accident management (SAM) program

The post-Fukushima safety assessment reviewed PSA results from Canadian NPP licensees as part of the assessment of the provisions for using existing plant capabilities, complementary design features and emergency mitigating equipment (EME) in SAM and recovery. Severe accident assessments have been extended to consider further design improvements that have either been implemented or are being planned.

Requirements for probabilistic safety assessment

The CNSC published REGDOC-2.4.2, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*, in May 2014. This document sets out the requirements for the PSA and it supersedes CNSC regulatory standard S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*. REGDOC-2.4.2 would also be applied to the construction phase for new-build projects. One of the key requirements is CNSC acceptance of the methodology and the computer codes used for the PSA.

The PSA update interval in REGDOC-2.4.2 is five years – or sooner, if major changes occur in the facility. The updates are subject to regulatory review.

REGDOC-2.4.2 refers to the IAEA safety series to provide general guidance on PSA methodology. In general, the methodologies developed by the licensees are based on the guidance available in documents issued by internationally recognized organizations such as the IAEA and the United States Nuclear Regulatory Commission, as well as good practices.

The PSA assessments of the probabilities of occurrences for severe core damage states, along with the assessments of the risks of major radioactive releases into the environment, are compared with safety goals. The safety goals for new NPPs, which are established in CNSC regulatory document REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants*, are summarized in the table below. These safety goals are consistent with those in International Nuclear Safety Group (INSAG) document INSAG-12, *Basic Safety Principles for Nuclear Power Plants*.

CNSC safety goals for new NPPs

Safety goal	Rationale	Numerical objective
Core damage frequency	Related to accident prevention	Sum of frequencies of all event sequences that can lead to core degradation is less than 10^{-5} per reactor-year
Small release frequency	Release that would trigger evacuation	Sum of frequencies of all event sequences that can lead to a release of more than 10^{15} Bq of I-131 is less than 10^{-5} per reactor-year
Large release frequency	Release that would trigger long-term relocation	Sum of frequencies of all event sequences that can lead to a release to the environment of more than 10^{14} Bq of Cesium-137 (corresponds to 1% of the Chernobyl accident radioactive release) is less than 10^{-6} per reactor-year

Although there are no explicit requirements for safety goals at the existing NPPs, the CNSC does expect the licensees of operating NPPs to establish safety goals that are aligned with international practices. Consistent with INSAG-12 and/or IAEA specific safety guide SSG-3, *Development and Application of Level 1 Probabilistic Safety Assessment for Nuclear Power Plants*, the NPP licensees have established and meet, the following safety goals for the existing NPPs:

- severe core damage frequency (SCDF) of less than 10^{-4} per reactor-year
- large release frequency (LRF) of less than 10^{-5} per reactor-year

Consistent with international practice, small release frequency is generally not included in the safety goals of existing Canadian NPPs.

Development of probabilistic safety assessment and implementation of REGDOC-2.4.2

At the time of writing the sixth Canadian report, NPP licensees had developed PSAs in accordance with CNSC regulatory document S-294, which required a Level 2 PSA that includes both internal and external events.

CNS Challenge C-2 for Canada from the Sixth Review Meeting
 “Enhance probabilistic safety assessment (PSA) to consider multi-units and to consider irradiated fuel bays (spent fuel pools)”

The new REGDOC-2.4.2 requires Level 1 and Level 2 PSAs that include all potential, site-specific initiating events and potential hazards:

- internal initiating events and internal hazards
- external hazards, both natural and human-induced, but non-malevolent

The new REGDOC-2.4.2 includes amendments regarding lessons learned from Fukushima. The revised requirements consider all sources of radioactivity – not just the reactor core. It introduced new requirements related to multi-units, irradiated fuel bays, and low-power operational states. It identifies specific external initiating events, such as seismic, flooding, and high wind. It also requires licensees to consider potential combinations of external hazards.

Consequential events (e.g., external consequential events, such as a tsunami caused by an earthquake) are also considered in the PSAs. A PSA is required for the full-power and shutdown states of the NPP as well as any state where the reactor is expected to operate for extended periods of time.

NPP licensees have either completed or are in the process of completing Level 1 and Level 2 PSAs that address, among other things, re-evaluation of site-specific external initiating events. These include:

- Level 1 and 2 at-power internal events
- Level 1 outage
- Level 1 internal flood
- Level 1 and 2 fire
- Level 1 and 2 seismic
- Level 1 and 2 high wind

The application of PSA in the assessment of external events is further discussed in subarticle 17(iii).

During the reporting period, the NPP licensees performed gap analyses against the revised requirements of REGDOC-2.4.2 and submitted their transition plans to CNSC. NPP licensees have started to transition towards compliance with REGDOC-2.4.2 requirements and all licensees are expected to be fully compliant by 2020. Full-scope PSAs are either completed or the licensees are making acceptable progress towards completion.

The new requirements for the irradiated fuel bay PSA may be dealt with through alternative methods to PSA (as allowed by REGDOC-2.4.2), for which guidance is currently being developed by industry. Licensees plan to complete this work in the next reporting period.

Recent PSA updates (now submitted every five years) have included estimates of the multi-unit PSA results (severe core damage frequency and large release frequency). Further, OPG is collaborating with other members of the industry in the development of a whole-site PSA methodology. A concept-level, whole-site PSA methodology has been issued as a COG document representing the common preliminary perspective of the industry. Industry, through COG, is developing a safety goal framework and a pilot

application of the whole-site PSA methodology. This methodology is expected to be completed by 2017.

Use of probabilistic safety assessment

Licensees are at various stages of utilizing the results from their PSAs. Typical applications include the use of PSA results in conjunction with deterministic analytical results to refine programs for reliability and maintenance. For example, PSA results are used to support the identification of the systems important to safety for the reliability program (see section 19(iii)). Recent developments at NPPs indicate a growing use of PSAs for risk monitoring. The most recent revisions of the PSAs for Darlington and Pickering were used to develop computerized tools for routine risk monitoring, using severe core damage frequency, for both outages and full-power operation. The PSAs have also been used to reduce risk at the NPPs by making changes to operating procedures that improve preparedness for an event. The PSAs will continue to be used to enhance operational risk monitoring programs, and will also provide input to NPP refurbishment decisions. For example, OPG investigated the implementation of possible cost-effective measures to meet its target core damage frequency for existing NPPs as part of the overall operational plan to the end of life for Pickering.

Design changes to improve safety have been identified through the use of PSA. Some examples are provided in annex 18(i).

Status of PSAs at each NPP

CNSC staff accepted in 2015 the results of the updated PSAs for Bruce A and B, which incorporate Fukushima enhancements. The PSA reports are consistent with the accepted methodologies, as well as applicable quality assurance requirements. The results show that the Fukushima enhancements improve safety in terms of providing mitigating capabilities as an additional layer of defence in depth for very rare events. The SCDF and the LRF limits were met for both Bruce A and Bruce B. The PSA results are posted on Bruce Power's website.

CNSC staff accepted in 2015 the Darlington PSA update, which evaluates the contribution of both the safety improvement opportunities and EME. CNSC staff accepted in 2014 the results of the updated Pickering PSA, which incorporated Fukushima enhancements. OPG is currently in the process of updating the Pickering PSA to incorporate the contribution of both the risk improvement plan and EME. The PSA reports are consistent with the accepted methodologies, as well as applicable quality assurance requirements. The Darlington and Pickering PSA update results show that the contributions described above and other Fukushima enhancements improved safety in terms of providing mitigating capabilities as an additional layer of defence in depth for very rare events. The SCDF and the LRF limits were met for both Darlington and Pickering. The results for both NPPs were posted on OPG's website.

NB Power is in the process of completing the first periodic update of its PSA reports that were originally submitted to and accepted by the CNSC in 2008. This update will include NB Power's responses to the CNSC Action Plan. The existing PSA reports are consistent with the accepted methodologies, as well as applicable quality assurance requirements. The results of the PSA updates submitted to-date have shown that the Fukushima enhancements improved safety in terms of providing mitigating capabilities as an additional layer of defence in depth for very rare

events. The assessments have demonstrated that the risk for severe core damage or large release frequency has been reduced significantly.

14 (i) (e) Reviews by the World Association of Nuclear Operators and IAEA

The NPP licensees and CNL are members of WANO, an organization dedicated to helping its members achieve the highest levels of operational safety and performance. WANO conducts periodic evaluations to promote excellence in the operation, maintenance and support of operating NPPs, with a focus on safety and reliability. These evaluations are not required by law or regulation but are requested on a voluntary basis by WANO members. Details of the WANO peer-review process are provided in the sixth Canadian report.

The following WANO peer reviews were conducted in Canada during the reporting period.

- | | |
|-----------------------------|----------------------------|
| • Bruce A and B (corporate) | September 2013 |
| • Bruce A | February 2014 |
| • Bruce B | June 2014 |
| • OPG (corporate) | November 2015 |
| • Darlington | March 2014 |
| • Pickering | June 2013, June 2015 |
| • NB Power (corporate) | December 2013 |
| • Point Lepreau | October 2013, October 2015 |
| • Gentilly-2 | No peer reviews conducted |

The feedback, insights and learning from the WANO peer-review process are highly valuable. The process drives major improvements and helps to continually raise the standard of performance and practice across the industry. In support of general improvement, WANO shares good practices identified during reviews with all members.

The following WANO peer reviews are planned in Canada during the next reporting period:

- | | |
|-----------------------------|---------------------------|
| • Bruce A and B (corporate) | 2017 |
| • Bruce A | September 2016 |
| • Bruce B | May 2017 |
| • Darlington | May 2016 |
| • Pickering | October 2017 |
| • Point Lepreau | Fall 2017 |
| • Gentilly-2 | No peer reviews scheduled |

An OSART mission was conducted at the Bruce B facility from November 30 to December 17, 2015. The OSART team identified 10 good practices, five recommendations, 12 suggestions and 25 good performances. Good practices were identified in planning for refurbishment and asset management, new tooling, safety, training, communications and emergency preparedness. The final report was posted on the Bruce Power and CNSC websites.

Canada has invited the IAEA to conduct OSART missions at several Canadian facilities over the next few years and one is scheduled for Pickering during the fall of 2016.

14 (i) (f) Integrated safety review for life extension

The following describes the work executed and announcements made related to ISR and life extension for NPPs during the reporting period. The incorporation of ISR in the licensing process is described in subsection 7(ii)(d).

Darlington refurbishment

The four reactors at Darlington came into service from the late 1980s to the early 1990s. During the reporting period, OPG completed an ISR and environmental assessment (EA) for Darlington refurbishment and continued operation. In March 2013, the Commission announced its positive decision on the EA, concluding that the proposed project is not likely to cause significant adverse environmental effects, taking into account mitigation measures identified in the assessment.

At the end of the reporting period, OPG had completed all of the necessary assessments for the refurbishment of all four Darlington units. As the Darlington refurbishment project started before the publication of CNSC regulatory document REGDOC-2.3.3, *Periodic Safety Reviews*, the assessments were performed per its predecessor regulatory document RD-360, *Life Extension of Nuclear Power Plants* instead. Specifically, in addition to the EA and an ISR in support of Darlington refurbishment, a global assessment report (GAR) and an integrated implementation plan (IIP) were completed, as required by RD-360. The ISR addressed all IAEA safety factors and CNSC safety and control areas and demonstrated a high level of compliance with modern codes, standards and practices. The ISR identified safety improvements to continue to enhance the current strong performance and allow for the safe long-term operation over the proposed extended plant life.

Darlington's new training facility for the refurbishment is described in annex 11.2(a).

Pickering extended operation

As mentioned in the sixth Canadian report, OPG conducted an extensive ISR in 2010 leading to its decision to incrementally extend the life of Pickering Units 5–8 (formerly known as Pickering B). The assessment covered not only various technical areas such as design and operation but also organizational and programmatic issues. The incremental life extension option was complemented by other activities linked to the end of life of the facility, such as annual updates of the continued operations plan (COP), the start of the sustainable operations plan (SOP) and preparations of longer term plans such as transition to safe storage prior to decommissioning.

The COP integrates the improvements necessary to close issues identified in the EA (2007) and ISR (2010) for Pickering Units 5–8. OPG has completed most of the activities identified in the Pickering Units 5–8 COP, with the remaining actions scheduled for completion prior to entering into the incremental life-extension time frame. Many of these improvements were related to lessons learned from the Fukushima accident and were described in the sixth Canadian report.

The SOP documents strategies, direction and actions to address the unique challenges, constraints and risks associated with the approach to the end of commercial operation. It describes the arrangements and activities required to demonstrate that safe and reliable operation of Pickering will be maintained and sustained, for each of the 14 CNSC safety and control areas, for the period of operation up to and until each reactor unit's permanent shutdown. From a program perspective, no changes were required. The plans dealt primarily with people issues and

with business issues pertaining to the life expectancy of the plant. The SOP also contains some preliminary information about the first stages of the transition to safe storage.

The assessment of remaining pressure tube life at Pickering Units 5–8 is described later in subsection 14(ii)(b).

In conjunction with the pending decision to extend the life of Pickering Units 5–8 to 2024 (see details in subsection D.2 of chapter I), a PSR update is required. It will build on the review basis of earlier PSR work and other associated assessments, specifically the ISR for Pickering Units 5-8, the integrated safety assessments for Pickering Units 1–4 (formerly known as Pickering A) and the ISR for Darlington.

Additional details on Canada’s introduction of PSRs for licence renewals can be found in subsection 7.2(ii)(d).

14 (i) (g) Assessment and resolution of CANDU safety issues

Comprehensive provisions for the assessment and verification of safety for Canadian NPPs have confirmed the ongoing safety of operating NPPs in Canada. As part of this process, these provisions have led to the identification and resolution of safety issues, some of which have been described in previous Canadian reports. In recent years, it was recognized that a more systematic approach to identifying, prioritizing and resolving safety issues would optimize the improvements to safety that would be realized by these efforts.

In 2009, the CNSC and industry collaborated on a project to survey generic safety issues related to CANDU NPPs, rank them and evaluate strategies for addressing them in a risk-informed manner. The CANDU safety issues (CSIs) were distributed into three broad categories according to the adequacy and effectiveness of the control measures implemented by the licensees to maintain safety margins.

- **Category 1** represents issues that have been satisfactorily addressed in Canada.
- **Category 2** represents issues that are a concern in Canada, but appropriate measures are in place to maintain safety margins.
- **Category 3** issues are a concern in Canada and measures are in place to maintain safety margins, but the adequacy of these measures needs to be confirmed.

The continued operation of an NPP in the presence of these issues is judged to be permissible – none of the Category 3 issues involves a level of incremental risk that requires immediate corrective action. Issues with confirmed and immediate safety significance are addressed by other means on a priority basis (see subarticles 7.2(iii) and (iv)).

A risk-informed decision making process (as described in the sixth Canadian report) was applied to the Category 3 CSIs to identify, estimate and evaluate the risks associated with each issue and to recommend risk control measures. In accordance with defence-in-depth principles, the risk assessment covered all possible combinations of events that could potentially lead to fuel damage, adverse effects to people or the environment, or any combination thereof.

To address the Category 3 CSIs effectively, they have been logically separated into two groups – those associated with LBLOCAs and those that are not (referred to as non-LBLOCA issues).

The CNSC maintains regulatory control of the resolution of the CSIs by monitoring the path forward, established through a mutual agreement with the NPP licensees. During the reporting

period, no new Category 3 CSIs were opened and seven of the CSIs were downgraded from Category 3 to Category 2 for all NPPs:

- computer code and plant model validation
- fuel-channel integrity and effect on core internals
- impact of ageing on safe plant operation
- analysis methodology for neutron overpower protection/regional overpower protection
- steam line breaks in balance of plant
- aging of equipment and structures
- fuel bundle/element behaviour under post dryout conditions

Some of the other issues were downgraded from Category 3 to Category 2 for some (but not all) of the NPPs.

The remaining Category 3 CSIs divided by category, are as follows:

- Category 3 LBLOCA CSIs:
 - Analysis for void reactivity coefficient
 - Fuel behaviour in high temperature transients
 - Fuel behaviour in fuel pulse transients
- Category 3 non-LBLOCA CSI:
 - Systematic assessment of high energy line break effects

For the LBLOCA CSIs, the CNSC has developed an interim regulatory position, which established a set of interim action level limits for safety margin parameters and design-basis accident acceptance criteria for all NPPs. This position is consistent with the risk control measures for CSIs and will remain in effect until the recommendations of the industry LBLOCA working group are accepted by the CNSC and are fully implemented by the industry. The non-LBLOCA CSI requires further experimental and/or analytical studies to resolve it; this work is ongoing. It is expected that the work to address the remaining four Category 3 CSIs will be completed in the next reporting period.

The CNSC annual *Regulatory Oversight Report for Canadian Nuclear Power Plants*, which describes the Category 3 issues and the required risk control measures, is publicly available.

14 (i) (h) Fulfilling principle (2) of the 2015 Vienna Declaration on Nuclear Safety

Principle (2) of the 2015 *Vienna Declaration of Nuclear Safety* (VDNS) requires comprehensive and systematic safety assessments to be carried out periodically and regularly for existing installations throughout their lifetime to identify safety improvements that are oriented to meet the objective of principle (1) of the VDNS (chapter I). As described in section E of chapter I, the objective in principle (1) is that new NPPs are designed, sited and constructed, consistent with the objective of preventing accidents in the commissioning and operation and, should an accident occur, mitigating possible releases of radionuclides causing long-term off site contamination and avoiding early radioactive releases or radioactive releases large enough to require long-term protective measures and actions. Principle (2) of the VDNS also requires reasonably practicable or achievable safety improvements, in support of that objective, to be implemented in a timely manner.

Canada fulfils principle (2) through both global and specific assessments that are described in detail in this article. Licensees have completed ISRs for the refurbishment of specific NPPs,

which included comparisons with the latest CNSC regulatory documents and other modern standards. ISRs have been completed for Bruce A, Units 1 and 2 (2007), Point Lepreau (2008), Pickering 5-8 (2010), and Darlington (2015). Reasonably practicable safety improvements were made as a result; see the sixth Canadian report for details. Furthermore, CNSC is introducing PSRs into the licensing process (see subsection 7.2(ii)(d)). Some licensees have already begun preparation of PSRs in anticipation of the next renewal of their licences to operate the NPPs. These PSRs are being conducted using the most recent regulatory documents which, as explained in subsection 7.2(i)(b), satisfy the objective in principle (1) of the VDNS. The PSR process will include IIPs to systematically execute safety improvements that address gaps found during the PSR.

Other assessments and verifications (which are also conducted using updated regulatory documents and standards) include:

- updated safety analyses and safety analysis reports
- PSAs (and ongoing work to enhance them)
- surveillance, testing and inspection activities that confirm that the NPPs meet the appropriate detailed design and safety requirements as well as operational limits and conditions
- rigorous aging management programs

These assessments and verifications, also described in this article, have led to safety improvements aligned with the updated regulatory documents and standards.

In summary, comprehensive and systematic assessments of the existing NPPs have been carried out and will continue to be carried out, periodically. These have resulted in numerous safety improvements that helped meet the objective stated in principle (2) of the VDNS.

14 (ii) Verification of safety

This subsection describes the activities to verify – by analysis, surveillance, testing or inspection – that an NPP meets the appropriate design and safety requirements as well as its operational limits and conditions. While these activities are carried out primarily by the licensee, the CNSC also conducts various verifications of safety (as described in other articles of this report). For example, the CNSC maintains permanent staff members at each NPP (see subsection 8.1(b)) who monitor operations, verify safety in certain circumstances and conduct a wide range of inspections with the assistance from specialists from CNSC headquarters in Ottawa.

CNSC staff members also review details in reports submitted by NPP licensees per CNSC regulatory document REGDOC-3.1.1. These include event reports and quarterly/annual reports on matters such as safety performance indicators, fuel monitoring and inspection, pressure boundaries, radiation protection, environmental protection, and risk and reliability. The most safety-significant situations are pursued by special reviews or focused inspections, which are often followed up through specific action items at individual NPPs. CNSC staff members also review the safety analysis reports and safety system reliability studies that are submitted per REGDOC-3.1.1.

Furthermore, CNSC staff members also review and approve certain operational changes or other changes to items in the licensing basis (see subsection 7.2(ii)(d)). CNSC staff members verify that proposed changes are within the licensing basis (e.g., by confirming that they do not

significantly erode the margin of safety for the NPP that was agreed upon at the time of licensing).

CNSC licences to operate the existing NPPs contain conditions governing the licensee's verification of safety through various fitness-for-service programs. The licensees' programs include testing (see subsection 14(ii)(a)) and various aging management programs to address specific critical systems and aging mechanisms (see subsection 14(ii)(b)).

14 (ii) (a) Testing - General

CNSC regulatory document RD/GD-98, *Reliability Programs for Nuclear Power Plants*, which is part of the licensing basis for NPPs – includes general requirements for the reliability program for systems important to safety. RD/GD-98 addresses the roles of inspection, testing, modelling and monitoring in the identification of systems important to safety, their failure modes and their appropriate reliability targets, as well as confirmation that the targets are met (see subarticle 19(iii) for more information). The licensing basis also includes other standards that include extensive requirements for testing safety-related components and systems. For example, requirements for testing and acceptance criteria are found in the following CSA standards:

- N285.4, *Periodic inspection of CANDU nuclear power plant components*
- N285.5, *Periodic inspection of CANDU nuclear power plant containment components*
- N287.7, *In-service examination and testing requirements for concrete containment structures for CANDU nuclear power plants*

As described in the following section, the licensees execute periodic inspection programs for critical components and systems. The various testing requirements are addressed in the management systems, policies and operational programs and procedures at the NPPs.

Thousands of safety-related tests are conducted annually at each NPP. These tests typically have a pass rate on the order of 99.9 percent. Testing to confirm the availability and functionality of safety and safety-related systems is also described in subarticle 19(iii).

14 (ii) (b) Aging management

All NPPs experience materials degradation. Their SSCs are subjected to a variety of chemical, mechanical and physical influences during operation. In time, stressors such as corrosion, load variations, flow conditions, temperature and neutron irradiation cause degradation of materials and equipment. This time-dependent degradation is referred to as aging. Aging management is the set of engineering, operational, inspection and maintenance actions that control, within acceptable limits, the effects of physical aging and obsolescence on an NPP's SSCs.

Experience with several significant material degradation mechanisms during the life of currently operating NPPs in Canada has led to the development, formalization and documentation of a number of aging management programs. These programs provide for materials and component inspection and assessment techniques and intervals to ensure that all safety-significant SSCs are maintained within the safe operating limits allowed by relevant codes and standards. Aging management programs are based on comprehensive methodologies involving surveillance, the production and monitoring of system health reports, inspections by qualified inspection personnel and preventive maintenance. They are regularly reviewed and updated, as required, to incorporate and allow for new information and findings. CNSC staff members regularly review the results of activities covered by the aging management programs.

In 2015, the CNSC issued the regulatory document REGDOC-2.6.3, *Aging Management*, to provide regulatory requirements and guidance for aging management. REGDOC-2.6.3 supersedes CNSC regulatory document RD-334, *Aging Management of Nuclear Power Plants*. The requirements and guidance set out in REGDOC-2.6.3 are consistent with the guidance in the IAEA safety guide NS-G-2.12, *Ageing Management for Nuclear Power Plants* and the IAEA safety report series No. 82, *International Generic Ageing Lessons Learned*. REGDOC-2.6.3 emphasizes the need for early and proactive consideration of aging management for all stages of an NPP's lifecycle: design, fabrication, construction, commissioning, operation, life extension, and decommissioning. It also provides requirements for the establishment, implementation and improvement of integrated aging management programs, through the application of a systematic and integrated approach. The approach includes organizational arrangements, data management, SSC selection, aging evaluation and condition-assessment processes, documentation and interfaces with other supporting program areas (such as the review and improvement of the program).

During the reporting period, the NPP licensees began to adapt their aging management programs, as necessary, to meet the requirements of REGDOC-2.6.3.

The main areas of focus under aging management include feeder pipes, fuel channels, flow-accelerated corrosion, steam generators, containment and general component replacement. The basic aging management programs for these areas are described in annex 14(ii)(b). The fuel channel lifecycle management project is particularly important in that its results help confirm the safety of ongoing operation of the NPPs as they approach their anticipated end of life, since the pressure tubes in the fuel channels are typically the major life-limiting component in the CANDU design.

The current assumed pressure tube design life is based on 30 years of operation at 80 percent capacity factor (which correspond to 210,000 EFPH per reactor from the date of first criticality).

For Pickering Units 5–8, the assumed design life for the lead reactor would have been reached in late 2014. When the Pickering operating licence was renewed in 2013, it included a regulatory hold point requiring the licensee to obtain permission from the Commission to continue operation prior to the lead reactor unit reaching 210,000 EFPH.

Through a joint fuel channel lifecycle management project, industry developed refined engineering methodologies and models of degradation mechanisms in materials used for pressure tubes (including delayed hydride cracking as a result of deuterium uptake). These methodologies and models were used to conservatively assess the fitness for service of the pressure tubes. Additionally, industry developed inspection and maintenance programs to ensure continued validation of the engineering assessments.

CNSC staff assessed and accepted the methodologies and models submitted by OPG along with the results that showed safe operation of Pickering beyond 210,000 EFPH. Based on the evidence provided for safe operation of pressure tubes, the Commission removed the regulatory hold point in 2014 and approved operation of Pickering up to 247,000 EFPH. In its decision, the Commission required increased monitoring, inspection and reporting by OPG and CNSC staff on the operation of Pickering.

During the licence renewal hearings held in 2015, both Bruce Power and OPG requested operation of the Bruce A and B and Darlington facilities, respectively, beyond 210,000 EFPH.

The Commission approved the operation of Bruce A and B up to 247,000 EFPH and the operation of Darlington up to 235,000 EFPH.

The CNSC has also established a licence condition requiring licensees to develop inspection programs to monitor the conditions of safety-significant, balance-of-plant pressure boundary components and structures (containment structures are addressed by separate licence requirements). Industry and the CNSC developed the new CSA standard N285.7, *Periodic inspection of CANDU nuclear power plant balance of plant systems and components* that provides minimum periodic inspection requirements for balance of plant systems and components. The first edition of N285.7 was published in 2015. Portions of this standard have been developed using the methodologies and definitions for risk-informed in-service inspection from EPRI and the American Society of Mechanical Engineers publications.

Article 15 – Radiation protection

Each Contracting Party shall take the appropriate steps to ensure that in all operational states the radiation exposure to the workers and the public caused by a nuclear installation shall be kept as low as reasonably achievable and that no individual shall be exposed to radiation doses which exceed prescribed national dose limits.

Canada sponsors significant R&D in the field of nuclear safety, as described in appendix E. A significant portion of the activity addresses the areas of radiation protection, radiation monitoring, environmental protection, environmental management and other related topics.

In Canada, high-level requirements related to controlling radiation exposure of nuclear energy workers² and members of the public are found in the *General Nuclear Safety and Control Regulations*. Paragraph 12(1)(c) of the *General Nuclear Safety and Control Regulations* requires every licensee to take all reasonable precautions to protect, among other things, the health and safety of persons. Key requirements are also found in the *Radiation Protection Regulations*. The CNSC recently recognized the need to review the *Radiation Protection Regulations* in light of developments since their introduction in the year 2000, including:

- **Changes to international benchmarks**

In 2007, the International Commission on Radiological Protection (ICRP) published a revised set of recommendations for its system of radiological protection. These recommendations were published in ICRP Publication 103 (ICRP 103), which incorporates updates based on more recent scientific information as well as new guidance on controlling radiation exposure. The current *Radiation Protection Regulations* are largely based on ICRP 60, which was published in 1990. Additionally, in 2006, the IAEA undertook a review and initiated a revision of the 1996 edition of its *International Basic Safety Standards*, in cooperation with other organizations. The IAEA published the revised standards in 2014, incorporating the ICRP 103 recommendations and other safety-related improvements.

- **The Fukushima accident**

The CNSC's review of the regulatory framework following the Fukushima accident found, specifically, that the *Radiation Protection Regulations* needed to be updated and aligned with the above international benchmarks in order to ensure that the prescribed dose limits for emergency workers are consistent with the actions that workers are required to take during the control of an emergency.

- **Other lessons learned**

Since the *Radiation Protection Regulations* came into force in May 2000, the CNSC has identified opportunities to address specific gaps and provide additional clarity.

² Nuclear energy worker is a person who is required, in the course of the person's business or occupation in connection with a nuclear substance or nuclear facility, to perform duties in such circumstances that there is a reasonable probability that the person may receive a dose of radiation that is greater than the prescribed limit for the general public.

The CNSC published a discussion paper describing the proposals to amend the *Radiation Protection Regulations* in August 2013 and posted it on the CNSC website for 120 days. Following this, in January 2014, the CNSC posted on its website the comments it had received, and issued an invitation for stakeholders to provide their feedback on the comments. The CNSC received 42 submissions, totalling more than 400 comments from stakeholders, over the course of the two comment periods. CNSC staff subsequently published a report in 2015 detailing the feedback received from stakeholders and the next steps for the project to amend the *Radiation Protection Regulations*. The CNSC is drafting the amended regulation. It is anticipated that the amended *Radiation Protection Regulations* will be published in 2017.

To verify compliance with licence conditions and regulations, CNSC staff members review documentation and operational reports submitted by applicants and licensees and evaluate the implementation of licensees' radiation protection and environmental protection programs through desktop reviews and onsite inspections. CNSC staff members also:

- monitor and evaluate the radiological and environmental impacts of licensed activities
- conduct onsite evaluations of licensed dosimetry service providers

Events related to potential and actual exposure to radiation or hazardous substances, releases to the environment of nuclear and hazardous substances (e.g., reaching an action level for radiation protection or environmental protection, see below) are reported to the CNSC in accordance with CNSC regulatory document REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*. CNSC staff members review the event reports and the reporting, analysis, and corrective processes of licensees, to verify their compliance with regulatory requirements and their effectiveness in correcting weaknesses. CNSC staff members also investigate significant events related to radiation protection.

Paragraph 3(1)(f) of the *General Nuclear Safety and Control Regulations* requires that an application for a licence contain any proposed action levels. An action level is defined in subsection 6(1) of the *Radiation Protection Regulations* as a specific dose of radiation or other parameter that, if reached, may indicate a loss of control of part of a licensee's radiation protection program and triggers a requirement for specific action to be taken. When an action level, whether radiation protection or environmental protection, is reached, the licensee must notify the CNSC, conduct an investigation to establish the cause for reaching the action level, and identify and (if appropriate) take action to restore the effectiveness of the radiation or environmental protection program. REGDOC-3.1.1 requires that when a licensee becomes aware that an action level has been reached they must submit a report to the Commission within the time period specified in the licence, which is currently set at seven days. These reports must describe the results of the investigation, identify the actions taken to restore the effectiveness of the program, identify any missing information, and further describe how and when the remaining information will be provided to the CNSC. If any required information was missing from the initial report, the licensee must file the missing material within 60 days of the original report.

15 (a) Radiation protection for workers and application of the ALARA principle

General requirements and activities for radiation protection of workers

In addition to the requirements in the *General Nuclear Safety and Control Regulations* mentioned above, paragraph 12(1)(e) requires all persons at the site of a licensed activity to use

equipment, devices, clothing and procedures in accordance with the NSCA, the regulations and the licence.

Paragraph 4(a) of the *Radiation Protection Regulations* requires that every licensee implement a radiation protection program and, as part of that program, keep the amount of exposure to radon progeny and the effective dose and equivalent dose received by and committed to persons as low as is reasonably achievable (ALARA), social and economic factors being taken into account.

In addition, section 13 of the *Radiation Protection Regulations* requires that every licensee ensure the following effective dose limits are not exceeded:

- 50 mSv in a one-year dosimetry period and 100 mSv over a five-year dosimetry period for a nuclear energy worker
- 4 mSv for a pregnant nuclear energy worker for the balance of pregnancy
- 1 mSv per calendar year for a person who is not a nuclear energy worker

Additional information on the *Radiation Protection Regulations*, dosimetry requirements, and guidance related to the ALARA principle and the setting of radiation protection action levels is provided in annex 15(a).

To fulfill the related regulatory requirements, NPP licensees establish, maintain and document programs to effectively manage and control radiological risk to workers, as well as the public. An objective of these programs is to ensure that workers are only exposed to radiological risks that are low, understood and voluntarily accepted. To ensure that the exposures to workers are ALARA, the licensees implement processes for:

- management control over work practices
- personnel qualification and training
- control of occupational and public exposure to radiation
- planning for unusual situations

Examples of three specific licensee strategies to minimize the dose to workers are described below.

Increased use of technology is a key component of the ALARA program. Some licensees have installed remote monitoring equipment to improve radioactive work planning and reduce dose to workers. Remote monitoring for radiological hazards has reduced dose by not requiring staff to enter certain areas to perform routine radiation surveys, and have enabled workers to select protective equipment appropriate to the current and anticipated hazard conditions, as well as respond to changing conditions. Robotics have been used by some licensees to inspect and remove hot spots of elevated contamination, thereby minimizing worker dose. Remotely operated cameras have been used to perform visual inspections and monitoring of inaccessible areas. Radiography services at NPPs are implementing pulsed x-ray technology instead of gamma sources to reduce the dose that workers would normally receive from handling the sources. One licensee has designed and implemented a new reactor inspection maintenance tool to reduce worker time in high dose rate areas.

Source term control measures are in place to reduce doses to workers from exposure to various hazards. The measures include more frequent replacement of desiccant in dryer units and improvement of the material condition of dryer systems; some licensees also de-tritiate their heavy-water inventory. Several licensees have implemented shielding canopies and reactor face shielding tiles to reduce gamma dose to workers. Licensees are also working to reduce the

recurrence of hot spots through initiatives involving either reduction of the filter pore size or an increase in the flow rate of the heat transport purification system. Filter pore size reduction is being addressed through new technology such as new-generation nano-fibre media to improve efficiency at removing colloidal matter from the primary heat transport system. Finally, by applying operational experience, all licensees have enhanced their contamination control programs to better manage and control risks from alpha hazards.

Training is also essential to keeping doses ALARA. Some licensees provide mock-up training for jobs with elevated radiological risk. In preparation for refurbishment, full-scale mock-ups for tool testing and worker familiarization have been built. The use of mock-ups enables optimization of procedures that reduce time spent in the radiation field. One licensee has actively pursued the use of dynamic learning activities, wherein an activity or task being taught includes, as is best possible, the actual conditions encountered and tools required; real world situations are simulated and the activity is enhanced with role playing by other participants. To further limit tritium exposure, some licensees reinforce the need to plug in plastic suits at every opportunity to refill them with fresh air (thereby limiting unplugged periods to less than 60 seconds).

Each year, licensees establish challenging radiation dose performance targets based upon the planned activities and outages for the year. They are analogous to the constraints recommended in the IAEA safety guide NS-G-2.7, *Radiation Protection and Radioactive Waste Management in the Operation of Nuclear Power Plants*. CNSC staff members verify that the NPP licensees monitor their performance against internal radiation dose performance targets and that this information is used to improve radiation protection performance.

Doses to workers

Health Canada maintains the National Dose Registry, which contains the radiation monitoring records of all occupationally exposed workers in Canada.

Doses to workers were below regulatory limits during the reporting period (see annex 15(a), which charts and discusses doses to workers at Canadian NPPs). During the reporting period, the total collective dose at Canadian NPPs varied due to a number of factors such as:

- the dose rates associated with the type of work being performed
- the number of outages each year
- the scope and duration of outage work
- the number of people involved in outage work

15 (b) Environmental protection and radiological surveillance

Requirements for protection of the environment

The requirements related to protecting people and the environment by controlling the release of nuclear and hazardous substances are found in the *General Nuclear Safety and Control Regulations*. Paragraph 12(1)(c) of the *General Nuclear Safety and Control Regulations* requires every licensee to take all reasonable precautions to protect, among others, the health and safety of persons and the environment. Paragraph 12(1)(f) requires every licensee to take all reasonable precautions to control the release of radioactive nuclear substances or hazardous substances within the site of the licensed activity and into the environment as a result of the licensed activity.

As mentioned in subsection 15(a), section 13 of the *Radiation Protection Regulations* requires that every licensee ensure that doses to non-nuclear energy workers do not exceed 1 mSv per calendar year.

The CNSC regulatory policy P-223, *Protection of the Environment*, describes the principles and factors that guide the CNSC in regulating the development, production and use of nuclear energy, and the production, possession and use of nuclear substances, prescribed equipment and prescribed information. This policy describes how the CNSC assures that the environment is protected in a manner consistent with Canadian environmental policies, acts and regulations and consistent with Canada's international obligations. Pollution prevention is incorporated into this policy by applying the ALARA principle to all releases to the environment.

The CNSC regulatory document REGDOC-2.9.1, *Environmental Protection: Policies, Programs and Procedures*, which was published in September 2013, superseded regulatory document S-296, *Environmental Protection, Policies, Programs and Procedures at Class I Nuclear Facilities and Uranium Mills and Mines*. NPP licensees have implemented, or are in the process of implementing REGDOC-2.9.1. The REGDOC provides direction and guidance to the licensee towards developing and implementing an integrated set of documented activities (an environmental management system) as the means to adequately provide for the protection of the environment at Class I nuclear facilities and uranium mines and mills.

Programs to control and monitor radioactive releases

As part of environmental management systems, Canadian NPPs have established programs to control and monitor the effect of operations (both nuclear and hazardous) on human health and the environment. These programs include an objective to maintain a low level of public risk compared to other normal public risks that arise from industrial activity. Typical elements include management of releases and waste, worker training and informing the public.

In support of these programs, NPP licensees conduct environmental risk assessments (ERAs), which are evaluations or analyses of risks associated with contaminants and disturbances in the environment relevant to a facility. Details regarding ERAs are provided in CSA standard N288.6, *Environmental risk assessment at class I nuclear facilities and uranium mines and mills*, which is being implemented by the NPP licensees. ERAs are also used in developing environmental assessments (EA; see article 17) and are regularly updated, per the requirements of REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*.

Other important measures include the monitoring of releases, the establishment of environmental release limits and action levels, and environmental monitoring, which are discussed below.

Although radioactive material released into the environment through gaseous emissions and liquid effluents from NPPs can result in radiation doses to members of the public through environmental exposure pathways, the doses received by the public from routine releases from NPPs are too low to measure directly. Therefore, to ensure that the public dose limit is not exceeded, the CNSC restricts the amount of radioactive material that licensees may release. These gaseous and effluent limits are derived from the public annual dose limit of 1 mSv, and are called derived release limits (DRLs). A DRL for a given radionuclide/radionuclide group is a specific release limit for a route of release (exposure pathway) from an NPP. If the total of the measured releases for each gaseous or waterborne effluent, expressed as percentages of their

respective DRLs, exceeds 100 percent, members of the public with the greatest exposure may exceed the public dose limit over the calendar year. The phrase “members of the public with the greatest exposure” refers to individuals who receive the highest doses from a particular source due to factors such as proximity to the release, dietary and behavioural habits, age and metabolism, and variations in the environment.

The calculation of DRLs is based on methodology in the CSA standard N288.1, *Guidelines for Calculating Derived Release Limits for Radioactive Material in Airborne and Liquid Effluents for Normal Operation of Nuclear Facilities*. DRLs are also based on other developments in radiation protection (e.g., ICRP dose conversion factors). DRLs are unique to each facility, vary in values, and depend on several factors (assumptions, representative person characteristics, site-specific data, etc.). The calculation of DRLs can vary from simple to exceedingly complex. As a result, DRLs are reviewed and, if necessary, updated approximately every five years.

For environmental protection, licensees set environmental action levels well below the DRLs. These action levels provide a warning, when exceeded, of a possible loss of control in the emissions management systems and allows for prompt corrective action. This enables licensees to keep liquid effluent and gaseous emission releases well below their respective DRLs.

NPP licensees monitor airborne emissions for tritium, iodine, noble gases, carbon-14 and particulates, as well as waterborne emissions for tritium, carbon-14 and gross beta-gamma radioactivity. Releases of gaseous emissions and liquid effluents from Canadian NPPs from 2013 to 2015 are tabulated in annex 15(b), along with the corresponding DRLs. During the reporting period, all releases from Canadian NPPs were very low: less than 1 percent of the DRLs. From 2013 to 2015, there were no reported cases of environmental action levels being exceeded.

In addition to tracking radiological emissions from the NPP, licensees have radiological environmental monitoring programs to monitor radioactivity and other interactions with the environment around the facilities in the air, water and food chain products. These environmental monitoring programs are designed with the goal of protecting the environment and the health of persons. The environmental monitoring programs aim to:

- assess the level of risk on human health and safety, and the potential biological effects in the environment of the contaminants and physical stressors of concern arising from the facility
- demonstrate compliance with limits on the concentration and/or intensity of contaminants and physical stressors in the environment or their effect on the environment
- check, independently of effluent monitoring, on the effectiveness of containment and effluent control, and provide public assurance of the effectiveness of containment and effluent control
- verify the predictions made by the ERA, refine models used in the ERA, or reduce the uncertainty in the predictions made by the ERA

The licensee environmental monitoring programs are based on the requirements of CSA standards N288.5, *Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills* and N288.4 *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills*. The results from these monitoring programs are used to ensure that the public legal limit in Canada for effective dose from the operation of NPPs is not exceeded.

The Canadian Radiological Monitoring Network, established by Health Canada, offers Canadians accurate health assessments based on existing levels of radioactivity near NPPs, as well

as radioactivity that may result from a nuclear accident. The program consists of monitoring ambient gamma radiation at 34 sites, radioactive aerosols at 26 sites, and atmospheric tritium at 15 sites. These tests are augmented in a few locations with drinking water and milk sampling. (See appendix C of Canada's report to the Second Extraordinary Meeting of the CNS for additional details.) The Ontario Ministry of Labour's Radiation Protection Service also monitors environmental radiation, within the province of Ontario.

Study of Consequences of a Hypothetical Severe Nuclear Accident and Effectiveness of Mitigation Measures

In response to concerns raised during the December 2013 Commission hearing for the EA for the refurbishment of Darlington, the Commission requested CNSC staff to assess the health and environmental consequences of severe accident scenarios. The assessment, titled *Study of Consequences of a Hypothetical Severe Nuclear Accident and Effectiveness of Mitigation Measures*, was completed in 2014. It involved selecting a source term and various scenarios that reflected different containment hold-up periods and release durations. Further, to simulate an accident affecting all four reactor units at Darlington, the amount of radionuclides released in the scenario was increased fourfold for two of the scenarios. The transport and dispersion of the radioactive material through the environment was modelled. Based on this, doses were estimated and compared against provincial protective action levels for Ontario. The protective action levels were then applied to the estimated doses to determine how far to evacuate, shelter and administer potassium iodide (KI) pills for ingestion. Based on the assumed implementation and effectiveness of a given protective action, doses were adjusted accordingly. The residual doses that remained after the application of protective actions were used as inputs into the human health risk assessment. Using a methodology consistent with international practice, increased cancer risk for all cancers combined, leukemia and thyroid cancer (both adult and children) were quantitatively assessed based on an exposure to radiation from the hypothetical accident scenarios for the first seven days. The study concluded that, in the unlikely event of a severe radioactive release, there would be no detectable increased risk of cancer for most of the population, with the exception of an increase in childhood thyroid cancer risk.

Regardless of the scenario examined, the results of this theoretical study found that dose would decrease rapidly with distance. Furthermore, for all scenarios examined in this study, the emergency planning zones established under the Ontario Provincial Nuclear Emergency Response Plan using the established evacuation criteria would generally be sufficient in size to accommodate the evacuation needed. Emergency planning is inherently flexible and consideration of sensitive receptors, such as children in emergency planning, is an integral part of federal and provincial emergency decision making. In the event of an actual accident with this level of predicted risk, decision makers could further mitigate the risk in those areas most likely to be affected through the further administration of KI pills or by evacuation.

Following the public consultation period, the draft report was revised to address the comments received from the public. The report was finalized and published on the CNSC website in September 2015.

Release of hazardous substances

In addition to regulating the control of radioactive releases, the CNSC also requires licensees to control and monitor their releases of hazardous substances. The licensees monitor the releases of

hazardous substances in compliance with the various applicable local, provincial and federal regulations, and in accordance with CNSC regulations, policies and guides. The amount of hazardous substances released to the environment is reported to the CNSC per REGDOC-3.1.1.

Independent Environmental Monitoring Program

During the reporting period, the CNSC launched the Independent Environmental Monitoring Program (IEMP) to align with other Canadian and international regulatory bodies. The IEMP complements CNSC staff reviews and approvals of licensees' environmental monitoring programs and confirms that licensees are adhering to the regulatory requirements, licence conditions and approved programs throughout the operation of nuclear facilities.

The IEMP is performed by CNSC staff in public areas and consists of sampling environmental media and analyzing radiological and non-radiological substances released from facilities in all areas of the nuclear fuel cycle: uranium mines and mills, processing facilities, NPPs, research reactors and waste management facilities.

Samples are analyzed at the CNSC's state-of-the art laboratory using industry best practices. Samples are analyzed for radiological and non-radiological contaminants related to the activities of the nuclear facility. Samples may be taken for air, water, soil, sediment, vegetation (e.g., grass) and foodstuffs (e.g., meat and produce). The results are compared to appropriate federal and/or provincial guidelines to confirm that the public and the environment in the vicinity of the facility are safe and there are no health impacts as a result of facility operations. Conclusions and data are then published to a user-friendly map on the CNSC website. A full technical report is also available upon request.

IEMP results for Canadian NPPs are available on the CNSC website for the years indicated below:

- Bruce A and B 2013
- Darlington 2014
- Pickering 2014, 2015
- Point Lepreau 2014, 2015
- Gentilly-2 2015

Article 16 – Emergency preparedness

1. Each Contracting Party shall take the appropriate steps to ensure that there are on-site and off-site emergency plans that are routinely tested for nuclear installations and cover the activities to be carried out in the event of an emergency. For any new nuclear installation, such plans shall be prepared and tested before it commences operation above a low power level agreed by the regulatory body.
2. Each Contracting Party shall take the appropriate steps to ensure that, insofar as they are likely to be affected by a radiological emergency, its own population and the competent authorities of the States in the vicinity of the nuclear installation are provided with appropriate information for emergency planning and response.
3. Contracting parties which do not have a nuclear installation on their territory, insofar as they are likely to be affected in the event of a radiological emergency at a nuclear installation in the vicinity, shall take the appropriate steps for the preparation and testing of emergency plans for their territory that cover the activities to be carried out in the event of such an emergency.

16.1 Emergency plans and programs

16.1 (a) General responsibilities of the licensees, regulatory body and other authorities

In Canada, licensees of nuclear facilities are responsible for onsite emergency planning, preparedness and response. Onsite nuclear emergencies are those that occur within the physical boundaries of a Canadian NPP.

Offsite nuclear emergencies are those that have an effect outside the boundaries of a Canadian NPP. In the event of an accident at an NPP with potential offsite consequences, the offsite response would follow a process involving the following parties:

- the licensee
- municipal government
- provincial/territorial governments
- federal government

The **provincial governments** are responsible for:

- overseeing public health and safety and protection of property and the environment
- enacting legislation to fulfill the province's lead responsibility for public safety
- preparing emergency plans and procedures and providing direction to municipalities that they designate to do the same
- managing the offsite response by supporting and coordinating the efforts of organizations with responsibility in a nuclear emergency
- coordinating support from the NPP licensee and the Government of Canada during preparedness activities and response in a nuclear emergency

Federal government support and response for potential offsite impacts are required for addressing areas of federal responsibility, including an incident's effects that extend beyond provincial or national borders. Likewise, the coordination of federal assistance when requested

by an affected province is also required. Some provinces have agreements with the Government of Canada for the provision of specific types of technical support. Federal responsibility also encompasses a wide range of contingency and response measures to prevent, correct or eliminate accidents, spills, abnormal situations and emergencies, and to support provinces and territories in their responses to a nuclear emergency. The Government of Canada is also responsible for:

- liaison with the international community
- liaison with diplomatic missions in Canada
- the assistance of Canadians abroad
- coordination of the national response to a nuclear emergency occurring in a foreign country

Public Safety Canada ensures coordination across all federal departments and agencies responsible for national security and the safety of Canadians. It is responsible for coordinating the overall federal government response to emergencies in support of the provinces and territories, including nuclear emergencies.

Public Safety Canada is the lead authority for the *Federal Emergency Response Plan* (FERP). Health Canada is the lead authority for the *Federal Nuclear Emergency Plan* (FNEP), an event-specific annex to the FERP. It also has responsibilities related to radiation protection, including cross-Canada monitoring networks, laboratories and decision-support systems. Health Canada administers a federal interdepartmental and a federal–provincial nuclear emergency management committee, as well as a training and exercise program. Internationally, Health Canada and the CNSC serve as national competent authorities to the IAEA.

In addition to the CNSC, other federal organizations with responsibilities in nuclear emergency preparedness and response, as described in the FNEP, include:

- the Department of National Defense/Canadian Forces, which are responsible for dealing with emergencies involving foreign nuclear-powered vessels entering Canadian waterways
- Transport Canada, which is responsible for the Canadian Transport Emergency Centre
- Environment and Climate Change Canada, which is responsible for providing atmospheric modelling services to the FNEP Technical Assessment Group and the IAEA as part of its emergency response functions
- Natural Resources Canada (NRCan), which is responsible for providing emergency radiation mapping and surveying services, providing policy advice and coordinating federal actions in relation to nuclear liability
- the Public Health Agency of Canada, which is responsible for public health issues and is the national authority for reporting to the World Health Organization under the *International Health Regulations*

Response to Fukushima – Emergency preparedness in general

NPP licensees are required by the *Class I Nuclear Facilities Regulations* to submit their onsite emergency plans to the CNSC as part of the licence application and renewal process. The NPP licensees' onsite emergency plans, programs and performance are included in the CNSC regulatory oversight process (see subsection 16.1(b) for details). However, the *Class I Nuclear Facilities Regulations* do not require applicants to submit offsite emergency plans to the CNSC

(although the CNSC has always considered the preparedness of the offsite authorities when reviewing a licence application). Offsite emergency plans are discussed in subsection 16.1(d).

The CNSC Action Plan assigned an action to the CNSC to initiate a project to amend the *Class I Nuclear Facilities Regulations* to require submission of applicable provincial and municipal offsite emergency plans, along with evidence to support how the licensees are meeting the requirements of those plans, as part of the licence application. It is anticipated that the amendments to the *Class I Nuclear Facilities Regulations* to address lessons learned from Fukushima will be published in 2017.

Further, the Fukushima review during the IRRS follow-up mission to Canada in 2011 recommended that Canada should assure that the review and assessment of offsite emergency plans for NPPs include all relevant authorities and are comprehensive, and that the responsible organizations are capable of fulfilling their respective duties (IRRS recommendation RF7; see sixth Canadian report for details).

In response to Fukushima, several federal organizations, including the CNSC, Health Canada, Public Safety Canada, and Global Affairs Canada, conducted reviews and consulted extensively to identify lessons learned and next steps. A description of the response to Fukushima with respect to emergency preparedness, including the results of the reviews and findings can be found in the sixth Canadian report.

In 2013, the CNSC co-hosted, with Health Canada and Public Safety Canada, a multi-stakeholder event by holding two National Nuclear Emergency Preparedness Workshops involving key representatives from various organizations at all levels of government and industry. In the context of addressing lessons from the Fukushima accident, the objectives of these workshops were to improve the nuclear emergency management network in Canada by:

- ensuring a clear understanding of the various nuclear emergency plans and interfaces across multiple jurisdictions
- clarifying the related linkages, arrangements, governance structures and their implementation
- ensuring a better understanding of roles, responsibilities, capabilities and their integration across jurisdictions
- initiating a risk-based review of emergency response capabilities
- identifying current best practices, gaps and areas for improvements

These workshops helped ensure that offsite emergency plans are comprehensive and that the participating organizations are capable of fulfilling their duties, thus addressing IRRS recommendation RF7.

As discussed in subsection 15(a), the CNSC also anticipates that the *Radiation Protection Regulations* will be amended in 2017, addressing radiation protection for emergency workers and other changes.

The Fukushima review during the IRRS follow-up mission also recommended that Canada should assure that full-scale exercises of offsite emergency plans be held on a periodic basis, involving licensees and municipal, provincial, and federal organizations (IRRS recommendation RF8; see sixth Canadian report for details). This finding was addressed through the establishment of an ongoing nuclear exercise calendar and schedule, maintained by Health Canada through its nuclear emergency management committees. As part of this, Exercise Unified Response, a full-

scale, national nuclear exercise with participation from all levels of government and NPP licensees, was held at Darlington in May 2014. Exercise Unified Response, one of the largest ever held in North America, was determined to be a success and enabled those involved (operator, regulator, emergency services at all levels of government and industry) to exercise their emergency plans and response capabilities. As well, Exercise Intrepid held at Point Lepreau in November 2015 simulated an event which progressed into a severe accident with offsite implications, and was the first full-scale exercise for this NPP utilizing emergency mitigating equipment and other Fukushima related modifications. Details of these exercises can be found in annex 16.1(f). Subsequent exercises of different scope have also been held since that time as part of the ongoing exercise schedule.

During the reporting period, Health Canada and CNSC represented Canada on the IAEA working groups to develop the comprehensive report on the Fukushima accident.

Health Canada also participated on the IAEA’s Emergency Preparedness and Response Expert Group established in response to the *IAEA Action Plan on Nuclear Safety*. Upon its termination in 2015, both Health Canada and CNSC represented Canada on the IAEA’s Emergency Preparedness and Response Standards Committee.

CNS Challenge C-4 for Canada from the Sixth Review Meeting
“Invite an IAEA emergency preparedness review (EPREV) mission”

The Fukushima review during the IRRS follow-up mission to Canada also suggested that Canada would benefit from an international peer review of emergency preparedness (IRRS suggestion SF9; see sixth Canadian report for details).

As explained above, Health Canada has completed the current series of exercises, which were intended to validate the FNEP. Health Canada worked with stakeholders to implement the lessons learned from the 2014 Exercise Unified Response. Health Canada and the CNSC continue their planning for a future emergency preparedness review (EPREV) mission, including participating in external EPREV missions to observe best practices for hosting a peer review. An invitation for an EPREV mission to Canada is expected during the next reporting period.

CNS Challenge C-5 for Canada from the Sixth Review Meeting
“Update emergency operational intervention guidelines and protective measures for the public during and following major and radiological events”

Health Canada is finalizing, following extensive public consultation, the update to the *Canadian Guidelines for Protective Actions during a Nuclear Emergency*, which are cited in the *Federal Nuclear Emergency Plan (FNEP)*. This update will address protective measures for the public (including evacuation, sheltering and iodine thyroid-blocking agents) and will include operational intervention levels and guidelines for water and food-stuff consumption. The guidance updates the Health Canada document, *Canadian Guidelines for Intervention during a Nuclear Emergency*, which recommends evacuation of the population if the projected whole-body dose exceeds 50 mSv in seven days. The updates are based on the latest guidance from the

ICRP and IAEA (*International Basic Safety Standards*). The revised guidelines will also incorporate the existing *Canadian Guidelines for the Restriction of Radioactively Contaminated Food and Water Following a Nuclear Emergency*.

The revised Canadian guidelines were released in 2014 for public consultation, followed by a second round of public consultation in June 2016. After consideration of the feedback and possible revisions, the guidelines will be finalized and published during the next reporting period.

The CNSC posted on its website in October 2015 a factsheet on reference levels for nuclear emergency response and post-accident recovery. The factsheet provides information on the concept of reference levels, which indicate the level of residual dose or risk above which it is generally judged to be inappropriate to allow exposures to occur. The factsheet describes how they apply to the emergency response and post-accident recovery phases of a nuclear accident. It is also based on the ICRP recommended reference levels for the two situations of the emergency response phase and the post-accident recovery phase.

CNS Challenge C-3 for Canada from the Sixth Review Meeting

“Establish guidelines for the return of evacuees post-accident and to confirm public acceptability of it”

During the reporting period, the CNSC was involved in a number of post-accident recovery phase initiatives, including participation in the IAEA’s Modelling and Data for Radiological Impact Assessments Programme. Working groups within this initiative are studying a variety of topics, including model testing and comparison for accidental tritium releases and the use of decision-making tools in the post-accident recovery phase. The work to establish Canadian guidelines has been informed by the emergency exercises described above.

The CNSC has carried out benchmarking on recovery and, in collaboration with Health Canada, is developing a discussion paper on a proposed regulatory document that will address recovery. The main purpose of the discussion paper is to elicit early feedback and engagement with stakeholders, including federal and provincial governments, on the plans for the regulatory document that will describe roles and responsibilities for recovery as well as the important considerations to be addressed in advance of, and during, the recovery phase. The discussion paper is targeted for publication in the fall of 2016 and the goal is to subsequently publish the regulatory document during the next reporting period. Both the discussion paper and regulatory document will undergo an external consultation process prior to publication, helping to ensure public acceptability of the guidelines.

In addition to the above initiatives related to the Fukushima accident, other specific responses are described in the following subsections.

16.1 (b) Onsite emergency plans

While the CNSC would continue to have regulatory oversight of the NPP licensees in the event of a nuclear emergency, the licensees are responsible for onsite emergency preparedness and response. Paragraph 6(k) of the *Class I Nuclear Facilities Regulations* specifies the information related to emergency preparedness that must accompany an application for a licence to operate a

Class I nuclear facility. Specifically, the application must describe the proposed measures to prevent and 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 national security, including measures to:

- assist offsite authorities in planning and preparing to limit the effects of an accidental release
- notify offsite authorities of an accidental release or the imminence of an accidental release
- report information to offsite authorities during and after an accidental release
- assist offsite authorities in dealing with the effects of an accidental release
- test the implementation of the measures to prevent or mitigate the effects of an accidental release

The application should describe the proposed facility, activities, substances and circumstances to which its emergency plans apply. The emergency plans should also be commensurate with the complexity of the associated undertakings, along with the probability and potential severity of the emergency scenarios associated with the operation of the facility.

Each licensee's emergency plan is specific to its particular site and organization; however, all emergency plans typically cover:

- documentation of the emergency plan
- basis for emergency planning
- personnel selection and qualification
- emergency preparedness and response organizations
- staffing levels
- emergency training, drills and exercises
- emergency facilities and equipment
- emergency procedures
- assessment of emergency response capability
- assessment of accidents
- activation and termination of emergency responses
- protection of facility personnel and equipment
- interface arrangements with offsite organizations
- arrangements with other agencies or parties for assistance
- recovery program
- public information program
- public education program

Descriptions of the onsite emergency plans for each NPP are provided in annex 16.1(b).

A condition in each licence to operate an NPP requires the licensee to implement an emergency preparedness program to ensure it is capable of executing its onsite emergency plan. Emergency preparedness plans and programs are updated and fine-tuned over the life of the NPP as new requirements are identified or to address changing conditions, operating experience and identified deficiencies. The CNSC assesses licensees' emergency preparedness programs and inspects their emergency drills and exercises. Although the programs have matured and are well

maintained, CNSC staff members have observed that NPP licensees in Canada proactively seek ways to continuously improve their emergency preparedness programs.

The CNSC Action Plan assigned an action to the CNSC to develop a dedicated regulatory document on emergency management that incorporates the information in regulatory guide G-225, *Emergency Planning at Class I Nuclear Facilities and Uranium Mines and Mills*, and regulatory document RD-353, *Testing the Implementation of Emergency Measures* and to review and update the document. This action was completed in October 2014 with the publication of version 1 of CNSC regulatory document REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response*, which supersedes the two previously mentioned documents. NPP licensees will be implementing this document in the next reporting period.

CNSC published the updated regulatory document REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response, Version 2*, in February 2016 (see subsection 7.2(i)(b)).

Additionally, CSA standard N1600, *General requirements for emergency management for nuclear facilities* was published in May 2014 and revised in March 2016; it addresses lessons learned from the Fukushima accident. Implementation of these two newer documents will be pursued in the next reporting period.

All actions on NPP licensees related to emergency preparedness and resulting from the CNSC Action Plan have been completed. Details of the measures taken in response to the Fukushima accident with respect to onsite emergency plans can be found in the sixth Canadian report.

16.1 (c) Emergency preparedness expectations for new-build projects

The CNSC is establishing requirements and expectations for emergency preparedness for new-build projects. The CNSC regulatory document RD-346, *Site Evaluation for New Nuclear Power Plants*, specifies that the following issues related to population and emergency planning must be considered when a proposed site is being evaluated against safety goals:

- population density and distribution within the protective zone, with particular focus on existing and projected population densities and distributions in the region, including resident and transient populations (updated over the lifetime of the NPP)
- present and future use of land and resources
- physical site characteristics that could impede the development and implementation of emergency plans
- populations in the vicinity of the NPP that are difficult to evacuate or shelter (e.g., schools, prisons, hospitals)
- the ability to maintain population and land-use activities in the protective zone at levels not impeding implementation of the emergency plans

The “protective zone” is defined as the area beyond the exclusion zone that needs to be considered with respect to implementing emergency measures. In Canada, the term “exclusion zone” refers to a parcel of land, within or surrounding a nuclear facility, on which there is no permanent dwelling and over which a licensee has the legal authority to exercise control. The size of the exclusion zone is proposed by the applicant and is expected to demonstrate consideration of effective dose under normal operation and accident conditions, the design-basis threat (security) and emergency preparedness.

Expectations for emergency preparedness are conveyed, at a high level, to potential applicants in application guidance for a licence to prepare a site. This is to confirm the applicant has a

forward-looking emergency preparedness program in place as a part of the overall site evaluation program.

Prior to construction, the proponent is expected to confirm with the surrounding municipalities and the affected provinces, territories and neighbouring countries that the implementation of emergency plans and related protective actions will not be compromised during the entire lifecycle of the proposed site. For example, if a hospital expansion is anticipated as part of a long-term emergency plan, discussions between the proponent and the municipality should begin at the site evaluation stage to ensure appropriate agreements are in place prior to construction.

The following CNSC regulatory documents provide further information on these expectations:

- REGDOC-3.5.1, *Licensing Process for Class I Nuclear Facilities and Uranium Mines and Mills*
- RD/GD-369, *Licence Application Guide: Licence to Construct a Nuclear Power Plant*

The CNSC extends these considerations of emergency preparedness into the requirements for the licence to construct and the licence to operate power reactors, for which the following regulatory documents also apply:

- REGDOC-2.3.2, *Accident Management, Version 2*
- REGDOC-2.4.1, *Deterministic Safety Analysis*
- REGDOC-2.4.2, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*
- REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants*
- REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response, Version 2*

Specifically, the additional criteria related to emergency preparedness found in these regulatory documents that need to be considered at the design and construction phase include the following:

- The containment design allows sufficient time for the implementation of offsite emergency procedures.
- The design and functionality of the main control room, secondary control room and emergency response facilities reliably facilitate all operations and support required for onsite and offsite emergency measures.
- The design features and equipment to support post-accident environmental monitoring are robust and reliable.
- The hazard analysis defines the emergency planning and coordination requirements for effective mitigation of the hazards.
- The PSA is used to assess the adequacy of accident management and emergency procedures.

16.1 (d) Provincial and territorial offsite emergency plans

The provincial/territorial governments are responsible for overseeing public health and safety and the protection of property and the environment within their jurisdictions. Accordingly, they assume lead responsibility for the arrangements necessary to respond to the offsite effects of a nuclear emergency by enacting legislation and providing direction to the municipalities where the NPPs are located. Typically, their administrative structures include an emergency measures organization (or the equivalent) to cope with a wide range of potential or actual emergencies in accordance with defined plans and procedures. The provinces maintain emergency operations centres to coordinate protective actions for the public and to provide the media with information.

In addition, the provincial governments coordinate support from the licensees, the Government of Canada, and departments and agents of all levels of government during their preparedness and response activities.

The provinces determine the needs for and direct the implementation of protective actions, which include:

- sheltering
- evacuation
- ingestion of KI pills
- ingestion control measures

Furthermore, the provinces also ensure arrangements are in place for:

- facilitating the availability of KI pills
- establishing reception and evacuation centres to accommodate evacuees
- establishing emergency worker centres to ensure radiation protection for emergency workers

Provincial agencies participated in the national reviews of the lessons learned from the Fukushima accident. It was concluded that there are no emergency response issues requiring immediate action at the provincial level. However, the provinces, in conjunction with the CNSC, Health Canada and Public Safety Canada are pursuing the resolution of the following issues (related to the discussion in subsection 16.1(a)):

- Although provincial plans primarily address preparedness and response, there are no guidelines and plans for the recovery phase. Health Canada and the CNSC are developing a framework for addressing this issue. Refer to challenge C-3 in subsection 16.1(a).
- Full-scale emergency exercises should have a higher priority at the provincial level. As discussed in subsection 16.1(a), the provinces participated in nuclear exercises coordinated by Health Canada. Additional details on the exercises can be found in subsection 16.1(f) and annex 16.1(f).

The offsite nuclear plans are not approved by Health Canada; however, Health Canada reviews and approves the provincial annexes to the FNEP (see subsection 16.1(e)).

The offsite nuclear emergency plans of the provinces that host NPPs are described in annex 16.1(d). Additional details for each provincial plan, including a description of planning zones, event assessment, public alerting and protective measures, are provided in appendix B of Canada's report to the Second Extraordinary Meeting of the CNS.

During the reporting period, the CNSC published *Study of Consequences of a Hypothetical Severe Nuclear Accident and Effectiveness of Mitigation Measures*, which assessed the health and environmental consequences of severe accident scenarios. The study took into account potential scenarios for protective actions, based on offsite emergency plans, to help assess the possible health impacts of severe accidents. For details, see subsection 15(b).

Distribution of iodine thyroid-blocking agents

REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response (2014)* includes requirements for licensees to provide the necessary resources and support to provincial and regional authorities to ensure a sufficient quantity of iodine thyroid-blocking agents (such as potassium iodide (KI) pills) are pre-distributed. This involves both pre-distributing KI pills to all residences, businesses

and institutions within the primary zone (typically 8 to 16 km from the NPP) and stockpiling KI pills within the secondary zone (typically 50 to 80 km from the NPP).

During the reporting period, all NPP licensees with operating reactors worked closely with their respective regional government officials in the distribution of KI pills. The procurement and pre-distribution of KI pills for the areas surrounding the OPG NPPs and Bruce Power A and B was completed by the end of 2015. Pre-distribution of KI pills to residents within the specified area for Point Lepreau has been in place since 1982.

To date, Canadian NPP licensees have been responsible for the pre-distribution and stock piling of nearly 8.8 million KI pills in areas surrounding their facilities. Along with the pre-distribution, the NPP licensees also launched an education campaign through a pamphlet with information for the public on the use of KI pills.

16.1 (e) Federal emergency plans

The Government of Canada's emergency planning, preparedness and response are based on an "all-hazards" approach. The *Emergency Management Act* sets out broad policy direction and general responsibilities for Public Safety Canada and all other federal ministers and their respective departments/agencies. It broadens the scope of emergency preparedness at the federal level to include the four pillars of emergency management: mitigation, preparedness, response and recovery. Public Safety Canada has prepared the all-hazards *Federal Emergency Response Plan* (FERP) to address governance and coordination issues for federal entities and to support the provinces and territories. The Minister of Public Safety is responsible for coordinating the Government of Canada's response to any emergency. The FERP is designed to harmonize federal emergency response efforts with those of the provinces and territorial governments, non-government organizations and the private sector, through processes and mechanisms that facilitate an integrated response.

Because of the inherent technical nature and complexity of a nuclear emergency, hazard-specific planning, preparedness and response arrangements that supplement all-hazards arrangements are required. The Radiation Protection Bureau of Health Canada administers the comprehensive *Federal Nuclear Emergency Plan* (FNEP), which is integrated with and forms an annex to the FERP to coordinate the Government of Canada's technical response and support to the provinces/territories for managing the radiological consequences of any domestic, trans-boundary or international nuclear emergency. The FNEP complements the relevant nuclear emergency plans of other jurisdictions inside and outside Canada.

The FERP and FNEP were updated in 2011 and 2012, respectively; the updates addressed the lessons learned from Fukushima.

The FNEP describes the roles and responsibilities of federal departments and agencies as well as the measures they should follow to manage and coordinate the federal response to a nuclear emergency based on the scenarios identified in the plan, focusing on the provision of coordinated scientific support to manage radiological consequences. There are 18 federal departments and agencies involved with respect to FNEP, including Health Canada, Public Safety Canada, the CNSC, Environment and Climate Change Canada, the Public Health Agency of Canada, Global Affairs Canada, NRCAN and Transport Canada. AECL and CNL through the government-owned, contractor-operated (GoCo) arrangement, provide technical support to the FNEP. All departments and agencies are responsible for developing, maintaining and implementing their

own organization-specific emergency response plans that align with and support the objectives of the FERP and FNEP. (Some of these organization-specific plans are described below.) The Minister of Public Safety is responsible for exercising leadership relating to emergency management in Canada by coordinating emergency management activities, both among government institutions and in cooperation with the provinces and other entities. Health Canada supports this through its federal inter-departmental and federal-provincial nuclear emergency management committees. (One of these committees is described below.)

The governance provided by the FERP and FNEP allows the various jurisdictions and organizations that have responsibilities for aspects of nuclear emergency preparedness (municipal and provincial governments, the licensee, and federal departments and agencies) to discharge their responsibilities in a cooperative, complementary and coordinated manner. Provincial annexes to the FNEP describe interfaces between the Government of Canada and the provincial emergency management organizations in those provinces that have NPPs or ports hosting foreign nuclear-powered vessels.

During the reporting period, the annexes to the FNEP for Ontario and New Brunswick were revised. The Ontario annex was tested in Exercise Unified Response in May 2014, following which it was approved by Health Canada and the Ontario Office of the Fire Marshal and Emergency Management. The New Brunswick annex was revised and tested during Exercise Intrepid in November 2015. Lessons learned from the exercise will be incorporated in the annex, and a final version will be submitted for approval by Health Canada and the New Brunswick Emergency Measures Organization. The province of Quebec is reassessing the nuclear risk after the completion of the transition to safe shutdown state of Gentilly-2 in 2014. Discussions for revising the Quebec annex to the FNEP began in 2016.

Annex 16.1(e) describes the provisions of the FNEP in more detail.

In addition to managing the FNEP, Health Canada's Radiation Protection Bureau maintains a 24/7 duty officer service that receives notifications of any nuclear emergency, activates arrangements under the FNEP, and chairs the FNEP Technical Assessment Group. It is responsible for operating various radiological monitoring networks: the Fixed Point Surveillance Network, the Canadian Radiological Monitoring Network (see subsection 15(b)) and the radiation monitoring stations within the Canadian portion of the Comprehensive Nuclear Test-Ban Treaty International Monitoring System. See appendix C in Canada's report to the Second Extraordinary Meeting of the CNS for details.

Health Canada also operates radiological sample analysis laboratories (including fixed and mobile facilities), decision support, mapping and information-management platforms, contamination-monitoring capabilities (including portal monitors), and internal and external dosimetry programs for exposed individuals (including emergency workers). Health Canada provides radiation protection guidance and expertise, maintains a nuclear exercise calendar and organizes emergency exercises.

One of the emergency preparedness committees administered by Health Canada in the context of the FNEP is the Federal/Provincial/Territorial Radiological/Nuclear Emergency Management Coordination Committee. It provides a forum for information exchange and the development of plans and joint projects to improve nuclear emergency management (e.g., updates to standard operating procedures and technical assessment products). It also provides advice and assistance to authorities responsible for nuclear emergency management. During the reporting period,

committee topics included the FNEP exercise and training program, the revision of FNEP provincial annexes, and the revision of the Health Canada intervention guidelines.

Environment and Climate Change Canada – Canadian Centre for Meteorological and Environmental Prediction works closely with Health Canada to provide a suite of atmospheric modelling capabilities for nuclear emergency management, ranging from local to global atmospheric modelling capabilities, including dispersion and trajectory modelling, and forward/backward modelling. These products are provided to the FNEP Technical Assessment Group and provincial science groups. As described in the FNEP, other federal institutions, including the Department of National Defence and NRCAN, also contribute specific scientific and technical expertise and capabilities necessary to manage the actual or potential radiological consequences of a nuclear emergency.

Emergency plans of federal departments and agencies

The CNSC has its own nuclear emergency response plan that clearly defines and enables its roles within the context of the FNEP. The CNSC participates directly in emergency planning activities with other FNEP core agencies. The CNSC also participates in some exercises to practise discharging its own emergency-related responsibilities. A general description of the CNSC's role in emergency preparedness is provided in annex 16.1(e). The CNSC also has a well-developed and mature nuclear emergency management program that is based on its emergency response plan.

Other federal departments and agencies also develop their own nuclear emergency response plans. For example, Transport Canada administers the *Transportation of Dangerous Goods Act, 1992* and the *Transportation of Dangerous Goods Regulations* and operates the Canadian Transport Emergency Centre to ensure hazardous substances are transported safely and to help emergency response personnel handle related emergencies, including those involving nuclear substances. Transport Canada cooperates with the CNSC in emergencies and incidents involving nuclear substances, in accordance with the FNEP, relevant federal legislation and formal administrative arrangements.

Health Canada and the Public Health Agency of Canada maintain an all-hazards plan, the *Health Portfolio Emergency Response Plan*, which describes its response framework to a range of emergencies that could impact public health. A specific nuclear emergency annex to this plan, which supports the FNEP, was developed and approved in 2015.

Details of the activities and reviews conducted by federal government organizations in response to Fukushima can be found in the sixth Canadian report.

16.1 (f) Emergency training, exercises and drills

Emergency exercises confirm adequate implementation of onsite and offsite provisions in nuclear emergency response plans. Emergency drills are designed to provide training opportunities for enhancing the abilities of involved parties to respond to emergency situations and to protect public health and safety during an event at an NPP or other licensed nuclear facility. Emergency exercises serve to test the sharing of information and to ensure all response efforts are coordinated and communicated effectively.

The frequency of emergency exercises at NPPs is defined in CNSC regulatory document REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response, Version 1*, which was

published in October 2014 and further updated with REGDOC-2.10.1, Version 2 in February 2016. NPP licensees have already implemented or are implementing Version 1. REGDOC-2.10.1 and its predecessors state that licensees are directly responsible for training their personnel and involving them in emergency exercises, and for appointing qualified personnel to their emergency teams. A schedule for both emergency drills and emergency exercises is established every year to ensure all responders, including alternates, have the opportunity to practise the required skills on a regular basis. All emergency exercise objectives are addressed over a five-year period, with a full-scale emergency exercise conducted every three years.

CNSC staff members evaluate the full-scale emergency exercises at the NPPs to ensure licensees are effectively managing and implementing their emergency responses (specifically, the onsite provisions). During the reporting period, five such exercises were evaluated; the CNSC's conclusions are briefly summarized as follows:

- For the Pickering exercise (2013), OPG staff successfully demonstrated readiness to respond to a nuclear emergency.
- For the Gentilly-2 exercise (May 2014), Hydro-Québec staff demonstrated satisfactory performance and met the regulatory requirements.
- For the full-scale national exercise at Darlington (Unified Response, May 2014), OPG demonstrated that its emergency preparedness and response programs were robust and met the regulatory requirements. The licensee was effective in responding to the emergency, including from operating safety shutdown systems to continued cooling, and by providing necessary information and support to offsite authorities.
- For the Bruce A and B exercise (October 2014), Bruce Power staff successfully demonstrated their readiness to respond to a nuclear emergency and validated enhancements to its emergency response program.
- For the Point Lepreau (Intrepid, November 2015), NB Power staff and the offsite agencies demonstrated satisfactory performance in responding to a simulated severe accident with offsite implications.

In some cases, the municipalities, the provinces and the CNSC will also participate in the exercises with NPP licensees (to a certain degree). The CNSC observes emergency exercises to confirm adequate implementation of offsite provisions in nuclear emergency response plans. It also participates in emergency exercises to practise discharging its own emergency-related responsibilities and to ensure communication lines are in place and in a state of readiness. Other federal departments may participate to similarly practise their responsibilities. Exercise Unified Response validated the full integration of the FNEP, the FERP, Ontario's Provincial Nuclear Emergency Response Plan (PNERP), OPG's Consolidated Nuclear Emergency Plan and the plans of other non-governmental organizations.

Following the approval of the revised FNEP in 2012, Health Canada developed an evergreen five-year exercise program for the FNEP. The program includes five main types of exercises to be included in the long-term exercise plan. The program includes anticipated key FNEP events and exercises for 2015–2020 as well as an annual nuclear training and event calendar. The FNEP recommends a large-scale, multi-jurisdictional exercise occurring, in general, once every two to three years.

Training and emergency exercises conducted during the reporting period are described in more detail in annex 16.1(f).

16.2 Information to the public and neighbouring states

16.2 (a) Measures for informing the public during a national nuclear emergency

As described in subsection 9(c), the NPP licensees have implemented public disclosure programs that meet the requirements of CNSC regulatory document RD/GD-99.3, *Public Information and Disclosure*. The information to be disclosed would include the impact of natural events (such as earthquakes), routine and non-routine releases of radiological and hazardous materials to the environment and unplanned events, including those exceeding regulatory limits. These requirements therefore cover severe accidents.

For domestic nuclear emergencies, each level of government and the nuclear facility are responsible for providing emergency public information to the media on their own jurisdiction's aspect of the emergency response. The provinces, however, are responsible for providing detailed protective action messaging to the affected public (done by issuing emergency bulletins via broadcast and social media). The provinces inform all relevant stakeholders prior to issuing the emergency bulletins to the public.

The public alerting system for NPPs in Ontario includes the use of sirens within 3 kilometres of Pickering and Darlington. OPG purchased the sirens and provided funds to the local municipalities to install, maintain and use the sirens. The sirens have become an asset of the local municipalities. This system, coupled with the instructional messages broadcast over radio and television, ensures the population within 10 kilometres of these two NPPs is notified appropriately and in a timely manner.

At the federal level, the Federal Public Communications Coordination Group, led by Public Safety Canada and in collaboration with the provinces/territories, coordinates the federal government's communications response to the public, media and affected stakeholders (including private sector stakeholders). Federal government institutions contribute information to this group according to their mandates. FNEP federal spokespersons present the federal position on the nuclear emergency, according to the specific issues and in coordination with the provincial information centres. For emergencies occurring at licensed facilities, the facility operator and the CNSC provide information about onsite conditions. The Government of Canada also provides communications in areas of federal jurisdiction (e.g., information to federal workers in affected areas).

16.2 (b) International arrangements, including those with neighbouring countries

Canada participates in the IAEA International Nuclear Event Scale (INES) reporting system. Canada has excellent working relationships with the United States for the exchange of emergency preparedness expertise. In addition, Canada has signed the following international emergency response agreement and ratified the two conventions listed.

Statement of Intent between Health Canada and United States Department of Energy

Health Canada and the U.S. Department of Energy National Nuclear Security Administration developed a statement of intent supporting joint Canada–U.S. nuclear emergency preparedness and response capabilities. The statement, which updates arrangements in the previous *Canada–United States Joint Radiological Emergency Response Plan* (1996) was signed in February 2014. It is supported through annual coordination meetings between Health Canada and the U.S. Department of Energy, with the objective to identify areas where coordination and cooperation,

including information sharing and mutual assistance, would be beneficial to nuclear emergency management programs and capabilities, and to elaborate strategies for moving forward with these.

Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency

Canada is a signatory of the IAEA's *Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency* (1986), which sets out an international framework for cooperation among countries and with the IAEA to facilitate prompt assistance and support in the event of nuclear accidents or radiological emergencies. It requires countries to notify the IAEA of the available experts, equipment or other materials they could offer in assistance. In case of a request for assistance from an affected country, each country decides whether it can offer the requested assistance. The IAEA serves as the focal point for such cooperation by channelling information, supporting efforts and providing its available services. The agreement sets out how assistance is requested, provided, directed, controlled and terminated. Since 2012, Health Canada and AECL have registered their radiological biodosimetry capabilities with the IAEA's Response and Assistance Network (RANET) in support of this convention. During the reporting period, Health Canada participated in RANET technical meetings to update the RANET guidelines and to exchange experience in the practical arrangements for activating/deploying national assistance capabilities, such as radiological monitoring in response to nuclear or radiological incidents and emergencies. The CNSC also registered its NPP accident-analysis capability under RANET in 2016.

Convention on Early Notification of a Nuclear Accident

Canada is a signatory of the IAEA's *Convention on Early Notification of a Nuclear Accident* (1986), which establishes a notification system for nuclear accidents having the potential for international trans-boundary release that could be of radiological safety significance for another country. The accident's time, location, radiation releases and other data essential for assessing the situation must be reported, both directly to the IAEA and to other countries (either directly or through the IAEA). During the reporting period, Canada participated in various IAEA organized Convention Exercises (ConvEx) organized in support of this convention.

16.3 Emergency preparedness for Contracting Parties without nuclear installations

This part of article 16 does not apply to Canada.

Chapter III – Compliance with Articles of the Convention (continued)

Part D Safety of Installations

Part D of chapter III consists of three articles:

Article 17 – Siting

Article 18 – Design and construction

Article 19 – Operation

Article 17 – Siting

Each Contracting Party shall take the appropriate steps to ensure that appropriate procedures are established and implemented:

- (i) for evaluating all relevant site-related factors likely to affect the safety of a nuclear installation for its projected lifetime;
- (ii) for evaluating the likely safety impact of a proposed nuclear installation on individuals, society and the environment;
- (iii) for re-evaluating as necessary all relevant factors referred to in sub-paragraphs (i) and (ii) so as to ensure the continued safety acceptability of the nuclear installation;
- (iv) for consulting Contracting Parties in the vicinity of a proposed nuclear installation, insofar as they are likely to be affected by that installation and, upon request providing the necessary information to such Contracting Parties, in order to enable them to evaluate and make their own assessment of the likely safety impact on their own territory of the nuclear installation.

In Canada, the term “siting” comprises site evaluation and site selection. The applicant’s selection of a site is not a regulated activity. However, the resultant site selection case is assessed as part of the application for a licence to prepare a site. The framework and process for issuing a licence to prepare a site for an NPP are described in subarticle 7.2(ii), with further details in subsection 7.2(ii)(b).

Prior to the CNSC’s issuance of a site preparation licence, a positive decision regarding an environmental assessment (EA), which will be described in this article, is required. The EA process evaluates the effects of the project lifecycle of a proposed NPP on the environment. The CNSC separately evaluates the licence applicant’s proposed measures to protect individuals, society and the environment during site preparation activities.

Fulfilling principle (1) of the 2015 Vienna Declaration on Nuclear Safety as it relates to siting

Principle (1) of the 2015 *Vienna Declaration on Nuclear Safety* (VDNS) states that new NPPs are to be designed, sited and constructed, consistent with the objective of preventing accidents in the commissioning and operation and, should an accident occur, mitigating possible releases of radionuclides causing long-term offsite contamination and avoiding early radioactive releases or radioactive releases large enough to require long-term protective measures and actions.

Following the Fukushima accident, the IAEA revised five Safety Requirements, which were approved by the Board of Governors in March 2015. Subsequently, the Director General of the IAEA requested the Commission on Safety Standards (CSS) to review the need for further revisions to the Safety Requirements. In August 2015, the Chair of the CSS determined that there was no need for further revisions because the technical objectives of the VDNS were already well reflected in the Safety Requirements.

As explained in subsection 7.2(i)(b), CNSC regulations and regulatory documents align with the IAEA safety standards, including those used for siting NPPs. This article provides further examples of how the regulatory framework for siting addresses IAEA safety standards.

Therefore, the CNSC framework and processes used in the regulation of activities related to site preparation ensure that the siting of new NPPs in Canada will meet principle (1) of the VDNS. See article 18 for a similar statement on the activities of design and construction.

Level of NPP design information expected to demonstrate site suitability

Under the NSCA, the decisions made by the Commission on an application for a licence to prepare a site for a new NPP may be made with high-level facility design information from a range of reactor designs. The design information provided by the applicant must be credible and sufficient to adequately bound the evaluations of environmental effects and site suitability from a range of reactor designs that might later be deployed at the site.

The bounding design parameters must contain sufficient information to describe the NPP–site interface and take into consideration the characteristics of the proposed site. The underpinning of the bounding approach is that the environmental effects of the reactor design eventually selected for construction should be less than the bounding effects assessed in the site evaluation and the environmental impact statement (EIS), which the applicant prepares as part of the EA process.

Although the CNSC accepts high-level information in support of the site evaluation case, there is an increased level of regulatory scrutiny during the construction and operation licensing processes to validate the claims made. When applying for a licence to construct, the applicant will be expected to submit detailed design information verifying the evaluations presented previously remain valid. If the level of information provided at the outset is limited, however, there is a greater likelihood that fundamental barriers to licensing will appear during the review process for a licence to construct. Thus, it is in the best interest of the applicant to make its submissions as complete as possible at the outset.

The required level of design information for a site evaluation includes:

- a technical outline of the facility layout (preliminary or schematic in nature)
- qualitative descriptions of all major structures, systems and components (SSCs) that could significantly influence the course or consequences of principal types of accidents and malfunctions
- qualitative descriptions of the functionality of the SSCs important to safety
- qualitative descriptions of principal types of accidents and malfunctions to identify limiting credible sequences that include external hazards (both natural- and human-induced), design-basis accidents and beyond-design-basis accidents (BDBA, which include severe accidents)

For EA purposes, the limiting source terms must consider accident sequences that could occur with a frequency greater than 10^{-6} per reactor-year of operation. For those less than 10^{-6} per reactor-year, but sufficiently close to this frequency, the rationale for not including them for further analysis should be provided.

For site evaluation carried out in support of licensing (including emergency planning purposes), the CNSC expects severe accident sequences to be addressed. The severe accident sequences include, where applicable, multi-unit events, simultaneous with loss of the electrical grid/station blackout events, and events with a simultaneous loss of offsite power and loss of heat sink for an extended period of time.

A description of specific (out-of-reactor) criticality events must be provided, showing that these events do not violate criteria established by international standards and national guidance as triggers for public evacuation.

If the applicant chooses to pursue a licence to prepare a site without choosing a final NPP technology, the activities permitted under the issued licence to prepare the site would be limited to site preparation activities that are independent of any specific reactor technology. Such activities include clearing and grading the site or building support infrastructure such as roads, power, water and sewer services, but do not include excavation for the purposes of establishing the facility footprint.

Regardless of the approach used by an applicant to apply facility design information to its site selection case, a fundamental expectation of the CNSC is that the applicant will demonstrate the capability of a “smart buyer”. This means that the applicant will be expected to demonstrate a clear understanding of the technologies it is proposing to use and the basis from which the site selection case is developed.

Site evaluation criteria – general

The information provided in an application for a licence to prepare a site is assessed against the criteria described in the CNSC regulatory document RD-346, *Site Evaluation for New Nuclear Power Plants*. RD-346 adapts the tenets set forth by the IAEA safety requirements document NS-R-3, *Site Evaluation for Nuclear Installations*, and its associated guides. RD-346 addresses some Canadian expectations that are not addressed in NS-R-3, such as protection of the environment, security of the site, and protection of prescribed information and equipment. RD-346 elaborates upon the criteria for evaluating the effect of the site on the safety of the NPP (see subsection 7.2(i)) and the impact of the NPP on the surrounding population and the environment (see subsection 7.2(ii)(b)). Specifically, RD-346 articulates the CNSC’s expectations with respect to the evaluation of site suitability over the life of a proposed NPP, and includes:

- the potential effects of external events (such as earthquakes, tornadoes and floods) and human activity on the site
- the characteristics of the site and its environment that could influence the transfer to persons and the environment of radioactive and hazardous material that may be released
- the population density, population distribution and other characteristics of the region, insofar as they may affect the implementation of emergency measures (see subsection 16.1(c)) and evaluation of risks to individuals, the surrounding population and the environment

RD-346 also requires the consideration of certain aspects, such as security and decommissioning requirements, projected population growth in the vicinity of the site, and possible future life extension activities, when evaluating the site.

If the site evaluation indicates safety concerns that design features, site protection measures, or administrative procedures cannot remedy, the site is deemed unacceptable. The site evaluation includes:

- evaluation against safety goals
- consideration of evolving natural and human-induced factors
- evaluation of the hazards associated with external events

- determination of the potential effects of the NPP on the environment
- consideration of projected population growth in the vicinity of the site along with emergency planning that takes those projections into account

An example of an evaluation against safety goals, set in the context of OPG's EIS and application for a licence to prepare a site for the Darlington new-build project, was provided in annex 17 of the sixth Canadian report.

Additional details related to site evaluation criteria are provided under subarticles 17(i) and 17(ii) below.

17 (i) Evaluation of site-related factors

The safety case for the licence to prepare a site includes an assessment of hazards or bounding analysis and should address the impact of site-specific factors on the safety of the NPP. Such factors include the site's susceptibility to flooding (e.g., storm surge, dam burst), hurricanes, tornadoes, ice storms or other severe weather, and earthquakes. The return periods for severe weather, flood or wind are not prescribed. However, the applicant is expected to propose adequate periods based on criteria identified in the IAEA documents that are referenced in RD-346 (specifically, IAEA safety guides NS-G-1.5, NS-G-3.2, NS-G-3.4 and NS-G-3.5).

Licensees also have to perform a site-specific external hazards screening to identify other hazards that may require a PSA or a bounding analysis. Further, the licensees must consider combinations of events, including consequential and correlated events. Examples of consequential events include external events (such as a cooling water intake blockage caused by severe weather, a tsunami caused by an earthquake or a mud slide caused by heavy rain) and internal events (such as a fire caused by an earthquake). Examples of correlated events include heavy rainfall concurrent with a storm surge or high winds caused by a hurricane.

It should be pointed out that consequential events are also considered in the PSAs (see subsection 14(i)(d)) required in the licensing process following the application for a licence to prepare site.

RD-346 requires the applicant to consider climate change when evaluating the potential impact of these phenomena. An example of this consideration for Bruce A and B was provided in annex 17(iii)(a) of the sixth Canadian report.

Site-related factors also include the proximity of the site to one or more of the following:

- railroad tracks (possibility of derailments and the release of hazardous material)
- flight paths for major airports (possibility of airplane crashes)
- toxic chemical plants (possibility of toxic releases)
- propane storage facilities or refineries (possibility of industrial accidents)
- military test ranges (possibility of stray missiles)

The above concerns are further affected by projected land use near the site, access to the site, emergency preparedness and security.

The licence applicant addresses these criteria during the application process for a licence under the NSCA (and in its EIS), the results of which are integrated into the safety case. Applications identify and assess the site characteristics that may be important to the safety of the proposed NPP, including:

- land use
- present population and predicted population expansion
- principal sources and movement of water
- water usage
- meteorological conditions
- seismology
- local geology

17 (ii) Impact of the installation on individuals, society and environment

17 (ii) (a) Environmental assessment

An EA pursuant to the *Canadian Environmental Assessment Act, 2012* (CEAA) is initiated following an application for a licence to prepare a site. An EA under the *Nuclear Safety and Control Act* is undertaken for other licensing decisions such as licence renewal/amendment. EAs identify whether a specific project is likely to cause significant environmental effects taking mitigating measures into account. The potential impact on the environment is evaluated in the EA process by examining the effects on parameters such as water supply, air quality, wildlife, lakes and rivers. EAs ensure that, early in a project, potentially significant adverse effects are identified and mitigated to the extent possible. In accordance with RD-346, prior to the triggering of the EA and licensing processes, the applicant is expected to use a robust process to characterize proposed sites over the full lifecycle of the facility and then develop a fully documented defence of the site selection. This case forms the backbone for submissions in support of the EA and the application for a licence to prepare the site, which is reviewed by the CNSC and other applicable federal authorities.

EAs are conducted at every phase of the lifecycle of a facility or activity. These assessments are commensurate with the scale and complexity of the environmental risks associated with the facility or activity.

As stated above, EAs are carried out either under the CEAA or under the NSCA. An environmental risk assessment (ERA), see subsection 17(iii)(a), forms the basis of an EA, either under CEAA or under the NSCA. Early in the process, CNSC staff members determine which EA applies by reviewing the information provided by the applicant or licensee in their application and supporting documentation.

In accordance with paragraph 15(a) of CEAA, an EA is required when the CNSC is the responsible authority with respect to a designated project per the *Regulations Designating Physical Activities*. In addition, an EA under CEAA is carried out early in the licensing process (at the beginning of the lifecycle of the project) and serves as a planning tool.

For applicants proposing facilities or activities in areas of Canada subject to land claim agreements (such as the territories and parts of Quebec and Newfoundland and Labrador), CNSC staff members support the EA process of that land-claim regime and the Commission uses the information gathered in the EA process in its licensing decision under the NSCA.

There were no EAs conducted under CEAA for Canadian NPPs or new-build projects during the reporting period. Additionally, there were no applications submitted during the reporting period for new-build projects. Details on the site evaluation studies for the Darlington new-build project during the previous reporting period (2010–13) can be found in annex 17 of the sixth Canadian report. See subsection D.4 of chapter I for additional details on the EA and licensing decisions related to Darlington new-build.

As described in subsection 15(b), during the reporting period, the CNSC published regulatory document REGDOC-2.9.1, *Environmental Protection: Policies, Programs and Procedures*, in September 2013, superseding regulatory standard S-296, *Environmental Protection Policies, Programs and Procedures at Class I Nuclear Facilities and Uranium Mines and Mills* and regulatory guide G-296, *Developing Environmental Protection, Policies, Programs and Procedures at Class I Nuclear Facilities and Uranium Mines and Mills*. REGDOC-2.9.1 amended the guidance to reflect lessons learned from Fukushima.

The CNSC is currently drafting a new version of REGDOC-2.9.1. The updated document, which will be titled *Environmental Protection: Environmental Policy, Assessments and Protection Measures*, will outline the CNSC's EA and environmental protection practices.

17 (ii) (b) Criteria for evaluating the safety impact of the NPP on the surrounding environment and population

As stated above, RD-346 stipulates that the evaluation of site suitability includes consideration of specific factors relevant to the impact of the proposed NPP on the environment and population:

- site characteristics that could have an impact on the public or on the environment
- population density, distribution and other characteristics of the protective zone that may have an impact on the implementation of emergency measures

The safety impact on the population examines the population dose from postulated events. Given that the NPP will perform as designed under accident conditions, it is important to consider population-related factors to meet radiation dose limits set by regulations. Such factors include the size, nature (e.g., subdivision, rural, industrial, school or hospital), distribution and demographics of population around the facility. Other factors include: local weather, seismicity, neighbouring facilities, and air and rail transport corridor activity. The applicant addresses these criteria in the safety case, which calculates the population doses and verifies that the NPP design meets its safety targets.

17 (ii) (c) New-build outreach

Outreach to stakeholders and the local populace of the potential site – in particular, explaining the safety impact and how it is evaluated – is an important activity related to understanding the impact of a proposed NPP on the population and the environment. Significant outreach was conducted by OPG for its Darlington new-build project during the previous reporting period (2010–2013) as described in the sixth Canadian report.

17 (iii) Re-evaluation of site-related factors

17 (iii) (a) Licensee activities to maintain the safety acceptability of the NPP, taking into account site-related factors

The continued acceptability of the NPP against the criteria mentioned in subarticles 17(i) and 17(ii) is periodically verified against appropriate standards and practices. Possible changes to the site's demographics or significant changes to the understanding of the local environment must be examined through activities that include regular reviews of the licensee's emergency response measures, security measures and safety analysis report. Such changes include:

- new insights from updated hazard studies
- changes to neighbouring man-made facilities (such as a newly constructed oil refinery, rail corridor, airport flight path or chemical plant)
- climate change

CNSC regulatory document REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*, requires licensees to regularly submit to the CNSC certain reports describing the effects of the NPP on the environment:

- updates to facility descriptions and final safety analysis report
- PSA
- ERA

These reports are to be submitted within five years of a previous submission or when requested by the CNSC. They include consideration of any relevant new techniques or information, which could include new data or insights related to external events.

Deterministic safety analysis and PSAs are described in subsections 14(i)(c) and 14(i)(d), respectively. ERAs are described in subsection 15(b).

REGDOC-3.1.1 also requires an annual report detailing the results of environmental monitoring programs, together with an interpretation of the results and estimates of radiation doses to the public resulting from NPP operations. See subsection 15(b) for details.

17 (iii) (b) Results of environmental assessments for life-extension projects

An assessment of the environmental effects of life-extension projects helps ensure the continued protection of the environment during the operation of NPPs. During the reporting period, no EAs were conducted by NPP licensees for life-extension projects. The Darlington refurbishment and continued operation EA conducted during the previous reporting period resulted in the need for the installation of modifications to the NPP to further improve public safety. The modifications are underway and will be completed during the next reporting period. See annex 18(i) for details on the modifications to be installed.

17 (iii) (c) Re-evaluation of site-related factors in response to Fukushima

As part of the follow-up to the Fukushima accident, the licensees examined events more severe than those that have historically been regarded as credible, as well as their potential impacts on their NPPs. These events typically included earthquakes, floods, extreme weather events (e.g., high winds, heavy rainfalls) and events caused by human activities (e.g., explosions).

As reported in the sixth Canadian report, the NPP licensees reconfirmed that the risk posed to Canadian NPPs from tsunamis is negligible. Nevertheless, NRCAN conducted a preliminary probabilistic tsunami hazard assessment for Canada. As the licensee for the only coastline NPP in Canada (Point Lepreau), NB Power elected to further study the tsunami hazard to provide a high degree of assurance that the tsunami risk remains low. The results from the study were submitted by NB Power to the CNSC in 2015. Staff members from the CNSC, the National Research Council of Canada and Environment and Climate Change Canada have completed their respective reviews of the study. Based on the result of these reviews, CNSC staff members are satisfied with the assessment and related follow-up plans.

The post-Fukushima review reconfirmed the robustness of Canadian NPPs to withstand large external hazards. However, additional work was undertaken in the previous reporting period (see the sixth Canadian report) related to screening of external hazards and bounding analyses. Specifically, for NPPs that have not undergone ISRs and been refurbished, the licensees conducted more comprehensive assessments of site-specific external hazards to demonstrate that:

- considerations of magnitudes of design-basis and beyond-design-basis external hazards are consistent with current best international practices
- consequences of events triggered by external hazards are within applicable limits

In the previous reporting period, the licensees completed various tasks, including reviewing the bases of external events, completing or updating PSAs and expanding their application to analyze site-specific, external hazards. Furthermore, NPP licensees completed Level 1 and Level 2 PSAs (see subsection 14(i)(d)).

For more detailed information on Canada's re-evaluation of site-related factors in response to the Fukushima accident, refer to Canada's report to the Second Extraordinary Meeting of the CNS and the sixth Canadian report.

17 (iv) Consultation with other Contracting Parties likely to be affected by the installation

Canadian legislation and related processes (in particular, the CEAA and its regulations) do not obligate the CNSC or NPP licence applicants to consult with other jurisdictions outside Canada regarding proposed siting. These jurisdictions are primarily in the United States, the only country with which Canada shares a land border. However, the CEAA requires that effects to the environment that may occur outside of Canada (transboundary effects) be included in the EA review for designated projects listed in the *Regulations Designating Physical Activities*, including new NPPs.

Furthermore, public participation opportunities (such as public hearings) are an important component of the CNSC's licensing and EA process. The CNSC emphasizes public engagement and participation, and members of the public, including people from outside Canada, are provided the opportunity to review licensing and EA documentation and participate as intervenors in public hearings.

Canada and the U.S. have a longstanding practice of cooperation with respect to transboundary impacts through such treaties as the *Boundary Waters Treaty* of 1909, the *Great Lakes Water Quality Agreement* of 1978, and the *Canada-United States Air Quality Agreement* of 1991. In addition, the CNSC and the U.S. Nuclear Regulatory Commission have an administrative

arrangement for the exchange of technical information and cooperation in nuclear safety matters, including the siting of any designated nuclear facility in either country.

Article 18 – Design and construction

Each Contracting Party shall take the appropriate steps to ensure that:

- (i) the design and construction of a nuclear installation provides for several reliable levels and methods of protection (defence in depth) against the release of radioactive materials, with a view to preventing the occurrence of accidents and to mitigating their radiological consequences should they occur;
- (ii) the technologies incorporated in the design and construction of a nuclear installation are proven by experience or qualified by testing or analysis;
- (iii) the design of a nuclear installation allows for reliable, stable and easily manageable operation, with specific consideration of human factors and the man-machine interface.

All operating NPPs in Canada are CANDU designs. CANDU reactors feature heavy-water coolant and moderator, as well as fuel channel and fuel bundle designs that enable online fuelling. The pressure tube is the central component of the fuel channel that supports the fuel and acts as a pressure boundary for the coolant. Some specific CANDU design features related to assessing and improving defence in depth are described in annex 18(i). The first and second Canadian reports contain extensive information on the evolution of the design and construction of CANDU-type NPPs. Canada sponsors significant R&D that address the area of design and construction (see appendix E for details).

The general CNSC framework and process for issuing a licence to construct a Class IA nuclear facility (of which an NPP is an example) are described in subarticle 7.2(ii). In response to existing, and in preparation for potential, new-build licence applications, the CNSC continues to update its design requirements for NPPs, participate in the Multinational Design Evaluation Programme (MDEP) and conduct pre-project vendor design reviews. These activities are described in the following subsections. The CNSC has also developed work instructions for the review of applications for a licence to construct an NPP. Work instructions are described in more detail in subsections 7.2(ii)(a) and 8.1(d).

Specific design requirements and licensee provisions related to defence in depth, proven technologies, and reliable and manageable operation are described in subarticles 18(i), 18(ii) and 18(iii), respectively, for the currently operating NPPs and potential new-build projects.

Updating design requirements for new-build projects

CNSC criteria for evaluating designs of new NPPs continued to be updated to be technology-neutral and to allow for the licensing of a wide range of reactor technologies, sizes and uses, including non-water-cooled technologies.

CNSC regulatory document REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants*, was published in May 2014, superseding regulatory document RD-337, *Design of New Nuclear Power Plants*. It sets out requirements and guidance for the design of new, water-cooled NPPs. To a large degree, REGDOC-2.5.2 represents the CNSC's adoption of the tenets set forth in the IAEA safety standards document SSR-2/1, *Safety of Nuclear Power Plants: Design*, and

the adaptation of those tenets to align with Canadian practices. Annex 7.2(i)(b) describes in greater detail how REGDOC-2.5-2 reflects various IAEA safety standards. To the extent practicable, REGDOC-2.5.2 sets technology-neutral requirements related to defence in depth, the use of proven technology and easily manageable operation of NPPs (e.g., reliability, human factors). Similar to SSR-2/1, REGDOC-2.5.2 requires the concept of defence in depth be applied to all organizational, behavioural and design-related safety and security activities to ensure they are subject to overlapping provisions. Defence in depth is to be applied throughout the design process and operation of an NPP. The scope of REGDOC-2.5.2 addresses the interfaces between NPP design and other topics, such as environmental protection, safeguards, and accident and emergency response planning. Additional details on REGDOC-2.5.2 are provided in annex 18.

The CNSC's regulatory review of an application for a licence to construct will include a clause-by-clause assessment of the proposed design against the requirements in REGDOC-2.5.2.

Upgrading designs of existing NPPs

For existing NPPs, the licensees have continuously made design improvements even though many of the updated design requirements were established after the NPPs were built. For example, design changes have been made to address new standards, on an ongoing basis, when the licences are renewed or amended (as described in subsection 7.2(ii)(d)). Furthermore, life-extension projects have provided an opportunity to upgrade the existing CANDU NPPs to align with REGDOC-2.5.2 and other new standards. Integrated safety reviews (ISRs) conducted for life-extension projects and recently introduced periodic safety reviews (PSRs) require the licensee to determine reasonable and practical modifications to enhance the safety of the facility to a level approaching that described in modern standards. Integrated implementation plans identify strengths and shortcomings for each of the safety factors identified in the ISR or PSR, rank the shortcomings in terms of safety significance, and prioritize corrective measures, including design and other safety improvements. The design improvements that have been effected in Canada as part of life extension have addressed the various factors discussed in subarticles 18(i), (ii) and (iii). The general regulatory approach to life extension is described in subsection 7.2(ii)(d) and the safety assessment aspects of ISR for life extension are described in subsection 14(i)(f).

Some examples of design changes to existing NPPs are given in annex 18(i) in the context of improvements to defence in depth.

Fulfilling principle (1) of the 2015 Vienna Declaration on Nuclear Safety as it relates to design and construction

Principle (1) of the 2015 *Vienna Declaration of Nuclear Safety* (VDNS) states that new NPPs are to be designed, sited and constructed, consistent with the objective of preventing accidents in the commissioning and operation and, should an accident occur, mitigating possible releases of radionuclides causing long-term offsite contamination and avoiding early radioactive releases or radioactive releases large enough to require long-term protective measures and actions.

As explained in article 17, the technical objectives of the VDNS were already well reflected in previous updates of the IAEA Safety Requirements. Furthermore, as explained in subsection 7.2(i)(b), CNSC regulations and regulatory documents align with the IAEA safety standards, including those used for design and construction of NPPs (e.g., REGDOC-2.5.2, as discussed above). Therefore, the CNSC framework and processes used in the regulation of

activities related to design and construction ensure that new NPPs constructed in Canada will meet principle (1) of the VDNS.

Multinational Design Evaluation Programme

The CNSC plays an active role in MDEP, which has representatives from 14 countries, with the OECD's Nuclear Energy Agency (NEA) providing a technical secretariat function. Aiming to harmonize regulatory requirements and regulatory practices, MDEP seeks to:

- enhance multilateral cooperation within existing regulatory frameworks
- promote multinational convergence of codes, standards and safety goals
- implement MDEP products to facilitate licensing of new reactors

The involvement of the CNSC in MDEP covers multiple areas of interest to Canada, including:

- design-specific safety issues and activities surrounding the AREVA European Pressurized Reactor and Westinghouse AP1000 designs
- issue-specific activities, such as:
 - methods by which multinational vendor inspections can be utilized
 - convergence of pressure boundary component codes and standards
 - resolution of regulatory issues around digital instrumentation and control standards

Vendor pre-project design reviews

The CNSC has established a vendor-optional process to assess reactor facility designs based on a vendor's reactor technology. The term "pre-project" signifies that a design review is undertaken prior to the submission of a licence application to the CNSC. This service does not certify a reactor design or involve the issuance of a licence under the NSCA, and it is not required as part of the licensing process for a new NPP. The conclusions of any design review do not bind or otherwise influence decisions made by the Commission.

This process is used by a vendor to evaluate whether its reactor design will be acceptable with respect to Canadian regulatory requirements and expectations. This includes identification of fundamental barriers to licensing a new design in Canada. The CNSC has developed work instructions to guide its assessment of information submitted by the vendor. The process is divided into three distinct phases. Typically, the CNSC provides a confidential report to the vendor at the end of each phase and an executive summary is posted on the CNSC website. The phases of vendor pre-project design reviews and the status of specific reviews are described in annex 18.

The CNSC has found the vendor pre-project design reviews to be extremely valuable – not only as part of preparing for future licence submissions but also in investigating new design issues and their potential impacts on the regulatory framework. This process, in parallel with MDEP activities, has contributed significantly to the CNSC's readiness for future licensing activities. Utilities may find that the vendor pre-project design reviews are helpful for informing applications for a licence to prepare the site or construct an NPP.

CANDU design-related activities

During the reporting period, Candu Energy completed the development work for the Enhanced CANDU 6 (EC6) reactor, a Generation III design that represents an evolution from the

CANDU 6 reference design (Qinshan, China). In addition, Argentina announced it had signed an agreement for the construction of a new EC6 reactor during the reporting period. The EC6 reactor is intended to meet or exceed current regulatory design requirements, such as those in CNSC regulatory documents REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants*, REGDOC-2.4.1, *Deterministic Safety Analysis* and REGDOC-2.4.2, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*. In particular, this evolution has resulted in the addition of a new safety system (the emergency heat removal system) and the addressing of requirements related to safety goals, severe accidents, single failure criterion, system classification, containment design and malevolent acts, and seismic event frequency. The EC6 design also takes into account the lessons learned from the Fukushima accident.

During the reporting period, Candu Energy continued to be involved in the overall industry response to the Fukushima accident to reassess the safety of the existing CANDU reactors, in Canada and overseas. Candu Energy has provided services to support changes in design, equipment or processes, based on the Fukushima lessons learned.

Nuclear code of conduct for NPP vendor countries

Canada continued its participation in an initiative sponsored by the Carnegie Endowment for International Peace to develop *Nuclear Power Plant Exporters Principles of Conduct* (Principles of Conduct). Adopted during the previous reporting period, the Principles of Conduct address several important principles for NPP exports, including safety, health, radiological protection, physical security, environmental protection, the handling of spent fuel and nuclear waste, compensation for nuclear damage, non-proliferation, safeguards and ethics. Their purpose is to complement national laws and regulations, international laws and norms, and the recommendations of institutions (such as the IAEA) that promote the peaceful use of nuclear technology as a safe, secure, reliable and efficient source of energy. Semi-annual meetings of the signatories to the Principles of Conduct have reviewed the lessons learned during their implementation. Candu Energy is a signatory and is engaging the Secretariat of the Principles of Conduct to support revision of the organization's scope and future implementation.

18 (i) Implementation of defence in depth in design and construction

To ensure a low probability of failures or combinations of failures that would result in significant radiological consequences, design for the defence-in-depth approach considers the following:

- conservative design and high quality of construction to minimize abnormal operation or failures
- provision of multiple physical barriers (e.g., the fuel, pressure boundary and containment) that prevent the release of radioactive materials to the environment
- provision of multiple means for each of the basic safety functions (e.g., reactivity control, heat removal, confinement of radioactivity)
- use of reliable, engineered protective devices in addition to the inherent safety features
- supplementation of the normal control of the NPP by automatic activation of safety systems or by operator actions
- provision of equipment and procedures to detect failures, along with backup accident prevention measures to control the course and limit the consequences of accidents

The Canadian approach to NPP safety evolved from the recognition that even well-designed and well-built systems may fail. However, when the defence-in-depth strategy is properly applied,

no single human error or mechanical failure has the potential to compromise the health and safety of persons or the environment. Emphasis has been placed on designs that incorporate “fail-safe” modes of operation, should a component or a system failure occur. The approach also recognizes the need for separate, independent safety systems that can be tested periodically to demonstrate their availability to perform their intended functions.

The CANDU design and defence-in-depth strategy allows Canadian NPPs to safely operate and, when necessary, safely shutdown their reactors, even for low-probability or rare internal and external events.

Some of the criteria that have guided the design of the currently operating NPPs in Canada and contributed to defence in depth are described in conjunction with the safety analysis criteria (described in subsection 14(i)(c)). Specific design criteria and requirements are found in some of the CSA standards included in the licensing basis for existing NPPs, such as:

- N285.0, *General requirements for pressure retaining systems and components in CANDU nuclear power plants*
- N293, *Fire protection for CANDU nuclear power plants*

As well, REGDOC-2.5.2 contains updated requirements related to defence in depth (see annex 18) that will be applied to new-build projects and considered as part of ISRs and PSRs. The existing NPPs made various design improvements to enhance defence in depth during the reporting period. Some examples of the improvements are provided in annex 18(i).

During the reporting period, CNSC staff deemed the level of defence in depth at all Canadian NPPs to be acceptable. As provided in the sixth Canadian report, CNSC staff had specifically assessed the level of defence in depth of existing NPPs in light of the Fukushima accident. It was concluded that the design basis for Canadian NPPs is comprehensive and that the NPPs met the design requirements. It was also concluded that the risk to the Canadian public from beyond-design-basis accidents (BDBAs) at NPPs was very low. Given the design features and defence in depth for Canadian NPPs, adequate time would be available for long-term mitigation of a BDBA. Although the risk of an accident is very low, NPP operators implemented several modifications to improve their ability to withstand prolonged losses of power and other challenges, such as the loss of all heat sinks. See annex 18(i) of this report and the sixth Canadian report for details.

18 (ii) Incorporation of proven technologies

Measures are embedded in the Canadian licensing process to ensure the application of state-of-the-art, proven technologies. In each phase of licensing, documents have to be submitted that describe, verify and validate the technology employed. These include the design and safety analysis information contained in the safety analysis report and the quality assurance program for design and safety analysis.

The CANDU design criteria and requirements include the design and construction of all SSCs to follow the best applicable code, standard or practice and to be confirmed by a system of independent audit.

In particular, for pressure boundaries, the CNSC reviews the design against the requirements of the NSCA and the associated regulations and approves the classification using the requirements in CSA standard N285.0, *General requirement for pressure-retaining systems and components in*

CANDU nuclear power plants. The licensee then registers the design with an authorized inspection agency, which audits the fabrication of the design, inspects the construction, installation and tests, and countersigns the pressure test results.

Licensees use safety analysis computer codes that have been validated in accordance with the requirements of CSA standard N286.7, *Quality Assurance of Analytical, Scientific and Design Computer Programs for Nuclear Power Plants.*

CNSC regulatory document REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*, requires NPP licensees to update their safety analysis report at least once every five years or when requested to do so by the CNSC. As stated in subsection 14(i)(c), the tools and methodologies used in the safety analysis report have to be proven according to national and international experience and reflect the modern state of the knowledge. The safety analysis report must use or incorporate new methodologies, computer codes, experimental data, and R&D findings. As a result, some of the events in the safety analysis report are re-analyzed when necessitated by advances in science and technology.

Further, CNSC regulatory document REGDOC-2.4.1, *Deterministic Safety Analysis*, stipulates the selection of computational methods or computer codes, models and correlations that have been validated for the intended applications. The requirements in REGDOC-2.4.1 will be gradually addressed for existing NPPs, as explained in subsection 14(i)(c).

Environmental qualification programs at Canadian NPPs also help to prove that safety and safety-related systems will operate as intended, insofar as they are relied upon to help prevent, manage and mitigate accidents. The NPP licensees have ongoing programs to systematically sustain (and, if necessary, update) the environmental qualification of safety and safety-related systems in accordance with CSA standard N290.13, *Environmental qualification of equipment for CANDU nuclear power plants.* To ensure environmental qualification technical issues are managed in a timely way, these programs typically involve a governance mechanism, a list of equipment to be maintained in the environmental qualification state, staff training, technical basis documents, and processes for dealing with emerging issues. The CNSC monitors the progress of these programs, in addition to ongoing inspections of these systems.

For new-build projects, in addition to the criteria for existing NPPs (such as those found in CSA standards N285.0, N286.7 and N290.13), there are requirements in CNSC regulatory document REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants*, for proving engineering practices and qualifying designs (see annex 18). The safety analyses submitted in support of the application will also be assessed against the requirements in REGDOC-2.4.1 related to the use of methods and inputs that have been proven by validation.

18 (iii) Design for reliable, stable and manageable operation

Consideration is given to human factors and human–machine interfaces throughout the entire life of an NPP to make sure the NPP is tolerant of human errors.

The consideration of human factors in design and the application of human factors in engineering are described in subsection 12(e). Detailed design requirements in CNSC regulatory document REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants*, that are related to reliability, operability, human factors and the human–machine interface are provided in annex 18.

Additionally, CNSC regulatory document REGDOC-2.3.2, *Accident Management, Version 2*, published in September 2015, takes into account personnel needs, including aspects such as information, procedures, training and habitability of facilities required to manage accidents.

To illustrate how human factors and human–machine interface are considered in the design of Canadian NPPs, one can examine the requirements for safety parameter display. REGDOC-2.5.2 calls for a safety parameter display system that presents sufficient information on safety-critical parameters for the diagnosis and mitigation of design-basis accidents and design extension conditions. The safety parameter display system must be integrated and harmonized with the overall control room human–system interface design. Post-accident monitoring parameters, parameters that monitor when process or safety limits are being approached and the status of safety systems are all available on the panel displays for existing CANDU NPPs. Candu Energy has designed a dedicated safety parameter display system to provide a concise display of critical safety parameters and safety system status to the operations and emergency response staff, to aid them in rapidly and reliably determining the safety state of the NPP. This safety parameter display system has been integrated into the EC6 design in the main control room, secondary control area, technical support area and emergency support centre.

Article 19 – Operation

Each Contracting Party shall take the appropriate steps to ensure that:

- (i) the initial authorization to operate a nuclear installation is based upon an appropriate safety analysis and a commissioning programme demonstrating that the installation, as constructed, is consistent with design and safety requirements;
- (ii) operational limits and conditions derived from the safety analysis, tests and operational experience are defined and revised as necessary for identifying safe boundaries for operation;
- (iii) operation, maintenance, inspection and testing of a nuclear installation are conducted in accordance with approved procedures;
- (iv) procedures are established for responding to anticipated operational occurrences and to accidents;
- (v) necessary engineering and technical support in all safety-related fields is available throughout the lifetime of a nuclear installation;
- (vi) incidents significant to safety are reported in a timely manner by the holder of the relevant licence to the regulatory body;
- (vii) programmes to collect and analyse operating experience are established, the results obtained and the conclusions drawn are acted upon and that existing mechanisms are used to share important experience with international bodies and with other operating organizations and regulatory bodies.
- (viii) The generation of radioactive waste resulting from the operation of a nuclear installation is kept to the minimum practicable for the process concerned, both in activity and in volume, and any necessary treatment and storage of spent fuel and waste directly related to the operation and on the same site as that of the nuclear installation take into consideration conditioning and disposal.

19(i) Initial authorization

There were no initial licensing activities related to operating a new NPP during the reporting period.

The CNSC's consideration of an application for an initial licence to operate an NPP is predicated on the applicant having already demonstrated conformance with the requirements for siting, design and construction (as outlined in subsections 7.2(ii)(b) and 7.2(ii)(c), and in articles 17 and 18). (See subsection 7.2(ii)(d) for additional details regarding information that an applicant is required to submit with an application for a licence to operate.) The granting of an initial licence to operate is based upon an appropriate safety analysis and a commissioning program demonstrating that the NPP, as constructed and commissioned, meets design and safety requirements.

General requirements related to deterministic safety analysis and PSA are described in subsections 14(i)(c) and 14(i)(d), respectively. The final safety analysis report submitted with an application for a licence to operate a new NPP will be assessed against CNSC regulatory documents REGDOC-2.4.1, *Deterministic Safety Analysis*; REGDOC-2.4.2, *Probabilistic Safety*

Assessment (PSA) for Nuclear Power Plants; and REGDOC-2.5.2, Design of Reactor Facilities: Nuclear Power Plants.

The objectives of regulatory oversight of the NPP commissioning program are to determine that:

- the commissioning program is comprehensively defined and implemented to confirm that the SSCs important to safety and the integrated plant will perform in accordance with the design intent, safety analysis and applicable licensing requirements
- the operating procedures covering all operating and abnormal states have been validated to the maximum extent practicable
- the commissioning and operating staff have been trained and qualified to commission the NPP and operate it safely, in accordance with the approved procedures
- the management system has been adequately defined, implemented and assessed to provide a safe, effective and high-quality working environment to perform and support the conduct of the commissioning program

Commissioning tests are to be performed in phases and in a logical progressive sequence. There are at least four phases:

- Phase A: prior to fuel load
- Phase B: prior to leaving reactor guaranteed shutdown state
- Phase C: approach to critical and low-power tests
- Phase D: high-power tests

It should be noted that licensees may incorporate additional phases in a project. There is a regulatory hold point at the end of each phase and depending on the situation, the CNSC may request additional regulatory hold points. The selection of regulatory hold points will generally be agreed upon between the licensee and the CNSC and incorporated into the licence to operate.

Before proceeding to the next commissioning phase, the licensee demonstrates to the CNSC that all prerequisites established between the licensee and the CNSC necessary for proceeding beyond the current phase are met. In addition, before transitioning to the subsequent phase, the licensee assures that SSCs credited in the safety case for that phase have been installed and confirmed to the extent practicable to meet their designed safety function.

The following steps should be undertaken at the end of each commissioning phase:

- Documents to certify the performance of tests and provide phase clearances for the continuation of the commissioning program should be prepared and issued.
- Test certificates should be issued by the commissioning organization to certify that the tests have been completed in accordance with authorized procedures, stating any reservations about departures from or limitations of the procedures.
- Phase completion certificates should be issued by the commissioning organization to certify that all the tests in the respective commissioning phase have been satisfactorily completed (listing all deficiencies and non-conformances, if any). Phase completion certificates should also list associated test certificates.
- It should be ensured that succeeding phases can be conducted safely and that the safety of the reactor facility is never dependent on the performance of untested SSCs.

As there is a regulatory hold point in place at the end of each phase, the written request to the CNSC for approval to proceed beyond a commissioning phase should confirm that:

- all related project commitments tied to the phase have been completed

- all systems required for safe operation beyond the phase are available
- all specified operating procedures have been formally verified and validated
- specified training has been completed and staff are qualified
- all non-conformances and unexpected results identified leading up to the next phase have been addressed

For each phase of commissioning, the licensee is expected to establish a set of commissioning control points (CCPs) to achieve a transparent, accountable and effective process for ensuring that the prerequisites for the release of each CCP have been formally demonstrated.

Some CCPs will also be regulatory hold points, requiring prior authorization by the Commission or a person authorized by the Commission to proceed further in the commissioning program. “Non-licensing” CCPs are usually treated as witness points, observed by CNSC staff. Licensees are expected to exercise appropriate control of all CCPs. All applicable non-licensing CCPs must be satisfactorily completed to obtain the release from the regulatory hold points.

Details on the conduct of NPP commissioning programs, reactor designer input and the regulatory oversight of commissioning are provided in annex 19(i).

19 (ii) Operational limits and conditions

19 (ii) (a) Identification of safe operating limits

The requirement for NPP licensees to describe, in an application for a licence to operate a Class I nuclear facility, the systems and equipment, including their design and operating conditions, is stated in paragraph 6(b) of the *Class I Nuclear Facilities Regulations*.

The safe operating limits satisfy regulatory requirements, standards and guidelines related to NPP design and operation, including defence-in-depth principles. Historically, these are implemented in operating manuals and impairment manuals (see subarticle 19(iv)).

The full set of requirements for safe operation of a CANDU NPP includes:

- requirements on special safety systems and safety-related standby equipment or functions (e.g., set points and other limiting parameters, availability requirements)
- requirements on process systems (e.g., limiting parameters, testing and surveillance principles and specifications, performance requirements under abnormal conditions)
- prerequisites for removing special safety systems and other safety-related or process standby equipment from service

These requirements are derived from design-basis safety analyses that are described in the safety analysis report. The safety analysis examines the NPP’s responses to disturbances in process function, system failures, component failures and human errors. Other requirements (e.g., those identified through design support analysis or PSA) could include limitations related to equipment and materials, operational requirements, equipment aging, instrumentation and analysis uncertainties, and more. Assessments of failure modes and effects analysis can also identify requirements that form part of the safe operating limits. In principle, the analysis considers all allowable power levels; however, it is not feasible to analyze in advance every potential state that could occur throughout the life of an NPP. Therefore, the analysis attempts to consider sufficient situations to define safe operating limits that encompass the expected variations in conditions at a reasonable level of system/equipment performance detail.

Operating limits for Canadian NPPs that have the greatest impact on safety are identified in the operating policies and principles (OP&P; see subsection 9(b)) document and through the safe operating envelope (SOE) documentation (see subsection 19(ii)(b)). Changes to these limits that may negatively affect safety require appropriate justification by operations support staff and are reviewed by the CNSC.

19 (ii) (b) Safe operating envelope project

The purpose of the safe operating envelope (SOE) project was to more clearly define the safe operating limits for Canadian NPPs, so that they are readily measurable by operations staff. In the past, the licensees primarily used the OP&P to define relevant operational limits. However, because the OP&P represent only a subset of the relevant limits, the licensees undertook a project to more fully define the SOE as a complete and comprehensive set of limits derived from the safety analysis through controlled processes, based on the requirements of CSA standard N290.15-10, *Requirements for the safe operating envelope of nuclear power plants*.

In the process of developing and implementing SOE programs, it was noticed that there was strong alignment among the NPPs and any variations between them (in terms of the plant systems) were explicitly identified during the SOE project. To achieve consistency and rationalize differences, COG documented the industry position in 2013 with respect to rationalizing the plant systems considered to be part of the mandatory SOE scope for operating NPPs in Canada, and to identify criteria to rationalize the differences in SOE systems. This document will allow the licensees to focus on the aspects that are most important to safety.

All NPP licensees performed self-assessments against the requirements of N290.15 during the SOE implementation process, using the COG document as guidance. Additionally, CNSC staff conducted independent pilot SOE inspections at Canadian NPPs during the reporting period. NPP licensees took the necessary steps to address gaps identified in the self-assessments and the CNSC inspection findings. The inspections confirmed that all NPPs have completed the initial development and the baseline implementation of their SOE programs.

With SOEs implemented, all licensees commenced the maintenance phase, and will periodically review document changes resulting from revisions to design, operation, safety analysis or licence requirements against the SOE documents.

19 (iii) Procedures for operation, maintenance, inspection and testing

Operation, maintenance, inspection and testing of systems, equipment and components at the NPPs are conducted in accordance with approved governance and procedures. The governance and procedures are incorporated into various licensee programs (examples are provided in appendix C) within the structure of the NPP's management system (see subsection 13(a)).

The governance defines the organizational and administrative requirements for the establishment and implementation of preventive, corrective and predictive maintenance; periodic inspections; tests; repairs and replacements; training of personnel; procurement of spare parts; provision of related facilities and services; and generation, collection and retention of operating and maintenance records.

The CNSC regulatory document RD/GD-210, *Maintenance Programs for Nuclear Power Plants*, sets the requirements for policies, processes and procedures for maintaining the SSCs of each NPP. The range of maintenance activities specified includes monitoring, inspecting, testing,

assessing, calibrating, servicing, overhauling, repairing and replacing parts – all intended to ensure that the reliability and effectiveness of all equipment and systems continue to meet the relevant requirements.

CNSC regulatory document RD/GD-98, *Reliability Programs for Nuclear Power Plants*, specifies that a reliability program for an NPP shall:

- identify all systems important to safety
- specify reliability targets for those systems
- describe the potential failure modes of those systems
- specify the minimum capabilities and performance levels of those systems needed to satisfy regulatory requirements and the safety targets of the NPP
- provide input for the maintenance program to maintain the effectiveness of those systems
- provide for inspections, tests, modelling, monitoring and other measures to assess the reliability of those systems
- include provisions to assure, verify and demonstrate that the program is implemented effectively
- document the elements of the program
- report the results of the program

The identification of systems important to safety is done using input from PSAs (see subsection 14(i)(d)), deterministic analyses (see subsection 14(i)(c)) and expert panels. Operations are governed by the OP&P for each NPP that, among other things, set requirements for the maintenance and testing procedures for special safety systems to ensure no safety function is ever compromised by maintenance activities. Safety system testing is required at a frequency that demonstrates that each safety function is operating correctly and meets availability limits (typically, greater than 99.9 percent). Each component of a special safety system is subject to a regular functional test. Specific requirements for testing to confirm the availability/functionality of safety and safety-related systems are described in subsection 14(ii)(a).

Procedures used by NPP staff during routine operation of the NPP and its auxiliary systems are located in the operating manuals. The operating manuals contain:

- system-based procedures that assist the operators during normal operations, such as system start-up and shutdown and minor malfunctions limited to individual systems
- overall unit-control procedures that coordinate major evolutions such as unit start-up and shutdown and major plant transients
- alarm response manual procedures that provide the operations staff with information regarding alarm functions; typical information provided includes set points, probable causes of alarms, pertinent information, references and operator responses

To aid the safe and consistent operation of the NPPs, detailed station condition records or event reports are written by the licensees. These documents provide information on undesirable events considered significant in the operation of NPPs. They are reviewed to confirm safe operation and help identify necessary corrective actions or opportunities for improvement (see subarticle 19(vii) for more details). Less significant issues are also reported for trending purposes.

The NPP licensees implemented several improvements during the reporting period that will positively affect various aspects of operation, maintenance, inspection, testing and reliability.

Improvements to surveillance hardware and software were also implemented, to improve component and system surveillance and trending capabilities. At Darlington, the shutdown system monitoring computer was improved to enhance monitoring, calibrating and testing capabilities. At Pickering, a new computer interface for generator turbine temperature monitoring has been installed to improve temperature point monitoring capabilities for the turbine generator operators. The transition of control room instrumentation from analog to digital continued at all OPG NPP sites to improve monitoring and control capabilities.

19 (iv) Procedures for responding to operational occurrences and accidents

The *Class I Nuclear Facilities Regulations* require each NPP licensee to have measures to prevent or mitigate the effects of accidental releases of nuclear substances and hazardous substances, as well as, measures to assist offsite authorities in emergency preparedness activities. CNSC regulatory document REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response, Version 2*, which will be implemented in the next reporting period, provides the detailed requirements for onsite emergency plans and response capability. Emergency plans and programs, including accident management provisions, are submitted to the CNSC as part of the licence application (see subsection 16.1(b) for details). The CNSC also observes emergency training, exercises and drills to confirm adequate implementation of the licensees' onsite provisions in their emergency response plans.

It is recognized that the consequences of reactor accidents can be minimized by sound onsite and offsite accident management. This is achieved by developing operating procedures in advance to assist and guide operators in responding to accidents.

All Canadian NPPs have a comprehensive, hierarchical set of manuals and procedures – covering normal plant operation, anticipated operational occurrences and accident conditions – that are routinely tested in onsite drills. Although procedures vary among NPPs, the system generally contains:

- an abnormal incident manual
- a special safety system impairments manual (which may be a subset of the abnormal incident manual)
- a radiation protection manual (or radiation protection directives)

The suite of abnormal incident manual procedures directs the operations staff following safety system impairment, process system failure or a common mode event. These are typically event-based procedures and have as their end points the safe shutdown of the unit. Critical safety parameter procedures provide support for all procedures but are especially useful during transients. They provide structure for the augmented monitoring of critical NPP operating parameters during specific accident conditions and in cases when the specific event cannot be determined. They also provide symptom-based frameworks for controlling the reactor, cooling the fuel, and containing radioactivity.

Radiation protection manual procedures are provided to protect the safety of the operators and the general public under normal conditions and in the event of a significant radiation incident. These procedures:

- direct event classification and categorization
- provide for offsite notification
- direct protective actions and monitoring during accident conditions

Each NPP licensee maintains a minimum staff complement to make sure there are always sufficient numbers of appropriately qualified staff available to respond to emergencies (for details, see annex 11.2(a)).

The fundamental elements of licensee procedures for responding to anticipated operational occurrences and events were unchanged during the reporting period. As described in previous reports, licensees developed, and continue to maintain, operating procedures for dealing with anticipated operational occurrences, situations and events. Events are typically followed up by formal determination of root causes with corrective actions that are commensurate with the situation.

Examples of safety-significant operational events occurring at Canadian NPPs during the reporting period are listed in appendix D. They illustrate how the licensees responded to the events and how the CNSC conducted regulatory follow-up. The licensees' efforts to address these operational events were effective in correcting deficiencies and preventing recurrence. None of the events posed a significant threat to persons or the environment. For example, there were no serious process failures at any NPP during the reporting period. There were also no events that required rating using the International Nuclear Event Scale (INES), as all events based on pre-rating review were assessed as Level 1 or below-scale (i.e., Level 0).

Severe accident management

Severe accident management (SAM) focuses on preventing the progression of an accident into a severe accident or mitigating a severe accident when the preventive means have failed. It relies on the design, guidance and procedural provisions used by NPP staff, as well as appropriate training activities. Response to severe accidents can be enhanced by external resources that supplement or replace the onsite resources, including fuel, water, electric power or equipment such as pumps or generators. The CNSC's requirements and guidance can be found in the CNSC regulatory document REGDOC-2.3.2, *Accident Management, Version 1*, which was published October 2014 but is also addressed in the CNSC regulatory document REGDOC-2.3.2, *Accident Management, Version 2*, which was published September 2015.

The severe accident management provisions may differ between NPPs, depending on the location and nature of the NPP, as some NPPs are single-unit facilities in relatively remote rural locations and others are multi-unit facilities close to major urban centres.

As noted in the sixth Canadian report, the post-Fukushima review of licensees and their provisions for using existing plant capabilities, complementary design features and emergency mitigating equipment in SAM and recovery confirmed that they remain adequate.

Severe accident management guidelines

The development of CANDU generic severe accident management guidelines (SAMGs) is described in annex 19(iv). Conversion of the generic SAMGs into plant-specific ones and implementation of the plant-specific SAMGs have been completed for each of the Canadian NPPs except at Gentilly-2. Since the reactor at Gentilly-2 has been shut down and placed in a safe storage state, the licensee completed the development and implementation of its SAMGs for the irradiated fuel bay only.

The development and implementation of plant-specific SAMGs require considerations of plant-specific designs, operation, equipment, instrumentation and organizational structure. This has

included the development of instructions for roles and responsibilities of the personnel involved in SAM and emergency response, guidelines for control room and technical support group operations, specific staff training requirements, and appropriate drills and exercises as part of SAMG validation.

The post-Fukushima review of procedural guidance and design capabilities of operating NPPs to cope with accidents, including those involving significant core damage, confirmed that SAMGs are adequate. To further increase the capabilities to mitigate severe accidents, the CNSC assigned through the CNSC Action Plan, three Fukushima action items (FAIs) to licensees related to SAMGs:

- develop/finalize and fully implement SAMGs at each NPP
- expand the scope of SAMGs to include multi-unit and irradiated fuel bay events (see the Canadian report for the Second Extraordinary Meeting of the CNS for details)
- validate/refine SAMGs to demonstrate their adequacy to address lessons learned from the Fukushima accident

In response, a COG joint project was carried out to address issues related to updating of SAMGs, containment integrity, hydrogen mitigation and management, and implementation of in-vessel retention of the core debris as a key strategy for SAM. At the end of this reporting period, the COG joint project was completed. The above-listed FAIs have been closed for all NPPs. The implementation of the post-Fukushima updates in SAMGs, and the demonstration of SAMG effectiveness through exercises and plant drills are ongoing.

The emergency mitigating equipment guidelines (EMEGs) have been developed and implemented to guide the deployment of emergency mitigating equipment as an additional onsite capability to provide water and electricity to cope with accidents. Integration of plant procedures (e.g., abnormal incident manuals, emergency operating procedures) with SAMGs and EMEGs is ongoing.

Verification of the SAMG/EMEG documentation and training, along with the validation of the SAM program are being done mainly through table-top exercises, plant drills or large-scale emergency exercises that simulate severe accident scenarios. One such exercise conducted during the reporting period was Exercise Intrepid (see annex 16.1(f)).

During the reporting period, CNSC staff undertook a number of activities to review the licensees' SAM programs. These activities included:

- desktop reviews of technical basis and documentation for NPP-specific SAMGs
- reviews of the EMEGs and their integration with SAMGs and other plant procedures and manuals
- interviews with plant staff involving SAM and emergency response
- evaluations of plant drills simulating severe accidents where SAMGs and EMEGs are exercised
- analytical simulations of severe accident progression with and without the SAMG-specified actions
- integral assessment while taking into account all the above

Further details on the development and implementation of SAMGs at each NPP during the reporting period are provided in annex 19(iv).

19 (v) Engineering and technical support

Necessary engineering and technical support in all safety-related fields must be available throughout the lifetime of an NPP, including during accident conditions or under decommissioning.

Article 11 addresses licensee financial and human resources, which are planned throughout the NPP's life as well as decommissioning. Budgets are also made available to hire external service providers and establish contracts for support in areas outside the technical or engineering expertise of full-time staff. All NPP licensees have service contracts with other Canadian companies that include research, engineering, analysis, assessment, maintenance, inspections and design support. The CANDU R&D program, which supports the operating NPPs, is described in appendix E.

Canadian NPP licensees have smart buyer functions to assure that the services rendered to them serve the purpose and meet the relevant requirements. In short, a smart buyer is an organization that knows what it will likely receive, its implications, the methodology used by outside contractors to arrive at certain positions, and how the results received will be managed.

For example, OPG's smart buyer function establishes a number of key attributes to enable recognition of the quality of outputs provided by outside organizations that might affect safety:

- sufficient staff to maintain specialized expertise in the required discipline (e.g., thermal hydraulics)
- in-depth knowledge of past and present regulatory issues
- rapport with regulatory staff specialists
- in-depth knowledge of NPP design and operation
- ability to provide leadership on technical issues within the Canadian nuclear industry

The NPP licensees utilize a design authority function to ensure that the integrity of approved designs and the design process is maintained. The design authority is executed by the chief engineer, who has overall responsibility for the smart buyer function. The design authority encompasses overall responsibility for the design process, approval of design changes, and assurance that the requisite knowledge of the reference design is maintained as defined and implemented in the management system. The scope of accountability ensures that:

- a knowledge base of relevant aspects of the facility and products is established and kept up to date, while experience and research findings are taken into account
- all design information required for a safe facility is available
- the requisite security measures are in place
- design configuration is maintained for approved designs
- appropriate design verification is applied
- all necessary interfaces are in place
- all engineering and scientific skills are maintained
- appropriate design rules and procedures, including codes and standards, are used
- engineering work is executed by qualified staff using appropriate methods in compliance with procedures

All Canadian NPPs have generally the same reactor design and licensees therefore work closely with their partners, for example, through COG. Additionally, licensees can easily share technical

and engineering resources. The licensees presently share the same contractors, including specialists, in such areas as:

- emergency response organizations
- technical support groups that include contractors to provide support during accident response for SAMG

Further, there are mutual assistance agreements within industry. Membership in organizations such as the World Association of Nuclear Operators (WANO) and COG also provides access to assistance between member organizations.

Hydro-Québec is continuing to maintain the necessary engineering and technical support at Gentilly-2 during the safe storage state. The engineering and technical group at Gentilly-2 has access to additional support from Hydro-Québec staff working at other non-nuclear locations or specialized contractor organizations.

At Pickering, significant staff reductions are anticipated to be required as a result of the end of commercial operations at the NPP. In 2014, OPG established a team to focus on the end of commercial operations, led by the Senior Vice President of Nuclear Decommissioning and Waste and reporting directly to OPG's Chief Nuclear Officer. The team is accountable for the overall planning for the end of commercial operations at the NPP. This includes the plans for resourcing as well as plans for the physical plant, such as the safe storage project and decommissioning plans. Resourcing plans will ensure appropriate staff members are redeployed internally for decommissioning work.

19 (vi) Reporting incidents significant to safety

Licensees use station condition records or event reports to provide information on undesirable events that are considered significant in the operation of NPPs. The licensees determine the significance of these events using specific operational procedures. During the reporting period, the licensees reported safety-significant events to the CNSC in a timely manner and in accordance with the requirements of the CNSC regulatory document REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*. Additional information on the requirements and the work of CNSC staff to track and follow up on safety-significant events at NPPs is provided in subsection 7.2(iii)(b).

The CNSC submits the descriptions of events that meet INES thresholds to the IAEA Nuclear Event Web-based System (NEWS).

Canada is also committed to reporting to the International Reporting System (IRS), a database of international events that is operated by both the IAEA and the NEA, on significant events occurring at Canadian NPPs. Canada appoints a member of the CNSC staff as a national coordinator to collect, analyze and submit information on events occurring in Canada. Actions taken in Canada to address events reported internationally are presented annually by Canada through its delegates to the appropriate fora, such as the IRS technical committee and/or the NEA Working Group on Operating Experience.

Issues arising from operating experience (other than events) are reported in different fora. At the CNSC, such issues are disseminated at management meetings and via inspection reports. The screening of those issues that are to be shared with the public and international fora is performed as part of the preparation of event initial reports (EIRs), which are submitted to the Commission.

Guidance for screening EIRs is available to assist CNSC staff with preparing these reports for the Commission.

At all NPPs, the significance of discoveries other than incidents (e.g., unexpected degradation of equipment, management issues raised through various means including WANO peer reviews, design weaknesses) is rated using criteria in the corrective action program.

19 (vii) Operational experience feedback

The NPP licensees conduct analysis and trending of events with relatively small safety significance to help prevent the occurrence of events with more significant consequences. The licensees have active operating experience (OPEX) programs facilitated by COG, WANO and the Electric Power Research Institute (EPRI).

Existing mechanisms are used to share important OPEX throughout the CANDU industry and with international bodies and other operating organizations and regulatory bodies.

The process of collecting, analyzing and disseminating lessons learned from information arising from OPEX is normally part of the licensees' quality assurance programs. CSA standard N286, *Management system requirements for nuclear facilities*, requires measures to ensure OPEX is documented, assessed and incorporated into the operation of the NPP and its quality assurance programs, as appropriate. It also calls for sharing this information with personnel in the other phases of the NPP's lifecycle.

The primary sources of OPEX information are station condition records and event reports. Other licensee reports include the licensees' quarterly and annual reports, in-service reports and internal audit reports.

The licensees integrate OPEX into all aspects of NPP operation and management. For example, NB Power has developed a problem identification and corrective action system, while OPG has an OPEX website that incorporates station condition records. NPP licensees utilize OPEX from the WANO, COG and the Institute of Nuclear Power Operations (INPO) websites.

COG provides an information exchange program and chairs a weekly OPEX screening meeting teleconference that serves as a CANDU screening committee of industry OPEX representatives to review event reports from CANDU NPPs and nuclear industry sources.

Additionally, the CNSC has established the OPEX Clearinghouse program to systematically review domestic and international events, and to leverage the integrated expertise of CNSC staff, ensuring that relevant events are followed up in a timely manner. The OPEX Clearinghouse draws information from several sources including:

- Central Event Reporting and Tracking System, which is a database used to collect and categorize reported events at Canadian NPPs and track follow-up
- IRS
- NEA Working Group on Operating Experience

Problems or issues that arise from event reviews that may be applicable to other NPPs are identified and brought to the attention of CNSC site inspectors and different specialist groups in the CNSC.

CNSC staff members incorporate the results of root-cause analyses in their reviews and assessments of a licensee's corrective actions in response to a certain event. Further actions are

requested if the corrective actions undertaken by the licensee are considered inadequate. In addition, the CNSC site inspectors review the status of corrective actions to make sure they have been completed expeditiously.

CNSC inspection teams consult the OPEX in the Central Event Reporting and Tracking System when planning strategies for their audits and in identifying problem areas in operation or maintenance (such as procedural non-compliance, procedural deficiencies and the use of non-standard components). Similarly, CNSC assessments often utilize the OPEX recorded in this database. As part of the inspection baseline, CNSC inspectors check the licensee's station condition records or event reports, along with system health reports, to ensure OPEX and the extent of condition have been applied to the systems by the licensees.

19 (viii) Management of spent fuel and radioactive waste onsite

Responsibility

The Government of Canada has established a radioactive waste policy framework, to ensure the safe management of spent fuel and radioactive waste. Primary responsibility for the storage and long-term management of radioactive waste and spent fuel rests with waste producers and owners (licensees).

Operations

Canadian NPP licensees manage radioactive waste using methods similar to those practised in other countries. As disposal facilities are not yet available, primary emphasis is placed on minimization, volume reduction, segregation, conditioning and interim storage of the waste.

A key principle concerning the management of radioactive waste is that its generation should be minimized to the extent practicable through the implementation of appropriate design measures and operating/decommissioning practices.

The Canadian nuclear industry minimizes waste through:

- material control procedures to prevent materials from unnecessarily entering into radioactive areas
- enhanced waste monitoring capabilities to reduce inclusion of non-radioactive wastes in radioactive wastes
- use of launderable personal protective equipment, instead of single-use items
- improvements to waste handling facilities
- employee training and awareness

Reusing personal protective equipment has helped reduce the potential waste being generated during the operation of NPPs. Compaction of replaced components has also helped to significantly reduce the volume of waste generated during operations.

All waste produced at NPPs is segregated at its point of origin as contaminated or non-contaminated. Low-level and intermediate-level contaminated wastes are further sorted into distinct categories, such as:

- can be incinerated
- can be compacted
- cannot be processed to further reduce its volume

Further sorting of the waste helps facilitate subsequent handling, processing and storage.

Radioactive waste and spent fuel management

Radioactive wastes resulting from reactor operations are stored onsite or offsite in above- or below-ground engineered structures. Prior to storage, the volume of the wastes may be reduced by incineration, compaction or shredding. In addition, there are facilities for the decontamination of parts and tools, laundering of protective clothing, and the refurbishment and rehabilitation of equipment.

The NPP licensees have instituted methods to recover storage space after sufficient radioactive decay or reclaim existing storage space through further compaction (super compaction) and/or segregation.

It is possible to retrieve all stored radioactive waste.

Spent fuel from NPPs is stored in interim storage at the site where it was produced. When the fuel first exits the reactor, it is placed in water-filled irradiated fuel bays for cooling and radiation shielding. After the minimum amount of time in the bays – six to ten years (the exact cooling period is site-specific) – and when the associated heat generation has diminished, the spent fuel can be transferred to an onsite, interim dry storage facility.

The use of natural uranium in CANDU reactors results in fuel bundles – either fresh or irradiated – that cannot lead to a critical state either in air or light water. Therefore, a criticality accident cannot occur when CANDU fuel is stored in an irradiated fuel bay or dry storage facility. This is an inherent safety design of the CANDU system.

As for all nuclear activities, the facilities for handling radioactive waste and spent fuel must be licensed by the CNSC and conform to all pertinent regulations and licence conditions. The waste management objective throughout the industry – from mines to NPPs – is the same, which is to control and limit the release of potentially harmful substances into the environment. CNSC staff members inspect all licensed facilities to confirm the achievement of this objective.

Further information on Canada's provisions for radioactive waste and spent fuel can be found in the fifth *Canadian National Report for the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*, published in October 2014. This report is available on the CNSC and IAEA websites.

APPENDICES

Appendix A Relevant Websites

Document or organization	Web site
<i>Nuclear Safety and Control Act</i>	laws-lois.justice.gc.ca/eng/acts/N-28.3
<i>Canadian Environmental Assessment Act, 2012</i>	laws-lois.justice.gc.ca/eng/acts/C-15.21
<i>General Nuclear Safety and Control Regulations</i>	laws-lois.justice.gc.ca/eng/regulations/SOR-2000-202
<i>Class I Nuclear Facilities Regulations</i>	laws-lois.justice.gc.ca/eng/regulations/SOR-2000-204
<i>Radiation Protection Regulations</i>	laws-lois.justice.gc.ca/eng/regulations/SOR-2000-203
<i>Canadian Nuclear Safety Commission Cost Recovery Fees Regulations</i>	laws-lois.justice.gc.ca/eng/regulations/sor-2003-212
<i>Administrative Monetary Penalties Regulations (Canadian Nuclear Safety Commission)</i>	laws.justice.gc.ca/eng/regulations/SOR-2013-139
<i>Nuclear Liability and Compensation Act</i>	laws.justice.gc.ca/eng/acts/N-28.1
Atomic Energy of Canada Limited	aecl.ca
Bruce Power	brucepower.com
Canadian Environmental Assessment Agency	ceaa-acee.gc.ca
Canadian Nuclear Laboratories	cnl.ca
Canadian Nuclear Safety Commission	nuclearsafety.gc.ca
Candu Energy Inc.	candu.com
CANDU Owners Group	www.candu.org
CANTEACH	canteach.candu.org
Environment and Climate Change Canada	ec.gc.ca
Global Affairs Canada	international.gc.ca/international
Fisheries and Oceans Canada	dfo-mpo.gc.ca
Health Canada	hc-sc.gc.ca
Hydro-Québec	hydroquebec.com
Institute of Nuclear Power Operations	inpo.info
International Atomic Energy Agency	iaea.org
Natural Resources Canada	nrcan.gc.ca
NB Power	nbpower.com
Ontario Power Generation	opg.com
Public Health Agency of Canada	phac-aspc.gc.ca

Document or organization	Web site
Public Safety Canada	publicsafety.gc.ca
SNC-Lavalin Nuclear	snclavalin.com/en/nuclear
University Network of Excellence in Nuclear Engineering	unene.ca
University of Ontario Institute of Technology	uoit.ca
World Association of Nuclear Operators	www.wano.info

Appendix B

List and Status of Nuclear Power Plants in Canada

Reactor	Licensee	Gross capacity (MW)	Construction start	First criticality	Operating status
Bruce A, Unit 1	Bruce Power	830	Jun. 1, 1971	Dec. 17, 1976	Operating
Bruce A, Unit 2		800	Dec. 1, 1970	Jul. 27, 1976	Operating
Bruce A, Unit 3		830	Jul. 1, 1972	Nov. 28, 1977	Operating
Bruce A, Unit 4		830	Sep. 1, 1972	Dec. 10, 1978	Operating
Bruce B, Unit 5	Bruce Power	872	Jul. 1, 1978	Nov. 15, 1984	Operating
Bruce B, Unit 6		872	Jan. 1, 1978	May 29, 1984	Operating
Bruce B, Unit 7		872	May 1, 1979	Jan. 7, 1987	Operating
Bruce B, Unit 8		872	Aug. 1, 1979	Feb. 15, 1987	Operating
Darlington, Unit 1	Ontario Power Generation	934	Apr. 1, 1982	Oct. 29, 1990	Operating
Darlington, Unit 2		934	Sep. 1, 1981	Nov. 5, 1989	Operating
Darlington, Unit 3		934	Sep. 1, 1984	Nov. 9, 1992	Operating
Darlington, Unit 4		934	Jul. 1, 1985	Mar. 13, 1993	Operating
Gentilly-2	Hydro-Québec	675	Apr. 1, 1974	Sep. 11, 1982	Safe storage state
Pickering, Unit 1	Ontario Power Generation	542	Jun. 1, 1966	Feb. 25, 1971	Operating
Pickering, Unit 2		542	Sep. 1, 1966	Sep. 15, 1971	Safe storage state
Pickering, Unit 3		542	Dec. 1, 1967	Apr. 24, 1972	Safe storage state
Pickering, Unit 4		542	May 1, 1968	May 16, 1973	Operating
Pickering, Unit 5	Ontario Power Generation	540	Nov. 1, 1974	Oct. 23, 1982	Operating
Pickering, Unit 6		540	Oct. 1, 1975	Oct. 15, 1983	Operating
Pickering, Unit 7		540	Mar. 1, 1976	Oct. 22, 1984	Operating
Pickering, Unit 8		540	Sep. 1, 1976	Dec. 17, 1985	Operating
Point Lepreau	NB Power	705	May 1, 1975	Jul. 25, 1982	Operating

Appendix C

Examples of Program Descriptions and Plans Required to Support an Application to Renew a Nuclear Power Plant Operating Licence

Summary of programs organized by CNSC safety and control areas (not limited to the listed topics)		
<p>1. Management system</p> <ul style="list-style-type: none"> • Nuclear management system / nuclear safety policy • Managed systems / records and document control • Business planning / nuclear organization / organizational change control / contractor management program • Nuclear safety oversight / independent assessment / nuclear safety culture assessment 	<p>2. Human performance management</p> <ul style="list-style-type: none"> • Human performance / technical procedures • Continuous behaviour observation program / limits of hours of work / minimum shift complement • Leadership and management training / staff training 	<p>3. Operating performance</p> <ul style="list-style-type: none"> • Nuclear operations / operating policies and principles • Safe operating envelope / operational safety requirements • Plant status control / chemistry • Operating experience process / corrective action • Reactor safety program / reactivity management / heat sink management / response to transient • Accident management and recovery • Severe accident management and recovery
<p>4. Safety analysis</p> <ul style="list-style-type: none"> • Reactor safety program / risk and reliability program • Safety report (all parts) / analyses of record 	<p>5. Physical design</p> <ul style="list-style-type: none"> • Conduct of engineering / engineering change control / procurement engineering • Design management / configuration management • Fuel • Fire protection • Pressure boundary program • Environmental qualification • Software 	<p>6. Fitness for service</p> <ul style="list-style-type: none"> • Conduct of maintenance / integrated aging management • Equipment reliability / component and equipment surveillance / reliability and monitoring of systems important to safety • Major component / lifecycle management plans • Non-destructive examination
<p>7. Radiation protection</p> <ul style="list-style-type: none"> • Radiation protection / controlling exposure ALARA (as low as reasonably achievable) • Occupational action levels 	<p>8. Conventional health and safety</p> <ul style="list-style-type: none"> • Health and safety policy • Conventional safety / work protection 	<p>9. Environmental protection</p> <ul style="list-style-type: none"> • Environmental policy / environmental management / derived release limits and environmental action levels
<p>10. Emergency management and fire protection</p> <ul style="list-style-type: none"> • Emergency management policy / nuclear pandemic plan / consolidated nuclear emergency plan • Fire protection 	<p>11. Waste management</p> <ul style="list-style-type: none"> • Nuclear waste management program • Waste management • Decommissioning planning / preliminary decommissioning plan 	<p>12. Security</p> <ul style="list-style-type: none"> • Nuclear security • Security report
<p>13. Safeguards and non-proliferation</p> <ul style="list-style-type: none"> • Nuclear safeguards 	<p>14. Packaging and transport</p> <ul style="list-style-type: none"> • Radioactive material transportation 	<p>Other matters of regulatory interest</p> <ul style="list-style-type: none"> • Financial guarantees / nuclear liability insurances • Public information program • Aboriginal consultation

Appendix D

Significant Events During Reporting Period

Location/date ³	Description	Corrective action by licensee	Regulatory action
Manual shutdown at Pickering Units 1 and 4 June 5, 2013	During OPG system engineering environmental qualification walkdowns, a number of electrical connectors were found to be misaligned. A technical operability evaluation was initiated to ensure proper alignment of the connectors throughout the station. During the initial part of this evaluation, 461 connectors were inspected across Units 1–8. Three connectors on Unit 1 and two on Unit 4 were found to be misaligned. As a result, Units 1 and 4 were manually taken offline on June 5, 2013, per procedure, to complete repairs and inspect connectors in inaccessible areas. A total of 559 connectors have been inspected since the discovery.	OPG conservatively decided to shut down the units to perform the EQ inspections and complete all repairs. OPG performed a root-cause investigation and implemented a corrective action plan.	CNSC staff monitored OPG's progress through meetings and routine updates. CNSC staff verified that OPG took appropriate measures to protect the public, its workers and the environment.
Suspect valves at Bruce A and B, Darlington, Pickering and Point Lepreau March 2015	Licensees reported that some valves, which may have had suspect material used in their manufacture, were installed at Bruce A and B, Darlington, Pickering, and Point Lepreau. The potential non-conforming material in the suspect	Bruce Power, OPG and NB Power worked together to determine the extent of condition. A total of 1,116 valves and valve parts suspected of containing non-conforming material were found at Canadian NPPs. Of these, 740 were installed in operating NPPs.	CNSC staff concluded that the engineering assessments and reviews conducted by licensees, suppliers and authorized inspection agencies had been thorough and robust. The assessments demonstrated the components were fit for service with

³ All the events listed in this appendix were presented to the Commission during public hearings/meetings.

Location/date ³	Description	Corrective action by licensee	Regulatory action
	<p>valves came from a third-party supplier. These valves had been received as early as 2001 and some have been installed since that time. No impairments in special safety systems or safety-related systems were found attributable to the reported suspect items.</p> <p>The NPP licensees performed a root-cause analysis of the event. For this event, the root cause was identified as the supplier's employee misrepresenting information on the material test certificates about the materials used to manufacture certain parts of nuclear-class valves.</p> <p>As a result of the misrepresented material test certificates, these materials no longer met the material certification requirements of the <i>ASME Boiler and Pressure Vessel Code, Section III NCA 3862 – Certification of Material</i>.</p> <p>The vendors who conducted the engineering assessments concluded that there is no safety risk for the continued use of the valves and parts.</p>	<p>The affected NPP licensees determined the extent of condition and submitted related reports to the CNSC. Licensees determined that there were no operability or safety concerns with the supplied valves and components. Moreover, they quarantined all suspect components in storage to prevent installation and identified affected system(s). The licensees determined that there were no immediate operability or safety concerns with the supplied valves and components.</p> <p>The licensees committed to submitting further reports to the CNSC.</p> <p>This issue has no impact on safety at Gentilly-2.</p>	<p>no safety issues and that none of the safety-related components in service has had a pressure boundary failure. The CNSC also concluded that the licensees implemented appropriate corrective actions.</p> <p>The involved vendors and licensees completed focused supplementary audits to confirm the extent of condition and validate the results. A new CSA N299 standard, <i>Quality assurance program requirements for the supply of items and services of nuclear power plants</i> is being developed and will be published in 2016. It will provide a systematic and consistent set of requirements for suppliers for the prevention and detection of counterfeit, fraudulent or suspect items (CFSIs).</p> <p>The discovery and reporting of these incidents demonstrated the effectiveness of the NPP licensees' supply chain management and procurement quality assurance program for discovering and mitigating the intrusion of CFSIs into their operations as well as the overall robustness of their supply chain processes. To further improve the effectiveness of their programs,</p>

Location/date ³	Description	Corrective action by licensee	Regulatory action
			Canadian NPP licensees implemented a variety of enhancements after this event to increase surveillance of sub-suppliers' quality programs and to enhance awareness and training of supply-chain staff with respect to CFSI issues.
Heavy water leak during maintenance of Darlington Unit 2 April 14, 2015	A leak of heavy water from a disassembled valve in the Unit 2 heavy water transfer system occurred during planned maintenance. Approximately 7,000 litres of heavy water spilled from piping. The spill was contained in two rooms within confinement and drain tanks, per design.	Control room operators were able to quickly diagnose the event and isolate the leak, per procedures. Unit 2 was shut down normally without any operational or safety issues. There was no contamination of the maintainers at the site of the leak because they were wearing appropriate protective equipment and followed applicable procedures once the leak began. Dose uptakes received by these maintainers were negligible and were verified through prompt bioassays and readings of their thermoluminescent dosimetry badges. The water was recovered and, because operators were wearing appropriate protective equipment, no operator received any additional dose during the recovery, cleanup or decontamination. There were no risks to any other personnel at the station at any time. The cause of the event was the failure of an upstream isolation point that allowed	CNSC staff followed up on the adequacy of protection offered by the isolation valve, the quality of the valve chosen for work protection and the results of OPG's root-cause analysis. CNSC staff concluded that the licensee responded adequately to this issue and implemented appropriate corrective actions.

Location/date ³	Description	Corrective action by licensee	Regulatory action
		<p>the heavy water to pass through the valve under maintenance.</p> <p>OPG investigated the event and produced a root-cause analysis. The analysis identified the root cause as inadequate risk perception around guaranteed devices. Also, two contributing causes were identified:</p> <ul style="list-style-type: none"> • Personnel had a less-than-adequate questioning attitude when evaluating worksite conditions. • Evaluation and application of operating experience were not fully effective. <p>An extent of condition and extent of cause were also performed. A corrective action plan was developed and implemented to prevent a re-occurrence.</p>	
<p>Serious injury to a worker at Bruce B Unit 8</p> <p>February 1, 2016</p>	<p>During the Bruce B Unit 8 outage, mechanical maintenance staff members at Bruce Power were attempting to remove the plug inserted into the end of the turbine generator rotor in order to do a rotor inspection. This involved drilling to remove sections of the mechanical plug. While drilling, hydrogen gas, which had leaked past seals in the turbine generator rotor and was present inside the rotor bore, ignited and burned the</p>	<p>Prior to 2013, rotor inspections were performed by representatives from General Electric, the equipment manufacturer. In 2013, this duty was transitioned to Bruce Power employees. However, there was no procedure specific to Bruce Power available for this work. After the event, Bruce Power completed an extent of condition and shared its findings with industry through the COG OPEX forum as well as with WANO. A Bruce Power procedure has since been</p>	<p>Bruce Power submitted a detailed event report and root-cause report to the CNSC on March 31, 2016. CNSC staff members are reviewing the reports and corrective actions taken to determine whether the NPP licensee's response is complete and if any enforcement action will be necessary.</p>

Location/date ³	Description	Corrective action by licensee	Regulatory action
	<p>worker, who suffered burns to his arms, chest and face. Bruce Power first responders transported the worker to an offsite hospital for treatment. Work on the generator was stopped and the work area was quarantined. The event was reported to both the CNSC and the Ontario Ministry of Labour, per regulatory requirements. The event occurred on the non-nuclear side of the plant and there were no radiological implications from the gas ignition.</p>	<p>developed and issued. Furthermore, procedures governing the interface between Bruce Power and vendors are being revised to document expectations for contract supervisors to ensure its vendors attend briefings and to ensure Bruce Power personnel assigned to perform support tasks are aware of associated hazards and optimal work practices.</p>	

Appendix E

Nuclear Research in Canada Related to Nuclear Power Plants

E.1 Introduction and context

Canada holds the view that nuclear safety research is important in supporting the safe design and operation of NPPs. To obtain licensing approval in Canada, applicants (with the aid of the NPP designer) must be able to provide adequate safety justification. Fulfilling this responsibility includes the provision of adequate experimental data to support analytical models and safety analyses. As practice shows, ongoing experimental research is needed to address emerging issues for operating plants and for plant life extension. New reactor design requires substantial investment in research and development (R&D) to adequately demonstrate the safety of new technologies.

R&D supporting NPPs in Canada is conducted by many organizations, including Atomic Energy of Canada Limited (AECL), Canadian Nuclear Laboratories (CNL) and the CANDU Owners Group (COG), as well as utilities, universities and private-sector laboratories. The following subsections describe the key elements of R&D supporting NPPs in Canada, where the primary focus is on CANDU reactor design.

E.2 CANDU Owners Group research and development program

To support the safe, reliable and economic operation of CANDU reactors, the COG R&D program addresses current and emerging operating issues in the areas of:

- fuel channels
- safety and licensing
- health, safety and the environment
- chemistry, materials and components
- the Industry Standard Toolset (software for design, safety analysis, and operational support)
- strategic R&D

The COG R&D program is co-funded by domestic CANDU licensees, CNL, the Romanian Societatea Nationala Nuclearelectrica and the Korea Hydro and Nuclear Power Company, with current funding of about \$40 million annually, benefitting from a stable multi-year commitment. COG also arranges other projects that are executed by the Electric Power Research Institute (EPRI) and other R&D contractors, which leverage another \$15–20 million annually for R&D that supports NPPs in Canada.

Beginning in 2016, COG will embark on a strategic R&D program that will focus on developing technologies and other solutions to keep CANDU reactors operating safely, reliably and competitively for an extended plant life.

The COG member organizations also provide significant financial support to the Canadian University Network of Excellence in Nuclear Engineering (UNENE), an alliance of universities, nuclear power utilities, and research and regulatory agencies. Established as a not-for-profit corporation in 2002, UNENE supports and develops nuclear education, research and development capability in Canadian universities.

Fuel channels

The strategic objective of the fuel channels R&D program is to develop and support adequate models for the following phenomena and potential degradation mechanisms:

- crack initiation
- fracture toughness through the full operating range over the full operating life
- leak-before-break
- pressure tube rupture frequency
- deuterium ingress
- deformation including pressure tube to calandria tube gap predictions in support of blister avoidance
- fitness for service of Inconel X-750 fuel channel annulus spacers

Safety and licensing

The COG safety and licensing R&D program is focused on the following areas:

- plant aging
- safety design basis and safe operating envelope of existing facilities
- resolution of outstanding generic safety and licensing issues
- post-Fukushima enhancements and regulatory issues

This program is comprised of working groups and task teams covering containment, fuel and fuel channels, fuel normal operating conditions, reactor physics, thermalhydraulics and probabilistic risk assessment (PSA).

Health, safety and the environment

R&D on health, safety and the environment aims to:

- improve plant performance with respect to radiation protection and emissions reduction (both radiological and conventional)
- develop technologies to address issues associated with future refurbishment and decommissioning of aging facilities
- address regulatory issues associated with radiation dose management and with generating the required databases and models to address new and emerging regulations on the environmental impacts to non-human biota
- maintain R&D capability to address current and future industry issues in the areas of health physics and environmental impacts
- ensure future expertise will be available to deal with industry problems, by encouraging funding of R&D in Canadian universities to train future scientists and technologists for the industry
- leverage COG funding through the undertaking of collaborative research with other organizations that have common interests

Chemistry, materials and components

The chemistry, materials and components R&D program:

- covers a diverse range of issues that can affect the safe, reliable and efficient operation of major CANDU systems and their auxiliaries

- is focused to support long-term operation and plant life extension
- is integrated with the EPRI R&D program to maximize synergies and minimize duplication

It comprises working groups and task teams covering:

- chemistry
- concrete
- steam generator material integrity
- steam generator non-destructive inspection
- steels
- valves
- cables
- buried piping

Industry Standard Toolset

R&D for the Industry Standard Toolset – computer programs for CANDU reactor design and analysis – addresses:

- qualification, development and maintenance activities on computer codes
- migration to a modern thermalhydraulics code architecture

Strategic R&D

Once launched in 2016, the strategic R&D program will focus on developing the technologies and solutions needed to keep the current and refurbished fleet of CANDU reactors operating safely, reliably and competitively for an extended plant life (i.e., 60-90 years).

E.3 AECL/CNL research and development program

AECL, through the Federal Science and Technology (S&T) Work Plan, provides CNL with \$76 million annually to perform nuclear-related S&T research that supports core federal roles and responsibilities in the areas of energy, health protection, public safety, security and environmental protection, while maintaining necessary capabilities and expertise at CNL. CNL also supports the nuclear industry through access to S&T facilities and expertise on a commercial basis.

The research to be undertaken in the Federal S&T Work Plan is defined within five theme areas:

- supporting the development of biological applications and understanding the implications of radiation on living things
- enhancing national and global security by supporting non-proliferation and counter-terrorism
- supporting nuclear preparedness and emergency response
- supporting safe, secure and responsible use and development of nuclear technologies
- supporting environmental stewardship and radioactive management

E.4 CNSC research program

The CNSC funds an external research program to obtain knowledge and information needed to support the CNSC's regulatory mission. The program provides access to independent advice,

expertise, experience and information through contracts placed with the private sector or through grants or contributions to other organizations in Canada and elsewhere. The contracts issued under the program align with the CNSC's research-related safety and control areas, which include:

- human performance management
- safety analysis
- physical design
- fitness for service
- radiation protection
- environmental protection
- waste management

The CNSC research program issues grants and contributions to organizations and programs such as the following:

- UNENE
- IAEA
 - International Generic Ageing Lessons Learned
 - Coordinated Research Program on Evaluation of Materials from Decommissioned Reactors
 - FAST Nuclear Emergency Tools
 - International Seismic Safety Centre
 - Small Modular Reactor Working Group
- OECD/NEA
 - Component Operational Experience, Degradation and Ageing Programme
 - Cable Ageing Data and Knowledge Project Phase II
 - Propagation d'un incendie pour des scénarios multi-locaux élémentaires (program that conducts research on fire propagation)
 - Multinational Design Evaluation Programme (MDEP)
 - High Energy Arcing Fault Events Project
- USNRC
 - Cooperative Agreement of Thermalhydraulic Code Applications and Maintenance Program
 - Cooperative Severe Accident Research Program
 - Radiation Protection Code Analysis and Maintenance Program
- CSA Group
- ICRP

The annual budget of the CNSC research program is approximately \$4 million, most of which is allocated to NPP safety research.

E.5 Generation IV International Forum

Canada is a founding member of the Generation IV International Forum, which was initiated in 2001 with the signing of the Forum's Charter for the collaborative development of next generation nuclear energy systems that will provide safe and reliable energy in a competitively priced and sustainable way.

In 2005, Canada, along with four other countries, signed the Framework Agreement for International Collaboration on Research and Development of six Generation IV nuclear energy systems. This is a binding international treaty-level agreement that unites all participating countries in large-scale, multilateral research. As of 2016, nine countries plus Euratom are signatory to the Framework Agreement, which is currently being renewed.

In 2006, NRCan established the Generation IV National Program to support Generation IV R&D specifically relevant to Canada and to meet Canada's commitments. It brings together government, industry and universities from across the country to participate in the multilateral development of advanced nuclear-based energy systems, with a focus on improving safety, reducing waste, lowering costs and increasing resistance to proliferation.

Of the six reactor systems endorsed by the Generation IV International Forum, Canada is focusing on the development of the supercritical water-cooled reactor system. The system is viewed as the most natural evolution of existing CANDU technology and best enables Canada to contribute to the R&D initiative by mobilizing existing Canadian CANDU expertise and research facilities.

As part of Canada's overall national program, research funds are granted to universities through a peer-review process to investigate specific areas that support the development of the supercritical water-cooled reactor concept. In March 2012, the Government of Canada awarded grants that will provide \$8 million over four years (until 2016) to fund 27 Generation IV research projects at universities across Canada.

Appendix F

Description and Results of the CNSC's Assessment and Rating System for Nuclear Power Plants

The CNSC's rating system, which assesses the performance of NPP licensees across the 14 CNSC safety and control areas (SCAs), consists of four categories:

FS	Fully satisfactory
SA	Satisfactory
BE	Below expectations
UA	Unacceptable

The definitions of these categories are as follows.

Fully satisfactory

Compliance with regulatory requirements is fully satisfactory. Compliance within the area exceeds requirements and CNSC expectations. Compliance is stable or improving and any problems or issues that arise are promptly addressed.

Satisfactory

Compliance with regulatory requirements is satisfactory. Compliance within the area meets requirements and CNSC expectations. Any deviation is only minor and any issues are considered to pose a low risk to the achievement of regulatory objectives and CNSC expectations. Appropriate improvements are planned.

Below expectations

Compliance with regulatory requirements falls below expectations. Compliance within the area deviates from requirements or CNSC expectations, to the extent that there is a moderate risk of ultimate failure to comply. Improvements are required to address identified weaknesses. The licensee or applicant is taking appropriate corrective action.

Unacceptable

Compliance with regulatory requirements is unacceptable and is seriously compromised. Compliance within the overall area is significantly below requirements or CNSC expectations, or there is evidence of overall non-compliance. Without corrective action, there is a high probability that the deficiencies will lead to an unreasonable risk. Issues are not being addressed effectively, no appropriate corrective measures have been taken and no alternative plan of action has been provided. Immediate action is required.

The CNSC's annual assessment of NPPs

The CNSC prepares an annual staff report for the Commission and the public on all Canadian NPPs. The *Regulatory Oversight Report for Canadian Nuclear Power Plants* integrates information gathered through CNSC staff licensing and NPPs' compliance activities. The activities include:

- technical assessments (desktop reviews of licensees' management system documented information, such as policies, methods, procedures and records)

-
- Type I inspections (onsite assessments of the programmatic aspects of the management system's policies, methods, procedures and records)
 - Type II inspections (onsite assessments of the outcomes of licensed activities)

The report uses the rating system described on the previous page to summarize the SCA performance assessments and determine the integrated plant rating for each NPP. The integrated plant rating combines the ratings for the 14 SCAs to provide an overall safety assessment for each NPP. The document makes comparisons where possible, shows trends and averages, and highlights significant issues in the industry at large. It uses a variety of performance indicators to illustrate safety performance. The annual staff report describes major developments, initiatives, issues and challenges during the year as related to the operating NPPs. It also describes major revisions to licence conditions handbooks during the year.

Table F.1 shows the specific areas that comprise each CNSC SCA. Table F.2 compares the IAEA safety factors to the SCAs. Table F.3 shows the licensees' performance ratings during the reporting period. CNSC requirements and performance expectations in the 14 SCAs were met or exceeded at the NPPs for the three years of the reporting period.

Table F.1: CNSC functional areas, safety and control areas, and specific areas used to rate Canadian NPP performance

Functional area	Safety and control area	Specific area
Management	Management system	Management system
		Organization
		Change management
		Safety culture
		Configuration management
		Records management
		Management of contractors
		Business continuity
	Human performance management	Human performance program
		Personnel training
		Personnel certification
		Initial certification examinations and requalification tests
		Work organization and job design
		Fitness for duty
	Operating performance	Conduct of licensed activities
		Procedures
		Reporting and trending
		Outage management performance
		Safe operating envelope
		Severe accident management and recovery
		Accident management and recovery
Facility and equipment	Safety analysis	Deterministic safety analysis
		Probabilistic safety assessment
		Criticality safety
		Severe accident analysis
		Management of safety issues (including R&D programs)
	Physical design	Design governance
		Site characterization
		Facility design
		Structure design
		System design
		Components design
	Fitness for service	Equipment fitness for service/equipment performance
		Maintenance
		Structural integrity
		Aging management
		Chemistry control

Functional area	Safety and control area	Specific area
		Periodic inspections and testing
Core control processes	Radiation protection	Application of ALARA
		Worker dose control
		Radiation protection program performance
		Radiological hazard control
		Estimated dose to public
	Conventional health and safety	Performance
		Practices
		Awareness
	Environmental protection	Effluent and emissions control (releases)
		Environmental management system
		Assessment and monitoring
		Protection of the public
		Environmental risk assessment
	Emergency management and fire protection	Conventional emergency preparedness and response
		Nuclear emergency preparedness and response
		Fire emergency preparedness and response
	Waste management	Waste characterization
		Waste minimization
		Waste management practices
		Decommissioning plans
	Security	Facilities and equipment
		Response arrangements
		Security practices
		Drills and exercises
	Safeguards and non-proliferation	Nuclear material accountancy and control
		Access and assistance to the IAEA
		Operational and design information
		Safeguards equipment, containment and surveillance
		Import and export
	Packaging and transport	Package design and maintenance
Packaging and transport		
Registration for use		

Table F.2: Comparison of IAEA safety factors to CNSC safety and control areas

IAEA safety factor	Related CNSC safety and control areas
Plant design	Management system, operating performance, safety analysis, physical design, fitness for service, radiation protection, conventional health and safety, environmental protection
Actual condition of structures, systems and components important to safety	Management system, safety analysis, physical design, fitness for service, radiation protection, conventional health and safety, environmental protection
Equipment qualification	Management system, safety analysis, physical design, fitness for service, radiation protection, conventional health and safety, environmental protection
Ageing	Management system, human performance management, operating performance, safety analysis, physical design, fitness for service, radiation protection, conventional health and safety, environmental performance
Deterministic safety analysis	Management system, safety analysis, physical design, fitness for service, radiation protection, emergency management and fire protection
Probabilistic safety assessment	Safety analysis, physical design, fitness for service
Hazard analysis	Management system, operating performance, safety analysis, physical design, fitness for service, radiation protection, conventional health and safety, environmental protection, emergency management and fire protection, security, safeguards and non-proliferation, transport and packaging
Safety performance	Management system, operating performance, safety analysis, fitness for service, radiation protection, conventional health and safety, environmental protection, waste management
Use of experience from other plants and research findings	Management system, human performance management, operating performance
Organization, the management system and safety culture	Management system, human performance management, operating performance
Procedures	Management system, human performance management, operating performance, radiation protection, conventional health and safety, emergency management and fire protection
Human factors	Management system, human performance management, operating performance, fitness for service, radiation protection, conventional health and safety

IAEA safety factor	Related CNSC safety and control areas
Emergency planning	Management system, human performance management, operating performance, conventional health and safety, emergency management and fire protection
Radiological impact on the environment	Management system, operating performance, environmental protection

Note: The 14 IAEA safety factors listed above are from IAEA Specific Safety Guide SSG-25, *Periodic Safety Review for Nuclear Power Plants*.

Table F.3: Performance ratings of safety and control areas for NPPs, 2013–2015

Safety and control area	Bruce A			Bruce B			Darlington			Pickering			Gentilly-2			Point Lepreau		
	'13	'14	'15	'13	'14	'15	'13	'14	'15	'13	'14	'15	'13	'14	'15	'13	'14	'15
Management system	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Human performance management	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Operating performance	SA	SA	FS	SA	FS	FS	FS	FS	FS	SA	SA	FS	SA	SA	SA	SA	SA	SA
Safety analysis	SA	SA	SA	SA	SA	SA	SA	SA	FS	SA	SA	FS	SA	SA	SA	SA	SA	SA
Physical design	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Fitness for service	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Radiation protection	SA	SA	SA	SA	SA	SA	FS	FS	FS	FS	FS	FS	SA	SA	SA	SA	SA	SA
Conventional health and safety	FS	FS	FS	FS	FS	FS	FS	SA	FS	SA	SA	FS	SA	SA	SA	FS	FS	FS
Environmental protection	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Emergency management and fire protection	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Waste management	SA	FS	FS	SA	FS	FS	SA	FS	FS	SA	SA	FS	SA	SA	SA	SA	SA	SA
Packaging and transport	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Integrated plant rating	SA	SA	FS	SA	FS	FS	FS	FS	FS	SA	SA	FS	SA	SA	SA	SA	SA	SA

Legend: FS = Fully satisfactory

SA = Satisfactory

Note: Ratings for the **Security** and **Safeguards and non-proliferation** SCAs have been omitted from this table as they are outside the scope of the *Convention on Nuclear Safety*.

ANNEXES

Annex 7.2 (i) (a)

CNSC Regulation-making Process

When making or amending regulations, the CNSC must abide by the Government of Canada's regulatory policy *Cabinet Directive on Regulatory Management*, which came into effect in 2012. This directive updates and replaces the *Cabinet Directive on Streamlining Regulation* (April 1, 2007) and the *Government of Canada Regulatory Policy* (November 1999). Under the *Cabinet Directive on Regulatory Management*, the CNSC works with the Regulatory Affairs Sector of the Treasury Board of Canada Secretariat to assess regulatory proposals at an early stage by submitting a triage statement that considers the following factors:

- potential impact of the regulation on health and safety, security, the environment and the social and economic well-being of Canadians
- cost or savings to government, business or Canadians and the potential impact on the Canadian economy and its international competitiveness
- potential impact on other federal departments or agencies, other governments in Canada or on Canada's foreign affairs
- degree of interest, contention and support among affected parties and Canadians
- overall expected impact (i.e., low, medium or high) and the particular analytical and other requirements to be met

Once the triage statement is approved by the Treasury Board Secretariat, the CNSC, with assistance from the Department of Justice, proceeds with drafting the regulations and consulting stakeholders. The CNSC regulation-making process includes extensive consultation with both internal and external stakeholders. In developing its consultation plan, the CNSC recognizes a multiplicity of stakeholders with different levels of interest, points of view and expectations concerning the nature and content of a proposed regulatory regime. Internally, CNSC staff communications inform interested colleagues of the proposed consultative process and the proposed regulations. Externally, the CNSC coordinates regulatory consultations with other departments and agencies.

Draft regulations undergo a series of internal approvals before being presented to the Minister of Natural Resources for approval for pre-publication in the *Canada Gazette*, Part I. Pre-publication in the *Canada Gazette* is a requirement of the *Statutory Instruments Act* and Treasury Board policies. It is intended to ensure all Canadians have the opportunity to comment on the regulations. The comment period varies from 30 to 75 days. Comments received during the pre-publication period are posted on the CNSC website for interested parties to provide feedback.

Following the pre-publication comment period, the draft regulations are amended, if necessary, to take into account comments received from stakeholders. Once the final draft regulations are completed, they must again be circulated for internal approvals before being presented to the Commission. Under section 44 of the NSCA, the Commission may make regulations with the approval of the Governor in Council. Governor in Council approval is granted following a recommendation for approval from the Minister of Natural Resources. Once approved and registered, the new or amended regulations are published in the *Canada Gazette*, Part II.

Annex 7.2 (i) (b)

Regulatory Framework Documents

The information in this annex reflects the status of the CNSC regulatory document program at the end of the reporting period. As of April 2013, all regulatory documents are referred to as “REGDOC”. Previous naming conventions are described in the footnote to table 1 below.

REGDOCs may contain regulatory requirements (informing licensees and applicants of what they must achieve to meet the requirements), guidance (advising licensees and applicants on how to meet the requirements) or general information on the CNSC’s practices and processes.

REGDOCs are developed using a lifecycle approach, from identification of a regulatory issue or concern through analysis of the issue to determine the best regulatory tool to address the issues, development and publication of the document and finally to regular review and updating of the document. REGDOCs apply lessons learned from industry operating experience and from international standards and guides, such as those published by the IAEA (see table 1 for details). Requirements and guidance in REGDOCs are technology-neutral and performance-based where possible and permit the use of risk-informed approaches.

External stakeholders are provided the opportunity to comment on the proposed contents of individual REGDOCs through a rigorous public consultation process. This includes publishing the draft document on the CNSC website and informing stakeholders of this through various vehicles, including email notifications, the CNSC Facebook page and the Government of Canada’s “Consulting with Canadians” website. In addition, the CNSC makes use of newsletters or targeted mail-outs to ensure affected stakeholders are aware of the consultation. Stakeholders are invited to provide their comments through fax, email, conventional mail and through an online comment form. Following an initial consultation period, all comments are published on the CNSC website and feedback on these comments is invited from stakeholders.

Table 1 lists key documents from both the CNSC and the CSA Group (formerly the Canadian Standards Association) that are relevant to NPPs⁴. The CNSC documents are available on the CNSC website at nuclearsafety.gc.ca. Table 1 also shows the CNSC regulatory documents and CSA standards that are relevant to new-built licensing (as discussed in subsection 7.2(i)(c)), and lists the IAEA standards that were used in the development of the CNSC regulatory documents and CSA standards for NPP regulation.

The CNSC licensing process uses a phased approach to implement CNSC regulatory documents and CSA standards into licence conditions handbooks (LCHs). Many of the newly published CNSC regulatory documents (REGDOCs) and CSA standards listed in table 1 are in the process of being incorporated into LCHs upon licence renewal. The table shows which CNSC regulatory documents and CSA standards are part of the licensing basis for existing NPPs as of the end of the reporting period. Other documents in the table are typically captured in LCHs for existing NPPs as guidance (with prefixes G, GD), as information (with prefix P) on policy direction such as principles, factors and criteria, or as information in licence application guides for new-builds.

⁴ CNSC regulatory documents for NPPs are technology neutral and can be used for small modular reactors or other new power reactor technologies if proposed to be built and operated in Canada

Table 1: CNSC regulatory framework documents and CSA standards related to NPPs

Doc Number ⁵	Document title	Status ⁶	Applicable to new-build project licensing ⁷	Associated IAEA safety standard used in development
Regulated facilities and activities				
Reactor facilities				
REGDOC-1.1.1	<i>Licence to Prepare Site and Site Evaluation for New Reactor Facilities (draft)</i>		x	<ul style="list-style-type: none"> • Safety Series No. GS-R-3 • Safety Guide No. WS-G-2.3 • Nuclear Security Series 17 • Safety Standards Series No. NS-R-3 • Safety Standards Series No. NS-G-3.2 • Safety Standards Series No. SSG-9 • Safety Standards Series No. NS-G-1.5 • Safety Standards Series No. NS-G-3.6 • Specific Safety Guide No. SSG-18 • Safety Standards Series No. NS-G-3.1 • Safety Series No. GS-G-3.5 • Safety Guide No. RS-G-1.8 • Safety Standards Series No. GS-R-2 • TECDOC-1657
RD/GD-369	<i>Licence Application Guide: Licence to Construct a Nuclear Power Plant (2011)</i>		x	<ul style="list-style-type: none"> • Safety Standards Series No. GS-G-4.1
RD-346	<i>Site Evaluation for New Nuclear Power Plants (2008)</i>		x	<ul style="list-style-type: none"> • Safety Standards Series No. NS-G-3.2 • Safety Standards Series No. NS-G-3.3 • Safety Standards Series No. NS-G-1.5 • Safety Standards Series No. NS-G-3.1

⁵ The naming convention for regulatory documents has evolved over time. The Atomic Energy Control Board (predecessor to the CNSC) issued regulatory documents and also draft, consultative documents that were designated “C”. CNSC regulatory policies, standards, guides and notices were initially denoted by a “P”, “S”, “G” or “N”, respectively. Subsequently, the CNSC used the designation “RD” for documents containing requirements and “GD” for documents containing guidance. To facilitate the use of these documents, requirements and guidance were combined in RD/GD documents, now called simply REGDOCs.

⁶ Status refers to the inclusion of the document in the licensing basis for one or more operating licences as a regulatory requirement for existing NPPs.

⁷ Although “CANDU” appears in the title of the CSA standards applicable to new-build licensing, requirements can be applied generally to both water cooled and non-water-cooled designs. Specific applications and exceptions will be addressed on a case-by-case basis considering specific design information.

Doc Number ⁵	Document title	Status ⁶	Applicable to new-build project licensing ⁷	Associated IAEA safety standard used in development
				<ul style="list-style-type: none"> • Safety Standards Series No. NS-G-3.5 • Safety Standards Series No. NS-G-3.6 • Safety Standards Series No. NS-G-3.4 • Safety Series No. 50-C/SG-Q • Safety Standards Series No. NS-R-3 • Safety Series No. 110
REGDOC-1.1.3	<i>Licence Application Guide: Licence to Operate a Nuclear Power Plant (draft)</i>			
Nuclear substances and radiation devices				
REGDOC-1.6.1	<i>Licence Application Guide: Nuclear Substances and Radiation Devices (2015)</i>		x	<ul style="list-style-type: none"> • Safety Guide No. RS-G-1.9
Safety and control areas				
Management system				
REGDOC-2.1.2	<i>Safety Culture for Nuclear Licensees (draft)</i>		x	
N286-12	<i>Management system requirements for nuclear facilities (2012)</i>	x		<ul style="list-style-type: none"> • Safety Reports Series No. 42 • Safety Standard Series No. GS-R-3
N286-05	<i>Management system requirements for nuclear power plants (2005)</i>	x	x	<ul style="list-style-type: none"> • Safety Standard Series No. GS-G-3.1 • Safety Standard Series No. NS-G-2.9
N286.0.1	<i>Commentary on N286-12, Management system requirements for nuclear facilities (2014)</i>			<ul style="list-style-type: none"> • Safety Standard Series No. NS-R-2 • Safety Standard Series No. NS-R-3 • Safety Series No. 75-INSAG-3 Rev.1 • Safety Series No. 75-INSAG-4 • TECDOC-1101 • TECDOC-1491
N286.7	<i>Quality assurance of analytical, scientific and design computer programs for nuclear power plants (2016)</i>	x	X	
N286.7.1	<i>Guideline for the application of N286.7-99 (2009)</i>			<ul style="list-style-type: none"> • Safety Series No. 50-C/SG-Q
N286.10	<i>Configuration management for reactor facilities (draft)</i>			<ul style="list-style-type: none"> • INSAG-19 • TECDOC-1335

Doc Number ⁵	Document title	Status ⁶	Applicable to new-build project licensing ⁷	Associated IAEA safety standard used in development
				<ul style="list-style-type: none"> • Safety Series No. 65
N299 series	<i>Series of standards on quality assurance program requirements for the supply of items and services for nuclear power plants</i> (drafts)			<ul style="list-style-type: none"> • INSAG-15 • Safety Standard Series No. GS-G-3.5 • TECDOC-1329
Z1000	<i>Occupational health and safety management</i> (2014)			
Human performance management				
REGDOC-2.2.2	<i>Personnel Training</i> (2014)		x	<ul style="list-style-type: none"> • TECDOC-1057
REGDOC-2.2.3	<i>Personnel Certification: Initial Certification Examinations</i> (draft)		x	
REGDOC-2.2.3	<i>Personnel Certification: Radiation Safety Officers</i> (2014)		x	
	<i>Requirements for the Requalification Testing of Certified Shift Personnel at Canadian Nuclear Power Plants, Revision 2</i> (2009)	x		
REGDOC-2.2.4	<i>Fitness for Duty</i> (draft)			
REGDOC-2.2.4	<i>Managing Worker Fatigue</i> (draft)			
RD-204	<i>Certification of Persons Working at Nuclear Power Plants</i> (2008)	x	x	<ul style="list-style-type: none"> • Safety Guide No. NS-G-2.4 • Safety Guide No. NS-G-2.8
RD-363	<i>Nuclear Security Officer Medical, Physical, and Psychological Fitness</i> (2007)	x	x	<ul style="list-style-type: none"> • Safety Standards Series NS-G-2.8
G-323	<i>Ensuring Presence of Sufficient Qualified Staff at Class I Nuclear Facilities: Minimum Staff Complement</i> (2007)		x	
G-313	<i>Radiation Safety Training Programs for Workers Involved in Licensed Activities with Nuclear Substances and Radiation Devices, and with Class II Nuclear Facilities and Prescribed Equipment</i> (2006)			
P-119	<i>Policy on Human Factors</i> (2000)		x	
Operating performance				
REGDOC-2.3.1	<i>Conduct of Licensed Activities: Construction and</i>		x	<ul style="list-style-type: none"> • Specific Safety Guide No. SSG-28

Doc Number ⁵	Document title	Status ⁶	Applicable to new-build project licensing ⁷	Associated IAEA safety standard used in development
	<i>Commissioning</i> (2016)			<ul style="list-style-type: none"> • Safety Guide No. NS-G-2.3
REGDOC-2.3.2	<i>Accident Management, Version 2</i> (2015)	x	x	
REGDOC-2.3.2	<i>Severe Accident Management Programs for Nuclear Reactors</i> (2013)		x	<ul style="list-style-type: none"> • Safety Fundamentals No. SF-1 • Safety Standards Series No. NS-G-2.15, STI/PUB/1376 • Safety Standards Guide NS-G-2.15, STI/PUB/1376 • Safety Reports Series No. 32, STI/PUB/1167 • Services Series No. 9, IAEA-SVS-09 • Safety Requirements No. SSR-2/2 • Safety Fundamentals No. SF-1 • INSAG-10 • INSAG-12, 75-INSAG-3 Rev. 1 • TECDOC-1440 • INSAG-10
REGDOC-2.3.3	<i>Periodic Safety Reviews</i> (2015)	x	x	<ul style="list-style-type: none"> • Specific Safety Guide No. SSG-25 • Safety Fundamentals No. SF-1 • Safety Reports series No. 57 • Safety Guide NS-G-2.12 • Safety Guide NS-G-2.6 • INSAG-12, 75-INSAG-3 Rev.1
EG-1	<i>Requirements and Guidelines for Written and Oral Certification Examinations for Shift Personnel at Nuclear Power Plants</i> (2005)	x	x	
EG-2	<i>Requirements and Guidelines for Simulator-Based Certification Examinations for Shift Personnel at Nuclear Power Plants</i> (2004)	x	x	
RD-360	<i>Life Extension of Nuclear Power Plants</i> (2008)	x		<ul style="list-style-type: none"> • Safety Standards Series No. NS-G-2.10
G-306	<i>Severe Accident Management Programs for Nuclear Reactors</i> (2006)		x	
N290.15	<i>Requirements for the safe operating envelope of</i>	x		

Doc Number ⁵	Document title	Status ⁶	Applicable to new-build project licensing ⁷	Associated IAEA safety standard used in development
	<i>nuclear power plants (2010)</i>			
Safety analysis				
REGDOC-2.4.1	<i>Deterministic Safety Analysis (2014)</i>	x	x	<ul style="list-style-type: none"> • Safety Reports Series No. 55 • Safety Standards Series No. NS-R-4 • Safety Standards Series No. SSG-2 • Safety Standards Series No. GSR Part 4
REGDOC-2.4.2	<i>Probabilistic Safety Assessment (PSA) for Nuclear Power Plants (2014)</i>	x	x	<ul style="list-style-type: none"> • Safety Standard SSG-3 • Safety Standard SSG-4 • INSAG-10
RD-308	<i>Deterministic Safety Analysis for Small Reactor Facilities (2011)</i>		x	
RD-310	<i>Safety Analysis for Nuclear Power Plants (2008)</i>	x	x	
RD-327	<i>Nuclear Criticality Safety (2010)</i>	x	x	<ul style="list-style-type: none"> • Safety Standards No. SSG-5 • Safety Standards No. NS-R-5 • Safety Standards No. SSG-6 • Safety Standards No. GS-R-2
GD-327	<i>Guidance for Nuclear Criticality Safety (2010)</i>		x	
GD-310	<i>Guidance on Deterministic Safety Analysis for Nuclear Power Plants (2012)</i>		x	
S-294	<i>Probabilistic Safety Assessment (PSA) for Nuclear Power Plants (2005)</i>	x	x	<ul style="list-style-type: none"> • Safety Series No. 50-P-4 • Safety Series No. 50-P-8
G-144	<i>Trip Parameter Acceptance Criteria for the Safety Analysis of CANDU Nuclear Power Plants (2006)</i>		x	
G-149	<i>Computer Programs Used in Design and Safety Analyses of Nuclear Power Plants and Research Reactors (2000)</i>		x	
C-006	<i>Requirements for the Safety Analysis of CANDU Nuclear Power Plants (draft)</i>			
N290.16	<i>Requirements for beyond design basis accidents (2016)</i>			<ul style="list-style-type: none"> • INSAG-10 • Nuclear Energy Series No. NW-T-2.7 • Safety Series No. 98

Doc Number ⁵	Document title	Status ⁶	Applicable to new-build project licensing ⁷	Associated IAEA safety standard used in development
N290.17	<i>Probabilistic safety assessment for nuclear power plants</i> (draft)			<ul style="list-style-type: none"> • Safety Standards Series No. SSG-3 • Safety Standards Series No. SSG-4
N290.18	<i>Periodic safety review for nuclear reactor facilities</i> (draft)			<ul style="list-style-type: none"> • Safety Reports Series No. 57 • Safety Standards Series No. SSG-25 • TECDOC-1740
Physical design				
REGDOC-2.5.2	<i>Design of Reactor Facilities: Nuclear Power Plants</i> (2014)		x	<ul style="list-style-type: none"> • Specific Safety Requirements SSR-2/1 • Safety Guide NS-G-2.15 • INSAG-10 • Safety Guide NS-G-2.2 • Safety Series No. 50-P-1 • Safety Reports Series No. 46 • Safety Guide NS-G-2.9 • Nuclear Security Series No. 17 • Safety Guide NS-G-2.5 • Safety Guide WS-G-2.1 • Safety Guide NS-G-1.8 • Safety Guide NS-G-1.4 • TECDOC-1657 • Safety Guide NS-G-1.10 • Safety Guide NS-G-1.9 • Safety Guide NS-G-1.12 • Safety Standards No. SSG-2 • Safety Standards No. SSG-3 • Safety Standards No. SSG-4 • Safety Reports Series No. 3 • Safety Guide NS-G-1.5 • Safety Guide NS-G-3.1 • Safety Standards No. SSG-9 • Safety Guide NS-G-2.1 • Safety Guide NS-G-3.5 • TECDOC-967, Rev.1

Doc Number ⁵	Document title	Status ⁶	Applicable to new-build project licensing ⁷	Associated IAEA safety standard used in development
				<ul style="list-style-type: none"> • TECDOC-1276 • Safety Series No. 50-P-10 • Safety Guide NS-G-1.3 • INSAG-19 • Safety Guide NS-G-2.6 • Safety Requirements No. GS-R-3 • Safety Requirements No. GS-G-3.5 • Safety Requirements No. GS-G-3.3 • Safety Guide NS-G-3.4 • Safety Standards No. SSG-18 • INFCIRC-225, Rev.5 (draft) • Safety Guide No. RS-G-1.1 • Safety Report Series No. 8 • Safety Requirements No. GS-R-2 • Safety Guide NS-G-1.7 • Safety Guide NS-G-1.11 • Safety Guide NS-G-1.13 • Safety Reports Series No. 25 • Safety Guide NS-G-1.2 • General Safety Requirements Part 4 • Safety Series No. 110 • Specific Safety Requirements SSR-2/2 • Safety Guide NS-G-1.6 • Specific Safety Guide SSG-9 • Safety Guide NS-G-1.1 • Safety Guide NS-G-2.11 • Safety Series No. 50-P-7
RD/GD-352	<i>Design, Testing and Performance of Exposure Devices (2012)</i>			
RD-337	<i>Design of New Nuclear Power Plants (2008)</i>			<ul style="list-style-type: none"> • Safety Standard Series No. NS-R-1
RD-367	<i>Design of Small Reactor Facilities (2011)</i>			

Doc Number ⁵	Document title	Status ⁶	Applicable to new-build project licensing ⁷	Associated IAEA safety standard used in development
G-276	<i>Human Factors Engineering Program Plans (2003)</i>			
G-278	<i>Human Factors Verification and Validation Plans (2003)</i>			
R-77	<i>Overpressure Protection Requirements for Primary Heat Transport Systems in CANDU Power Reactors Fitted with Two Shutdown Systems (1987)</i>			
Pressure-retaining systems and components				
N285.0/N285.6 series	<i>General requirements for pressure-retaining systems and components in CANDU nuclear power plants/Material Standards for reactor components for CANDU nuclear power plants (2012)</i>	x	x	
Concrete containment structures				
N287.1	<i>General requirements for concrete containment structures for nuclear power plants (2014)</i>		x	
N287.2	<i>Material requirements for concrete containment structures for CANDU nuclear power plants (2008)</i>		x	
N287.3	<i>Design requirements for concrete containment structures for nuclear power plants (2014)</i>			
N287.4	<i>Construction, fabrication, and installation requirements for concrete containment structures for CANDU nuclear power plants (2009)</i>		x	
N287.5	<i>Examination and testing requirements for concrete containment structures for nuclear power plants (2011)</i>			
N287.6	<i>Pre-operational proof and leakage rate testing requirements for concrete containment structures for nuclear power plants (2011)</i>			
N291-15	<i>Requirements for safety-related structures for nuclear power plants (2015)</i>			
N291-08	<i>Requirements for safety-related structures for</i>		x	

Doc Number ⁵	Document title	Status ⁶	Applicable to new-build project licensing ⁷	Associated IAEA safety standard used in development
	<i>CANDU nuclear power plants (2008)</i>			
Seismic design and qualifications				
N289.1	<i>General requirements for seismic design and qualification of CANDU nuclear power plants (2008)</i>			<ul style="list-style-type: none"> • Safety Standards Series No. NS-G-1.6 • Safety Standards Series No. NS-G-2.10
N289.2	<i>Ground motion determination for seismic qualification of nuclear power plants (2010)</i>			<ul style="list-style-type: none"> • Draft Specific Safety Guide DS405 • Safety Standards Series No. NS-G-1.5 • Safety Standards Series No. NS-G-3.3 • Safety Standards Series No. NS-G-3.6
N289.3	<i>Design procedures for seismic qualification of nuclear power plants (2010)</i>			<ul style="list-style-type: none"> • Safety Standards Series No. NS-G-1.6 • Safety Standards Series No. NS-G-3.3 • Safety Standards Series No. NS-G-3.6
N289.4	<i>Testing procedures for seismic qualification of nuclear power plant structures, systems and components (2012)</i>			<ul style="list-style-type: none"> • Safety Guide No. NS-G-2.13
N289.5	<i>Seismic instrumentation requirements for nuclear power plants and nuclear facilities (2012)</i>			<ul style="list-style-type: none"> • Safety Report Draft, Rev.12
Special safety systems				
N290.0	<i>General requirements for safety systems of nuclear power plants (2011)</i>	x	x	
N290.1	<i>Requirements for the shutdown systems of nuclear power plants (2013)</i>			
N290.2	<i>Requirements for emergency core cooling systems of nuclear power plants (2011)</i>			
N290.3	<i>Requirements for the containment system of nuclear power plants (2011)</i>			
N290.4	<i>Requirements for reactor control systems of nuclear power plants (2011)</i>			
N290.5	<i>Requirements for electrical power and instrument air systems of CANDU nuclear power plants (2011)</i>		x	
N290.6	<i>Requirements for monitoring and display of</i>		x	

Doc Number ⁵	Document title	Status ⁶	Applicable to new-build project licensing ⁷	Associated IAEA safety standard used in development
	<i>nuclear power plant safety functions in the event of an accident (2009)</i>			
N290.11	<i>Requirements for reactor heat removal capability during outage of nuclear power plants (2013)</i>			
N290.14-15	<i>Qualification of digital hardware and software for use in instrumentation and control applications for nuclear power plants (2015)</i>			
N290.14-07	<i>Qualification of pre-developed software for use in safety-related instrumentation and control applications in nuclear power plants (2007)</i>			
N290.16	<i>Requirements for beyond design basis accidents (2016)</i>			<ul style="list-style-type: none"> • INSAG-10 • Nuclear Energy Series No. NW-T-2.7 • Safety Series No. 98
Design governance				
N290.12	<i>Human factors in design for nuclear power plants (2014)</i>		x	
Fitness for service				
REGDOC-2.6.3	<i>Aging Management (2014)</i>		x	<ul style="list-style-type: none"> • Safety Guide No. NS-G-2.12 • Safety Report Series No. 82 • Safety Report Series No. 57 • Specific Safety Guide SSG-25 • Safety Guide NS-G-2.6 • Safety Guide NS-G-2.4 • Safety Requirements NS-R-2 • Safety Report Series No. 3 • Safety Report Series No. 62 • TECDOC-1197 • TECDOC-1188 • TECDOC-1025 • TECDOC-981 • Safety Report Series No. 15
RD/GD-98	<i>Reliability Programs for Nuclear Power Plants</i>	x		<ul style="list-style-type: none"> • TECDOC-524

Doc Number ⁵	Document title	Status ⁶	Applicable to new-build project licensing ⁷	Associated IAEA safety standard used in development
	(2012)			
RD/GD-210	<i>Maintenance Programs for Nuclear Power Plants (2012)</i>			<ul style="list-style-type: none"> • TECDOC-658 • Safety Standards Series No. NS-G-2.6
RD-334	<i>Aging Management for Nuclear Power Plants</i>			
S-98, Rev.1	<i>Reliability Programs for Nuclear Power Plants (2005)</i>	x		
S-210	<i>Maintenance Programs for Nuclear Power Plants (2007)</i>	x		<ul style="list-style-type: none"> • Safety Reports Series No. 42 • Safety Series No. 110 • Safety Standards Series No. NS-R-2 • Standards Series NS-G-2.6 • Safety Standards Series No. 50-SG-07
N285.4-05	<i>Periodic inspection of CANDU nuclear power plant components (2005)</i>	x	x	
N285.4-14	<i>Periodic inspection of CANDU nuclear power plant components (2014)</i>			
N285.5	<i>Periodic inspection of CANDU nuclear power plant containment components (2008)</i>		x	
N285.7	<i>Periodic inspection of CANDU nuclear power plant balance of plant systems and components (2015)</i>		x	<ul style="list-style-type: none"> • TECDOC-1511
N285.8	<i>Technical requirements for in-service evaluation of zirconium alloy pressure tubes in CANDU reactors (2010)</i>		x	
N287.2	<i>Material requirements for concrete containment structures for CANDU nuclear power plants (2008)</i>		x	
N287.7	<i>In-service examination and testing requirements for concrete containment structures for CANDU nuclear power plants (2008)</i>	x	x	
N287.8	<i>Aging management for concrete containment structures for nuclear power plants (2015)</i>			<ul style="list-style-type: none"> • Safety Report Series No. 57 • Safety Standards Series No. NS-G-2.12 • TECDOC-1025

Doc Number ⁵	Document title	Status ⁶	Applicable to new-build project licensing ⁷	Associated IAEA safety standard used in development
				<ul style="list-style-type: none"> • Safety Standards Series No. NS-G-2.6 • TECDOC-1503 • TECDOC-1736 • Technical Reports Series No. 338 • Safety Report Series No. 15 • Safety Series No. 50-P-3 • Safety Report Series No. 82
N290.8	<i>Technical specification requirements for nuclear power plant components (2015)</i>			
N290.13	<i>Environmental qualification of equipment for CANDU nuclear power plants (2005)</i>	x	x	
Radiation protection				
R-85	<i>Radiation Protection Requisites for the Exemption of Certain Radioactive Materials from Further Licensing upon Transferral for Disposal (1989)</i>			
RD-58	<i>Thyroid Screening for Radioiodine (2008)</i>			
G-91	<i>Ascertaining and Recording Radiation Doses to Individuals (2003)</i>			
G-147	<i>Radiobioassay Protocols for Responding to Abnormal Intakes of Radionuclides (2003)</i>			
GD-150	<i>Designing and Implementing a Bioassay Program (2010)</i>			
G-129, Rev.1	<i>Keeping Radiation Exposures and Doses “As Low as Reasonably Achievable (ALARA)” (2004)</i>			<ul style="list-style-type: none"> • Safety Series No. 21 • Safety Series No. 102 • Safety Series No. 103
G-228	<i>Developing and Using Action Levels (2001)</i>			
Conventional health and safety				
No applicable CNSC regulatory documents				
No applicable CSA standards				
Environmental protection				
REGDOC-2.9.1	<i>Environmental Protection Policies, Programs and Procedures (2013)</i>		x	

Doc Number ⁵	Document title	Status ⁶	Applicable to new-build project licensing ⁷	Associated IAEA safety standard used in development
REGDOC-2.9.1	<i>Environmental Protection: Environmental Policy, Assessments and Protection Measures (draft)</i>			
S-296	<i>Environmental Protection Policies, Programs and Procedures at Class I Nuclear Facilities and Uranium Mines and Mills (2006)</i>	x		
G-296	<i>Developing Environmental Protection Policies, Programs and Procedures at Class I Nuclear Facilities and Uranium Mines and Mills (2006)</i>	x		
P-223	<i>Protection of the Environment (2001)</i>			
N288.1	<i>Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities (2008)</i>	x		<ul style="list-style-type: none"> • Safety Report Series No. 19 • Safety Series No. 50-5G-59 • TECDOC-857 • TECDOC-964 • Technical Reports Series No. 364 • Technical Reports Series No. 422 • Technical Report Series No. 472
N288.2-14	<i>Guidelines for calculating the radiological consequences to the public of a release of airborne radioactive material for nuclear reactor accidents (2014)</i>			<ul style="list-style-type: none"> • Safety Guide No. NS-G-3.2 • Safety Guide No. 50-P-12 • Safety Guide No. GS-G-2.1 • Safety Guide No. GSG-2 • Safety Guide No. GS-R-2 • TECDOC-955 • TECDOC-1200
N288.2-M91 (R2008)	<i>Guidelines for calculating radiation doses to the public from a release of airborne radioactive material under hypothetical accident conditions in nuclear reactors (2008)</i>			<ul style="list-style-type: none"> • Safety Guide Series No. 50-SG-S3
N288.3.4	<i>Performance testing of nuclear air-cleaning systems at nuclear facilities (2013)</i>			
N288.4	<i>Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills (2010)</i>			

Doc Number ⁵	Document title	Status ⁶	Applicable to new-build project licensing ⁷	Associated IAEA safety standard used in development
N288.4-10 (R2015)	<i>Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills (2015)</i>			
N288.5	<i>Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills facilities (2011)</i>			
N288.6	<i>Environmental risk assessments at class I nuclear facilities and uranium mines and mills (2012)</i>			<ul style="list-style-type: none"> • Safety Reports Series No. 21 • Technical Reports Series No. 332 • Technical Reports Series No. 472
N288.7	<i>Groundwater protection programs at Class I nuclear facilities and uranium mines and mills (2015)</i>			<ul style="list-style-type: none"> • Safety Guide No. WS-G-1.2
N288.8	<i>Establishing and implementing action levels to control releases to the environment from nuclear facilities (draft)</i>			
Emergency management and fire protection				
REGDOC-2.10.1	<i>Nuclear Emergency Preparedness and Response (2014)</i>		x	
REGDOC-2.10.1	<i>Nuclear Emergency Preparedness and Response, Version 2 (2016)</i>		x	<ul style="list-style-type: none"> • Safety Standards Series GS-R-2 • Safety Standards Series GS-G-2.1
RD-353	<i>Testing the Implementation of Emergency Measures (2008)</i>	x		<ul style="list-style-type: none"> • Safety Series No. 73 • Safety Standards Series No. GS-R-2
P-325	<i>Nuclear Emergency Management (2006)</i>			
G-225	<i>Emergency Planning at Class I Nuclear Facilities and Uranium Mines and Mills (2001)</i>			
N293-07	<i>Fire protection for CANDU nuclear power plants (2007)</i>	x		<ul style="list-style-type: none"> • INSAG Series No. 10 • INSAG Series No. 12 • Safety Reports Series No. 10 • Safety Reports Series No. 46 • Safety Series No. 50-P-9 • Safety Standards Series No. NS-G-1.7 • Safety Standards Series No. NS-G-2.1

Doc Number ⁵	Document title	Status ⁶	Applicable to new-build project licensing ⁷	Associated IAEA safety standard used in development
N293-12	<i>Fire protection for nuclear power plants (2012)</i>	x		<ul style="list-style-type: none"> • Same as for N293-07 (above), but not including Safety Series No. 50-P-9
N393	<i>Fire protection for facilities that process, handle, or store nuclear substances (2013)</i>			
N1600	<i>General requirements for nuclear emergency management programs (2014)</i>			<ul style="list-style-type: none"> • Safety Guide GS-G-2 • Safety Guide GS-G-2.1 • Safety Standards Series No. GS-R-2 • General Safety Requirements GSR Part 7
Waste management				
G-219	<i>Decommissioning Planning for Licensed Activities (2000)</i>			
G-320	<i>Assessing the Long term Safety of Radioactive Waste Management (2006)</i>			
P-290	<i>Managing Radioactive Waste (2004)</i>			
N292.0	<i>General principles for the management of radioactive waste and irradiated fuel (2014)</i>			<ul style="list-style-type: none"> • INFCIRC/164 • INFCIRC/225/Rev.5 • Safety Requirements No. TS-R-1 • Safety Guide No. SSG-15 • Safety Standards Series No. GS-R-2 • TECDOC-1325 • General Safety Guide No. GSG-1 • Safety Fundamentals No. SF-1 • Safety Guide No. GS-G-3.3 • Safety Guide No. GS-G-3.4 • Safety Guide No. WS-G-2.5 • Safety Reports Series No. 34 • Safety Reports Series No. 35 • Safety Series No. 111-F • Safety Series No. 115 • Safety Standards Series No. NS-G-2.7 • Safety Standards Series No. RS-G-1.7

Doc Number ⁵	Document title	Status ⁶	Applicable to new-build project licensing ⁷	Associated IAEA safety standard used in development
				<ul style="list-style-type: none"> • Safety Standards Series No. RS-G-1.9 • Safety Standards Series No. WS-G-2.7 • Safety Standards Series No. WS-G-6.1 • Safety Standards Series No. WS-R-2 • TECDOC-1222 • TECDOC-1256 • TECDOC-1282 • TECDOC-1372 • TECDOC-1398 • TECDOC-1504 • Technical Reports Series No. 402 • Technical Reports Series No. 421 • Technical Reports Series No. 427 • Technical Reports Series No. 434 • Technical Reports Series No. 441
N292.1	<i>Wet storage of irradiated fuel and other radioactive materials (draft)</i>			<ul style="list-style-type: none"> • General Safety Guide No. GSG-3 • INFCIRC/225/Rev.5 • Safety Fundamentals No. SF-1 • Safety Guide No. GS-G-4.1 • Safety Reports Series No. 55 • Safety Standards Series No. GSR Part 5 • Safety Standards Series No. GS-R-2 • Specific Safety Guide No. SSG-3 • Specific Safety Guide No. SSG-8 • Specific Safety Guide No. SSG-9 • Specific Safety Guide No. SSG-15 • Specific Safety Guide No. SSG-25 • Specific Safety Guide No. SSG-31 • TECDOC-1267
N292.2	<i>Interim dry storage of irradiated fuel (2013)</i>			<ul style="list-style-type: none"> • INFCIRC/164 • INFCIRC/164/Add.1 • Safety Standards Series No. GS-R-2

Doc Number ⁵	Document title	Status ⁶	Applicable to new-build project licensing ⁷	Associated IAEA safety standard used in development
N292.3	<i>Management of low- and intermediate-level radioactive waste (2008)</i>	x		<ul style="list-style-type: none"> • INFCIRC/164 • Safety Guide No. DS 390 (draft) • Safety Series No. 111-G-1.1 • Safety Standards Series No. GS-R-2 • Safety Fundamentals No. SF-1 • Safety Reports Series No. 34 • Safety Reports Series No. 35 • Safety Series No. 111-F • Safety Series No. 115 • Safety Standards Series No. NS-G-2.7 • Safety Standards Series No. RS-G-1.7 • Safety Standards Series No. RS-G-1.9 • Safety Standards Series No. WS-G-2.5 • Safety Standards Series No. WS-G-2.7 • Safety Standards Series No. WS-G-6.1 • Safety Standards Series No. WS-R-2 • TECDOC-1222 • TECDOC-1256 • TECDOC-1282 • TECDOC-1325 • TECDOC-1372 • TECDOC-1397 • TECDOC-1398 • TECDOC-1504 • Technical Reports Series No. 402 • Technical Reports Series No. 412 • Technical Reports Series No. 421 • Technical Reports Series No. 427 • Technical Reports Series No. 434 • Technical Reports Series No. 441
N292.5	<i>Guideline for the exemption or clearance from regulatory control of materials that contain, or</i>			<ul style="list-style-type: none"> • Safety Guide No. RS-G-1.7 • Safety Reports Series No. 44

Doc Number ⁵	Document title	Status ⁶	Applicable to new-build project licensing ⁷	Associated IAEA safety standard used in development
	<i>potentially contain, nuclear substances</i> (2011)			<ul style="list-style-type: none"> • Safety Series No. 115
N294	<i>Decommissioning of facilities containing nuclear substances</i> (2009)	x		<ul style="list-style-type: none"> • TECDOC-1476 • Safety Guide WS-G-5.1 • Technical Report Series No. 420
Security				
REGDOC-2.12.1	<i>High-Security Sites: Nuclear Response Force</i> (2013)	x	x	
REGDOC-2.12.2	<i>Site Access Security Clearance</i> (2012)	x	x	<ul style="list-style-type: none"> • Nuclear Security Series No. 8
REGDOC-2.12.3	<i>Security of Nuclear Substances: Sealed Sources</i> (2013)		x	<ul style="list-style-type: none"> • Safety Guide RS-G-1.9 • TECDOC-1344 • Safety Standards No. TS-R-1 • TECDOC-1355 • Nuclear Security Series No. 7 • INFCIRC/225/Rev.5 (draft) • INFCIRC/663 • TECDOC-953 • Nuclear Security Series No. 9 • Nuclear Security Series No. 11 • Nuclear Security Series No. 14 • TECDOC-1276 • Safety Standards No. SSG-5
RD-321	<i>Criteria for Physical Protection Systems and Devices at High Security Sites</i> (2010)	x		
RD-361	<i>Criteria for Explosive Substance Detection, X-Ray Imaging, and Metal Detection at High Security Sites</i> (2010)	x		
S-298	<i>Nuclear Response Force</i> (2003)	x		
G-205	<i>Entry to Protected and Inner Areas</i> (2003)			
G-208	<i>Transportation Security Plans for Category I, II or III Nuclear Material</i> (2003)			
G-274	<i>Security Programs for Category I or II Nuclear Material or Certain Nuclear Facilities</i> (2003)			

Doc Number ⁵	Document title	Status ⁶	Applicable to new-build project licensing ⁷	Associated IAEA safety standard used in development
N290.7	<i>Cyber security for nuclear power plants and small reactor facilities</i> (2014)			
Safeguards and non-proliferation				
REGDOC-2.13.2	<i>Import and Export</i> (draft)			
RD-336	<i>Accounting and Reporting of Nuclear Material</i> (2010)	x		• INFCIRC/164
GD-336	<i>Guidance for Accounting and Reporting of Nuclear Material</i> (2010)			
Packaging and transport				
No applicable CNSC regulatory documents				
No applicable CSA standards				
Other regulatory areas				
Reporting requirements				
REGDOC-3.1.1	<i>Reporting Requirements for Nuclear Power Plants</i> (2014)	x	x	• Safety Standards Series SF-1
Public and Aboriginal engagement				
RD/GD-99.3	<i>Public Information and Disclosure</i> (2012)	x		
REGDOC-3.2.2	<i>Aboriginal Engagement</i> (2016)			
Financial guarantees				
G-206	<i>Financial Guarantees for the Decommissioning of Licensed Activities</i> (2000)			
CNSC processes and practices				
REGDOC-3.5.1	<i>Licensing Process for Class I Nuclear Facilities and Uranium Mines and Mills</i> (2015)		x	
REGDOC-3.5.2	<i>Administrative Monetary Penalties, Version 2</i> (2015)		x	
GD-385	<i>Pre-licensing Review of a Vendor's Reactor Design</i> (2003)			
P-299	<i>Regulatory Fundamentals</i> (2005)			
P-211	<i>Compliance</i> (2001)			
P-242	<i>Considering Cost-Benefits Information</i> (2000)			

Annex 7.2 (i) (c)

Regulatory Framework for Activities Involving Small Modular Reactors

Over the past several years, a number of technology developers have expressed interest in the possible deployment of small modular reactors (SMRs) in Canada and have sought to understand how the CNSC is establishing a state of readiness to regulate activities that would utilize SMRs. Government agencies, science and technology institutions, utilities, industry associations and regulators from other countries have also expressed interest in the CNSC's readiness preparations.

Technologies being developed vary significantly in size, design features and cooling types. In addition, they could be sited in places quite different from past NPP projects. For example:

- small grids where power generators need to remain below, for example, 300 megawatts electrical (MWe) per facility to maintain grid stability
- edge-of-grid or remote power (off-grid) where power needs are small (2 to 30 MWe) but are currently very expensive and dependent on fossil fuel

In both cases, alternative uses for these SMRs, beyond electricity generation, are also being considered. They include steam supplies for industrial applications and district heating systems and production of value-added products such as hydrogen fuel or desalinated drinking water.

Most SMR concepts, although based on technological work and operating experience from older NPPs, employ a number of novel approaches. Novel approaches, or even proven approaches used in different ways, can affect the certainty of plant performance under both normal operation and accident conditions, raising regulatory questions during the licensing process.

In view of novel approaches, CNSC staff members are conducting investigations to understand:

- key regulatory issues that may need to be resolved in advance in order to meet Canadian licensing requirements
- adequacy of the existing regulatory framework tools for addressing both potential near-term and long-term projects
- clarifications or changes that might be needed for regulatory framework tools to ensure safety in the case of novel approaches

Investigations by CNSC staff have included meetings with technology developers and outreach activities with the public at conferences and academic institutions. The CNSC published discussion paper DIS-16-04, *Small Modular Reactors: Regulatory Strategy, Approaches and Challenges*, to collect information that can be used to further clarify requirements and guidance. Even with a flexible regulatory approach, some innovative features may present challenges in both the interpretation and application of requirements. The CNSC has examined a number of key areas where potential challenges could exist. In some cases, the CNSC has confirmed that existing requirements remain valid and useful. In a number of other areas, implications of innovative approaches need to be more thoroughly examined to confirm whether additional requirements or guidance are needed.

The following list of topics is covered in DIS-16-04 (although the paper also prompts discussion on other issues):

- technical information, including research and development activities used to support a safety case
- licensing process for multiple module facilities on a single site
- licensing approach for a new demonstration reactor
- licensing process and environmental assessments for fleets of SMRs
- management system considerations
 - e.g., SMR applicants may operate or be managed quite differently than current NPP licensees
- safeguards verification
- deterministic/probabilistic safety analyses
- defence in depth and mitigation of accidents
- emergency planning zones
- transportable reactor concepts
- increased use of automation for plant operation and maintenance
- human/machine interfaces in facility operation
- impact of new technologies on human performance
- financial guarantees for operational continuity
- site security provisions
- waste management and decommissioning
- subsurface civil structures important to safety

The CNSC plans to update its regulatory framework for SMRs using feedback from stakeholders on the discussion paper.

Annex 7.2 (iii) (b) Details Related to Verification of Compliance

Table 1 indicates some of the systems and areas of verification activities that are covered by Type II inspections at NPPs.

Table 1: Systems and areas of verification activities

Processes and functions	Facilities and equipment
Fuel handling	Control room
Startup	Reactor building
Shutdown safety	Turbine hall
Heat sinks	Battery room
Outage management	Control equipment room
Fuel and physics	Containment
Pressure boundary	Emergency coolant injection
Effluent control and monitoring	Shutdown system 1
Environmental monitoring	Shutdown system 2
	Stand-by safety systems
	Safety-related systems
	Electrical systems

Annex 8

CNSC Assessment of the IAEA Director General Report of the Fukushima Daiichi Accident

Purpose

This assessment, performed by CNSC staff, addresses the key observations and lessons learned identified in the IAEA's report, *The Fukushima Daiichi Accident: Report by the Director General* (DG-IAEA Report), published in 2015. The DG-IAEA Report was the result of an extensive international collaborative effort involving five working groups with about 180 experts from 42 IAEA Member States with and without nuclear power programs, and several international bodies. The DG-IAEA Report not only examines the causes and consequences of the accident at the Fukushima Daiichi NPP in Japan, but also evaluates measures taken in response to the accident. The executive summary further synthesizes lessons drawn from five detailed technical studies completed by the international experts.

The purpose of the CNSC staff assessment was to benchmark the observations and action items identified in two CNSC documents – the *CNSC Fukushima Task Force Report* and the *CNSC Action Plan on the Lessons Learned from the Fukushima Daiichi Nuclear Accident* (CNSC Action Plan) – against the DG-IAEA Report and to ensure all elements being considered by international peers were reflected in the Canadian review scope. Other organizations contributing to this review include Health Canada and Public Safety Canada.

Canada's general approach to assessing lessons learned and developing the CNSC Action Plan had previously been weighed against the broader objectives of the *IAEA Action Plan on Nuclear Safety* and its goals for enhanced global nuclear safety. As reported in the sixth Canadian report, the Canadian responses were well aligned with the IAEA's objectives. (Annex 8 of the sixth Canadian report provides extensive information about Canada's post-Fukushima actions.)

Review

The CNSC assessment of the 45 lessons learned identified in the IAEA-DG Report is given in tabular form in this annex. The assessment and actions taken are provided against each of the lessons learned, and are categorized in the following four areas (per the sections of the DG-IAEA Report):

- the accident and its assessment (section 2)
- emergency preparedness and response (section 3)
- radiological consequences (section 4)
- post-accident recovery (section 5)

From these four categories, the CNSC's assessment of the lessons learned is presented as two distinct phases (phase 1 and phase 2, in tables 1 and 2, respectively).

The tables stipulate that many actions are complete and therefore closed with no outstanding actions; however, it does not necessarily terminate the continuing responsibility for the safe operation of nuclear facilities. The CNSC ensures this is achieved through its established licensing, compliance and regulatory framework processes. Where necessary, station-specific action items were raised to monitor the implementation at Canadian NPPs as part of the compliance verification program. Additionally, Health Canada's nuclear emergency management

coordinating committees (as defined in the *Federal Nuclear Emergency Plan (FNEP)*) and provincial-level committees provide a venue for ongoing improvements to offsite emergency preparedness activities at the national level.

Phase 1: Enhancing defence in depth and emergency response

Table 1 lists the actions taken in Canada against each lesson learned identified in sections 2 and 3 of the DG-IAEA Report. The information presented here was largely available at the time the CNSC Action Plan was developed. For this phase, the focus is on identifying any gaps in the work performed in Canada to date. The status of the actions is summarized and a conclusion is drawn.

Canadian NPP licenses have addressed the lessons learned given in sections 2 and 3 and there are no outstanding actions. All CNSC actions to address the lessons learned in these two sections are closed.

Phase 2: Assessing radiological consequences and post-accident recovery

Table 2 lists the actions taken in Canada against each lesson learned identified in sections 4 and 5 of the DG-IAEA report. The information presented here was not available at the time the CNSC Action Plan was developed. For this phase, the focus is on ensuring appropriate processes are either in place or will be developed to address the lessons learned.

The lessons given in sections 4 and 5 have been, or are being, addressed. All CNSC-led lessons learned have been completed.

For section 4, Radiological consequences, eight of the eleven lessons learned have no outstanding actions. For the remaining three lessons learned, work is ongoing and it is being led by Health Canada with input from CNSC. Completion of this work is planned by 2017.

For section 5, Post-accident recovery, five of the nine lessons learned have no outstanding actions. For the remaining four lessons learned, work is ongoing and it is being led by Health Canada with input from CNSC. Completion of this work is planned by 2017.

Conclusions

The CNSC Action Plan, developed within one year of the accident, focused on the prevention and mitigation of similar events of higher consequences and lower likelihood. Actions related to strengthening defence in depth, enhancing emergency response, improving the regulatory framework and enhancing international collaboration were quickly imposed on the CNSC and its licensees of major nuclear facilities. Additionally, actions to strengthen offsite emergency response were quickly identified and implemented by offsite authorities at the federal and provincial levels. The actions are well aligned with the lessons reported in sections 2 and 3 of the DG-IAEA Report. Lessons related to public communication are also well aligned. With the exception of a very small number of modifications that require design changes by the licensee (which are on schedule for completion), the implementation of the regulatory requirements has been completed.

The DG-IAEA Report was developed over the period from 2012 to 2015 and includes lessons learned that could not have been identified in the first year following the accident, specifically in the areas of radiological consequences and post-accident recovery. These areas, covered in

sections 4 and 5 of the DG-IAEA report, touch on the subjects of radiation protection, recovery, remediation and communication, where Canada played a major role in development of the lessons learned.

Post-accident recovery guidelines addressing the elements of the DG-IAEA Report that speak to offsite measures related to the transition from emergency early response to recovery are being drafted by the CNSC. These guidelines will also be based on the outcomes and lessons learned arising from the mandatory emergency exercises conducted by multiple jurisdictions (including the CNSC, other local federal/provincial authorities and the licensees) and will be reported to the Commission via regular updates.

The CNSC Action Plan and its regulatory requirements are now integral to the CNSC's licensing, compliance and communication activities to ensure continuous safety enhancement. For example, the implementation of periodic safety review in the CNSC regulatory framework introduces an effective tool to improve safety and guard against complacency.

Canadian actions in response to the Fukushima Daiichi accident are compatible with and address the lessons learned that were identified in the DG-IAEA Report. They will also prove to be a valuable resource for future actions and updates against the lessons learned identified in the CNSC Action Plan, particularly for the areas of assessing radiological consequences and post-accident recovery. This assessment affirms that the CNSC was and continues to be on the right path with respect to its continuous enhancements to safety through committed work and verification under normal licensing, compliance, regulatory framework and communications processes.

Phase 1: Enhancing defence in depth and emergency response

Table 1 below reproduces the lessons learned (LL) identified in sections 2 and 3 of the DG-IAEA Report and provides information about Canada's actions related to each lesson. The lessons are numbered based on the section of the DG-IAEA Report in which they appear.

Table 1: Assessment of sections 2 and 3 of the DG-IAEA Report

LL#	IAEA lesson	CNSC action and assessment
Section 2. The accident and its assessment		
2.1	<p><i>The assessment of natural hazards needs to be sufficiently conservative. The consideration of mainly historical data in the establishment of the design basis of NPPs is not sufficient to characterize the risks of extreme natural hazards. Even when comprehensive data are available, due to the relatively short observation periods, large uncertainties remain in the prediction of natural hazards.</i></p>	<p>CNSC action:</p> <p>This lesson is addressed in the <i>CNSC Integrated Action Plan</i>, with the following action items applicable to all sites:</p> <p>A.2.1.1: <i>Re-evaluate, using modern calculations and state-of-the-art methods, the site-specific magnitudes of each external event to which the plant may be susceptible.</i></p> <p>A.2.1.2 <i>Evaluate if the current site-specific design protection for each external event assessed in A.2.1.1 is sufficient. If gaps are identified a corrective plan should be proposed.</i></p> <p>These action items are closed (or are on track for closure) for all Canadian nuclear power plant (NPP) licensees based on an acceptable probabilistic safety assessments (PSAs) and plans for additional work. This additional work is still ongoing and subject to CNSC review. Verification is integrated into licensing and compliance processes.</p> <p>Note: Implementation of CNSC regulatory standard S-294 has since been replaced with REGDOC-2.4.2, <i>Probabilistic Safety Assessment (PSA) for Nuclear Power Plants</i>, which includes improvements based on the lessons learned from the Fukushima Daiichi accident.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Strengthens defence in depth. • The assessment of natural hazards will be updated periodically to reflect gained knowledge and changes in requirements. <p>No outstanding actions.</p>
2.2	<p><i>The safety of NPPs needs to be re-evaluated on a periodic basis to consider advances in knowledge, and necessary corrective actions or compensatory measures need to be implemented promptly.</i></p>	<p>CNSC action:</p> <p>This lesson is directly addressed in the <i>CNSC Integrated Action Plan</i>, with the following action item applicable to CNSC staff:</p> <p>A.11.1 <i>The CNSC will consider the development of a regulatory framework for the implementation of the periodic safety review process.</i></p> <p>In April 2015, the CNSC published REGDOC-2.3.3, <i>Periodic Safety Reviews</i>, as part of its regulatory framework for implementing the periodic safety review process.</p> <p>Note: The CNSC has always re-evaluated the safety of NPPs with frequent reviews (typically conducted every five years) in support of licence renewals and scheduled safety analysis report updates (also covering a five-year period). Larger re-evaluations (i.e.,</p>

LL#	IAEA lesson	CNSC action and assessment
		<p>integrated safety reviews) have been performed in support of NPP life extensions to identify practicable upgrades. Nevertheless, the <i>CNSC Fukushima Task Force Report</i> recommended the implementation of periodic safety reviews in Canada.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Improves the regulatory framework. • Re-evaluation of NPP safety on a periodic basis is implemented via the established compliance program and is a licence requirement for all Canadian licensees of operating NPPs. <p>No outstanding actions.</p>
2.3	<p><i>The assessment of natural hazards needs to consider the potential for their occurrence in combination, either simultaneously or sequentially, and their combined effects on an NPP. The assessment of natural hazards also needs to consider their effects on multiple units on an NPP site.</i></p>	<p>CNSC action:</p> <p>Natural hazards and combinations of hazards are included in PSAs to meet the requirements of the following action items outlined in the <i>CNSC Integrated Action Plan</i>:</p> <p>A.2.1.1 <i>Re-evaluate, using modern calculations and state-of-the-art methods, the site-specific magnitudes of each external event to which the plant may be susceptible.</i></p> <p>A.2.1.2 <i>Evaluate if the current site-specific design protection for each external event assessed in A.2.1.1 is sufficient. If gaps are identified a corrective plan should be proposed.</i></p> <p>Accidents on multiple units are considered in action items A.3.1 (extension of severe accident management guidelines to include multi-unit accidents) and A.3.2 (improved modelling of multi-unit severe accidents):</p> <p>A.3.1 <i>Licensees should:</i></p> <ol style="list-style-type: none"> 1. <i>develop/finalize and fully implement severe accident management guidelines (SAMGs) at each station.</i> 2. <i>expand the scope of SAMGs to include multi-unit and IFB [Irradiated Fuel Bay] events.</i> 3. <i>demonstrate effectiveness of SAMGs. Licensees should validate and/or refine SAMGs to demonstrate their adequacy in the light of lessons drawn from the Fukushima Daiichi nuclear accident.</i> <p>A.3.2. <i>Licensees of multi-unit NPPs should develop improved modelling of multi-unit plans in severe accident conditions, or demonstrate that the current simple modelling assumptions are adequate. This assessment should consider elements of HOP [Human and Organizational Performance] under accident conditions.</i></p> <p>Action items are closed for all Canadian NPP licensees based on the following:</p> <ul style="list-style-type: none"> • Acceptable PSAs and plans for additional work. This additional work is still ongoing and subject to CNSC review as it pertains to site-wide PSA. • Implementation and expansion of accident management guidelines, including coverage for spent fuel storage and multi-unit accidents. • Development of simplistic analysis models for multi-unit severe

LL#	IAEA lesson	CNSC action and assessment
		<p>accidents and concrete plans for developing more realistic models. The CNSC has evaluated the plans and is in agreement with the direction being taken.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Strengthens defence in depth. • Verification is integrated into licensing and compliance processes. <p>No outstanding actions.</p>
2.4	<p><i>Operating experience programmes need to include experience from both national and international sources. Safety improvements identified through operating experience programmes need to be implemented promptly. The use of operating experience needs to be evaluated periodically and independently.</i></p>	<p>CNSC action:</p> <p>Operating experience (OPEX) programs were assessed and were not identified as a weakness in Canada by the <i>CNSC Fukushima Task Force Report</i> (see sections 6.3.7, 6.4.1, 6.5, 9). No actions were raised on licensees.</p> <p>The CNSC continues to perform periodic evaluation of licensees' OPEX programs and has introduced an OPEX clearinghouse to make OPEX reviews more systematic.</p> <p>Licensees use the peer reviews of the World Association of Nuclear Operators, the CANDU Owners Group and other organizations to obtain independent review of their programs, including OPEX. In addition, the CNSC reports to the IAEA Event Database on events and incidents.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Defence in depth is acceptable. • Verification is integrated into licensing and compliance processes. <p>No actions required.</p>
2.5	<p><i>The defence in depth concept remains valid, but implementation of the concept needs to be strengthened at all levels by adequate independence, redundancy, diversity and protection against internal and external hazards. There is a need to focus not only on accident prevention, but also on improving mitigation measures.</i></p>	<p>CNSC action:</p> <p>Parts A1 to A6 of the <i>CNSC Integrated Action Plan</i> were aimed at strengthening defence in depth and improving emergency response. Actions covered all levels of defence in depth, with the majority aimed at improvements to levels 4 and 5. The CNSC's regulatory philosophy has shifted from prevention to prevention and mitigation.</p> <p>The related action items are closed for all Canadian NPP licensees.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Strengthens defence in depth and enhances emergency response. • Verification is integrated into licensing and compliance processes. <p>No outstanding actions.</p>

LL#	IAEA lesson	CNSC action and assessment
2.6	<p><i>Instrumentation and control systems that are necessary during beyond design basis accidents need to remain operable in order to monitor essential plant safety parameters and to facilitate plant operations.</i></p>	<p>CNSC action:</p> <p>This lesson is directly addressed in the <i>CNSC Integrated Action Plan</i>:</p> <p>A.1.8 <i>Licensees should provide a reasonable level of confidence that the means (e.g., equipment and instrumentation) necessary for severe accident management and essential to the execution of SAMGs will perform their function in the severe accident environment for the duration for which they are needed. This assessment should consider elements of HOP under accident conditions.</i></p> <p>The action item is closed for all Canadian NPP licensees.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Strengthens defence in depth. • Verification is integrated into licensing and compliance processes. <p>No outstanding actions.</p>
2.7	<p><i>Robust and reliable cooling systems that can function for both design basis and beyond design basis conditions need to be provided for the removal of residual heat.</i></p>	<p>CNSC action:</p> <p>This lesson is directly addressed in the <i>CNSC Integrated Action Plan</i>:</p> <p>A.1.7 <i>A plan and schedule for optimizing existing provisions and putting in place additional coolant make-up provisions and supporting analyses.</i></p> <p>All action items are closed for all Canadian NPP licensees. All key equipment is now in place and the associated changes to procedures, training and drills have been completed.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Strengthens defence in depth. • Verification is integrated into licensing and compliance processes. <p>No outstanding actions.</p>
2.8	<p><i>There is a need to ensure a reliable confinement function for beyond design basis accidents to prevent significant release of radioactive material to the environment.</i></p>	<p>CNSC action:</p> <p>This lesson is directly addressed in the <i>CNSC Integrated Action Plan</i>:</p> <p>A.1.3 <i>Licensees should evaluate the means to prevent the failure of the containment systems and, to the extent practicable, unfiltered releases of radioactive products in beyond-design-basis accidents including severe accidents. If unfiltered releases of radioactive products in beyond-design-basis accidents including severe accidents cannot be precluded, then additional mitigation should be provided. This assessment should consider elements of HOP under accident conditions.</i></p> <p>Hydrogen mitigation has been expanded by accelerating the installation of passive autocatalytic recombiners at all NPPs. Filtered containment venting is either installed or committed to at most NPPs.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Strengthens defence in depth. • Verification is integrated into licensing and compliance processes. <p>No outstanding actions.</p>

LL#	IAEA lesson	CNSC action and assessment
2.9	<p><i>Comprehensive probabilistic and deterministic safety analyses need to be performed to confirm the capability of a plant to withstand applicable beyond design basis accidents and to provide a high degree of confidence in the robustness of the plant design.</i></p>	<p>CNSC action:</p> <p>Per LL #2.1, comprehensive PSAs are performed to meet the requirements of action item A.2.1.1 of the <i>CNSC Integrated Action Plan</i>:</p> <p>A.2.1.1 <i>Re-evaluate, using modern calculations and state-of-the-art methods, the site-specific magnitudes of each external event to which the plant may be susceptible.</i></p> <p>Although deterministic safety analyses were in place from initial licensing and have been continuously updated, further improvements to meet the more modern requirements of RD-310, <i>Safety Analysis for Nuclear Power Plants</i>, were already in progress as identified in action item A.2.2:</p> <p>A.2.2 <i>Implementation of RD-310, Safety Analysis for Nuclear Power Plants, is already in progress and being tracked by the CNSC/Industry Safety Analysis Improvement Initiative working group.</i></p> <p>RD-310 has since been updated as REGDOC-2.4.1, <i>Deterministic Safety Analysis</i>, with increased emphasis on multi-unit events and cliff-edge effects. Implementation of the requirements of REGDOC-2.4.1 is phased in through safety report update work.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Strengthens defence in depth and improves the regulatory framework. • Verification is integrated into licensing and compliance processes. <p>No outstanding actions.</p>
2.10	<p><i>Accident management provisions need to be comprehensive, well designed and up to date. They need to be derived on the basis of a comprehensive set of initiating events and plant conditions and also need to provide for accidents that affect several units at a multi-unit plant.</i></p>	<p>CNSC action:</p> <p>This lesson is directly addressed through the following actions items in the <i>CNSC Integrated Action Plan</i>:</p> <p>A.3.1.1 <i>Where SAMGs have not been developed/finalized or fully implemented, provide plans and schedules for completion.</i></p> <p>A.3.1.2 <i>For multi-unit stations, provide plans and schedules for the inclusion of multi-unit events in SAMGs.</i></p> <p>A.3.1.3 <i>For all stations, provide plans and schedules for the inclusion of IFB events in station operating documentation where appropriate.</i></p> <p>A.3.1.4 <i>Demonstrate the effectiveness of SAMGs via table-top exercises and drills.</i></p> <p>Work was phased, beginning with completing the implementation of SAMGs under A.3.1.1 (which was almost complete at the time of the Fukushima accident) and then expanding to include irradiated fuel bays (spent fuel storage) under A3.1.3 and multi-unit SAMGs under A.3.1.2. Implementation work for A.3.1.2 is still in progress. The effectiveness of the SAMGs (A.3.1.4) has been demonstrated, but further demonstrations will be made as work continues.</p> <p>All action items are closed for Canadian NPP licensees.</p> <p>CNSC assessment:</p>

LL#	IAEA lesson	CNSC action and assessment
		<ul style="list-style-type: none"> • Strengthens defence in depth and improves the regulatory framework. • Verification is integrated into licensing and compliance processes. <p>No outstanding actions.</p>
2.11	<p><i>Training, exercises and drills need to include postulated severe accident conditions to ensure that operators are as well prepared as possible. They need to include the simulated use of actual equipment that would be deployed in the management of a severe accident.</i></p>	<p>CNSC action:</p> <p>Per LL #2.10, this lesson is directly addressed in the <i>CNSC Integrated Action Plan</i>:</p> <p>A.3.1.4 Demonstrate the effectiveness of SAMGs via table-top exercises and drills.</p> <p>All licensees have demonstrated the capability to deploy mobile equipment in the prevention and mitigation of a severe accident.</p> <p>This action item is closed for Canadian NPP licensees.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Strengthens defence in depth and enhances emergency response. • Verification is integrated into licensing and compliance processes. <p>No outstanding actions.</p>
2.12	<p><i>In order to ensure effective regulatory oversight of the safety of nuclear installations, it is essential that the regulatory body is independent and possesses legal authority, technical competence and a strong safety culture.</i></p>	<p>CNSC action:</p> <p>The CNSC’s independence, legal authority, technical competence and safety culture have been assessed by the IAEA’s Integrated Regulatory Review Service (IRRS) missions.</p> <p>Canada hosted an IRRS mission in 2009 that included a thorough peer review of the CNSC’s independence, legal authority, adequacy of human and financial resources, corporate culture, and technical and scientific support. These areas were assessed to ensure they met the relevant IAEA requirements.</p> <p>Canada hosted a follow-up IRRS mission in 2011 that assessed the new (at that time) IRRS Fukushima core module as well as the CNSC’s responses to the findings of the 2009 mission. There were no new findings related to the CNSC’s regulatory independence, legal authority, technical competence or strong safety culture. The 2011 IRRS mission concluded that the CNSC response to the Fukushima nuclear accident was robust and comprehensive, and that the CNSC had an “effective and pragmatic framework” in place to implement the lessons learned from Fukushima.</p> <p>Results of the IRRS missions were made publicly available.</p> <p>The CNSC currently has in place an initiative to define and strengthen its safety culture as a regulator.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Enhances international collaboration and improves communication and public consultation. <p>No outstanding actions.</p>
2.13	<p><i>In order to promote and strengthen safety culture,</i></p>	<p>CNSC action:</p>

LL#	IAEA lesson	CNSC action and assessment
	<p><i>individuals and organizations need to continuously challenge or re-examine the prevailing assumptions about nuclear safety and the implications of decisions and actions that could affect nuclear safety.</i></p>	<p>The CNSC has in place a comprehensive human and organizational performance program that assesses elements such as licensees' safety culture.</p> <p>In addition, the CNSC issued a discussion paper titled <i>Safety Culture for Nuclear Licensees</i>. This paper highlights the importance of safety culture in the nuclear industry and what has been done, both internationally and in Canada, to promote safety culture. It also sets the CNSC's strategy for safety culture in the Canadian nuclear industry.</p> <p>The discussion paper predates the Fukushima accident. However, because safety culture was already an integral part of the licence review process (under the established safety and control area of the CNSC's management system requirements), the CNSC Fukushima Task Force did not identify safety culture as a gap. Safety culture is continuously evaluated by CNSC staff.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Improves the regulatory framework and improves communication and public consultation. <p>No outstanding actions.</p>
2.14	<p><i>A systemic approach to safety needs to consider the interactions between human, organizational and technical factors. This approach needs to be taken through the entire life cycle of nuclear installations.</i></p>	<p>CNSC action:</p> <p>The CNSC has in place a comprehensive human and organizational performance program that assesses elements such as licensees' safety culture.</p> <p>The action items listed in the <i>CNSC Integrated Action Plan</i> included consideration of human and organizational performance.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Strengthens defence in depth. • Verification is integrated into licensing and compliance processes. <p>No outstanding actions.</p>
Section 3. Emergency preparedness and response		
3.1	<p><i>In preparing for the response to a possible nuclear emergency, it is necessary to consider emergencies that could involve severe damage to nuclear fuel in the reactor core or to spent fuel on the site, including those involving several units at a multi-unit plant possibly occurring at the same time as a natural disaster.</i></p>	<p>CNSC action:</p> <p>Offsite emergency response is directly addressed in the <i>CNSC Integrated Action Plan</i>:</p> <p>A.4.1 <i>Licensees should evaluate and revise their emergency plans in regard to multi-unit accidents and severe external events. This activity should include an assessment of their minimum complement requirements to ensure their emergency response organizations will be capable of responding effectively to multi-unit accidents or to severe natural disasters. This assessment should consider elements of HOP under accident conditions.</i></p> <p>(For onsite emergency response, see LL #2.10.)</p> <p>This action item is closed for Canadian NPP licensees.</p> <p>CNSC assessment:</p>

LL#	IAEA lesson	CNSC action and assessment
		<ul style="list-style-type: none"> • Enhances emergency response. • Verification is integrated into licensing and compliance processes. <p>No outstanding actions.</p>
3.2	<p><i>The emergency management system for response to a nuclear emergency needs to include clearly defined roles and responsibilities for the operating organization and for local and national authorities. The system, including the interactions between the operating organization and the authorities, needs to be regularly tested in exercises.</i></p>	<p>CNSC action:</p> <p>The need for emergency exercises is directly addressed in the <i>CNSC Integrated Action Plan</i>:</p> <p>A.4.2 <i>Licensees should review their drill and exercise programs, to ensure that they are sufficiently challenging to test the performance of the emergency response organization under severe events and/or multi-unit accident conditions. This assessment should consider elements of HOP under accident conditions.</i></p> <p>Emergency exercises involving all responsible agencies have been performed. Verification is integral to CNSC regulatory oversight.</p> <p>Roles and responsibilities of responding organizations at the federal level, along with interfaces between the federal and provincial/territorial levels, were addressed in the update to the <i>Federal Nuclear Emergency Plan</i> and are further described in the all-hazards <i>Federal Emergency Response Plan</i>.</p> <p>Federal and provincial nuclear emergency management coordinating committees meet routinely to ensure common understanding of roles and responsibilities across all jurisdictions.</p> <p>Exercises that include all offsite response authorities are incorporated into an integrated nuclear exercise calendar maintained by Health Canada. They are also integrated with a national all-hazards exercise calendar.</p> <p>This action item is closed for all Canadian NPP licensees.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Strengthens defence in depth and enhances emergency response. • Verification is integrated into licensing and compliance processes. <p>No outstanding actions.</p>
3.3	<p><i>Emergency workers need to be designated, assigned clearly specified duties, regardless of which organization they work for, given adequate training, and be properly protected during an emergency. Arrangements need to be in place to integrate into the response those emergency workers who had not been designated prior to the emergency, and helpers who volunteer to assist in the</i></p>	<p>CNSC action:</p> <p>This lesson is being addressed through amendments to section 15 of the <i>Radiation Protection Regulations</i>, which addresses doses to emergency personnel, to ensure it is in line with international practices. (The amendments are currently being drafted by the Department of Justice.)</p> <p>Coordination of offsite emergency workers is addressed in offsite response plans through the implementation of emergency worker centres. At the federal level, emergency workers who may be mobilized to assist with offsite monitoring activities are pre-designated, trained and assigned specific roles and responsibilities according to the existing concept of operations and standard operating procedures. Coordination and protection of emergency workers was tested in recent exercises; lessons learned are being addressed through inter-jurisdictional activities related to emergency worker operations and safety, and through updates to standard operating procedures. Future exercises to test these arrangements are incorporated in a nuclear emergency exercise calendar maintained by Health Canada.</p>

LL#	IAEA lesson	CNSC action and assessment
	<i>emergency response.</i>	<p>In addition, this lesson is being addressed through:</p> <ul style="list-style-type: none"> • Health Canada’s 2016 update to the <i>Canadian Guidelines for Protective Actions during a Nuclear Emergency</i> • Ontario’s 2016 update to the <i>Provincial Nuclear Emergency Response Plan</i> • an update to the CSA N1600, <i>General requirements for nuclear emergency management programs</i>, issued in 2014 with a second edition in 2015 <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Enhances emergency response and improves the regulatory framework. • Verification is integrated into licensing and compliance processes. <p>No outstanding actions.</p>
3.4	<i>Arrangements need to be in place to allow decisions to be made on the implementation of predetermined urgent protective actions for the public, based on predefined plant conditions.</i>	<p>CNSC action:</p> <p>The CNSC Fukushima Task Force verified that the responsibilities for making decisions about urgent protective actions are adequately defined. No action was necessary in Canada. Discharge of responsibilities has been tested in emergency exercises such as Huron Challenge at Bruce Power and Exercise Unified Response at Darlington Nuclear Generating Station.</p> <p>In addition, the <i>Study of Consequences of a Hypothetical Severe Nuclear Accident and Effectiveness of Mitigation Measures</i> has determined that, if the identified protective measures are applied in accordance with plans, they will be effective in ensuring protection of the public.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Emergency response is acceptable. • Verification is integrated into licensing and compliance processes. <p>No actions required.</p>
3.5	<i>Arrangements need to be in place to enable urgent protective actions to be extended or modified in response to developing plant conditions or monitoring results. Arrangements are also needed to enable early protective actions to be initiated on the basis of monitoring results.</i>	<p>CNSC action:</p> <p>The CNSC Fukushima Task Force verified that the responsibilities for making decisions about urgent protective actions are adequately defined.</p> <p>Monitoring is directly addressed in the <i>CNSC Integrated Action Plan</i>:</p> <p>A.5.3 <i>Licensees should install automated real-time station boundary radiation monitoring systems with appropriate backup power and communications systems.</i></p> <p>Health Canada also maintains a national real-time radiation monitoring system, with monitoring stations around all nuclear power plants and across the country to support the initiation of early protective actions based on monitoring results.</p> <p>This action item is closed for all Canadian NPP licensees.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Enhances emergency response.

LL#	IAEA lesson	CNSC action and assessment
		<ul style="list-style-type: none"> • Verification is integrated into licensing and compliance processes. <p>No outstanding actions.</p>
3.6	<p><i>Arrangements need to be in place to ensure that protective actions and other response actions in a nuclear emergency do more good than harm. A comprehensive approach to decision making needs to be in place to ensure that this balance is achieved.</i></p>	<p>CNSC action:</p> <p>This lesson is directly addressed in the <i>CNSC Integrated Action Plan</i>:</p> <p>A.5.4 <i>Licensees should develop source term estimation capability, including dose modelling tools.</i></p> <p>The important subject of balancing risks is addressed by provincial and federal off-site plans to a certain extent.</p> <p>Health Canada is currently revising its protective action guidance to align with the recommendations of the IAEA with respect to generic criteria and operational intervention levels aimed at doing more good than harm. Decision makers are encouraged to weigh the possible dose consequences with other prevailing conditions, such as weather, traffic and time of day, all of which can influence the success or failure of actions such as evacuation.</p> <p>Health Canada will also participate in the development of a new IAEA document on considerations in the development of protection strategies for a nuclear emergency at a CANDU reactor.</p> <p>This action item is closed for all Canadian NPP licensees.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Enhances emergency response. • Verification is integrated into licensing and compliance processes. <p>No outstanding actions.</p>
3.7	<p><i>Arrangements need to be in place to assist decision makers, the public and others (e.g., medical staff) to gain an understanding of radiological health hazards in a nuclear emergency in order to make informed decisions on protective actions. Arrangements also need to be in place to address public concerns locally, nationally and internationally.</i></p>	<p>CNSC action:</p> <p>This lesson is directly addressed in the <i>CNSC Integrated Action Plan</i>:</p> <p>A.6.1 <i>CNSC staff will meet with provincial and federal nuclear emergency planning authorities, to ensure understanding of recommendations and findings.</i></p> <p>It is also addressed through emergency exercises such as Huron Challenge at Bruce Power and Exercise Unified Response at Darlington Nuclear Generating Station.</p> <p>While not specific to decision makers, the CNSC has made available a great deal of information on its website (e.g., videos, infographics, feature articles, online modules) to explain complex concepts, particularly the effects of radiation and its sources, in a way that is easily understood by the public.</p> <p>Per LL #3.6, this action item is complete.</p> <p>The CNSC and Health Canada are participating in the development of the new IAEA safety guide DS475, which will focus on arrangements for public communications in preparedness and response for a nuclear or radiological emergency.</p> <p>The <i>Federal Nuclear Emergency Plan</i> includes arrangements to ensure that</p>

LL#	IAEA lesson	CNSC action and assessment
		<p>decision makers are informed, in plain language, of potential impacts of a nuclear emergency.</p> <p>Health Canada and its partners deliver periodic training on radiological health hazards and treatment to first responders and medical staff through the Medical Emergency Treatment for Exposures to Radiation (METER) program. This training program will soon be available online to increase its reach. Health Canada has also published the <i>Canadian Guide on Medical Management of Radiation Emergencies</i>.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Enhances emergency response. • Verification is integrated into licensing and compliance processes. <p>No outstanding actions.</p>
3.8	<p><i>Arrangements need to be developed at the preparedness stage for termination of protective actions and other response actions, and transition to the recovery phase.</i></p>	<p>CNSC action:</p> <p>Canada has begun developing a framework for the post-accident recovery and remediation phases of a nuclear accident or a radiological emergency. This includes the issue of transitioning from the emergency phase to the post-accident phase.</p> <p>In particular, the CNSC has engaged with some of its federal partners in the development of the strategy for post-accident recovery and there are plans to host either a workshop or exercise to test this phase of the response once the framework is either finalized or close to final.</p> <p>CNSC staff have completed benchmarking the guidelines and strategies developed by other countries, including France, the United States, the Nordic countries (Denmark, Finland, Iceland, Norway and Sweden), and other nuclear organizations.</p> <p>In addition, Health Canada is currently revising its guidelines for protective actions during a nuclear emergency. While the focus of the new draft guidelines remains on the early and intermediate phases of the emergency, recommendations for protective actions, such as temporary relocation and food and drinking water control, could continue to be applied during the recovery phase.</p> <p>The CNSC is participating in the development of the new IAEA safety guide DS474, which focuses on arrangements for the termination of a nuclear or radiological emergency.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Enhances emergency response and enhances international collaboration. <p>No outstanding actions.</p>

LL#	IAEA lesson	CNSC action and assessment
3.9	<p><i>Timely analysis of an emergency and the response to it, drawing out lessons and identifying possible improvements, enhances emergency arrangements.</i></p>	<p>CNSC action:</p> <p>This lesson is directly addressed in the <i>CNSC Integrated Action Plan</i>:</p> <p>A.6.1 <i>CNSC staff will meet with provincial and federal nuclear emergency planning authorities, to ensure understanding of recommendations and findings.</i></p> <p>Per REGDOC-2.10.1, <i>Nuclear Emergency Preparedness and Response</i>, the CNSC also requires applicable licensees to ensure a sufficient quantity of iodine thyroid-blocking agents is pre-distributed to all residences, businesses and institutions within the designated plume exposure planning zone (primary zone), along with instructions on the proper administration of these agents.</p> <p>Potassium iodide (KI) pills have been made available to residents in a 50-kilometre radius around the facilities, with delivery to the doorstep of every household within an 8- or 10-kilometre radius.</p> <p>The distribution of KI pills is accompanied by ongoing information and education programs that explain why the pills are available, how they should be stored and under what circumstances they should be administered.</p> <p>The CNSC has also published the <i>Study of Consequences of a Hypothetical Severe Nuclear Accident and Effectiveness of Mitigation Measures</i>, which sheds light on the importance of considering sensitive receptors (i.e., children) in emergency planning efforts such as KI pill administration.</p> <p>Both the <i>Federal Emergency Response Plan</i> and <i>Federal Nuclear Emergency Plan</i> include the requirement to analyze an emergency and the response to it, and then develop after-action reports and management response action plans based on the lessons identified. At the federal level, Health Canada's nuclear emergency management coordinating committees, as well as the Continuous Improvement to Federal Emergency Response (CIFER) process managed by Public Safety Canada, provide for implementing and tracking corrective actions.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Enhances emergency response and improves communication and public consultation. • Verification is integrated into licensing and compliance processes. <p>No outstanding actions.</p>
3.10	<p><i>The implementation of international arrangements for notification and assistance needs to be strengthened.</i></p>	<p>CNSC action:</p> <p>Requests for assistance are directly addressed in the <i>CNSC Integrated Action Plan</i>:</p> <p>A.5.2 <i>Licensees should formalize all arrangements and agreements for external support, and should document these in the applicable emergency plans and procedures. This assessment should consider elements of HOP under accident conditions.</i></p> <p>Regarding international arrangements, part A4 of the <i>CNSC Integrated Action Plan</i> addresses strengthening international collaboration. In particular, action items A.12.1 and A.13.1 placed actions on CNSC staff to:</p> <ul style="list-style-type: none"> • initiate discussions with CANDU senior regulators to determine areas

LL#	IAEA lesson	CNSC action and assessment
		<p>of interest where mutual support can be offered during a nuclear emergency</p> <ul style="list-style-type: none"> • participate in collaboration with industry and other government stakeholders at the Second Extraordinary Meeting of the Convention on Nuclear Safety in August 2012 <p><i>A.12.1 The CNSC is to initiate discussions with CANDU senior regulators, to determine areas of interest where mutual support can be offered during a nuclear emergency.</i></p> <p><i>A.13.1 Canada, as a signatory to the Convention on Nuclear Safety, is required to participate in triennial review meetings of the Convention and any extraordinary meeting that may be agreed to by contracting parties. The CNSC on behalf of Canada is responsible for coordinating the preparation and submission of the national reports for peer review and the participation of Canadian delegates at the review or extraordinary meetings. The CNSC in collaboration with industry and government stakeholders is to prepare a national report for peer review by contracting parties and to participate at the 2nd Extraordinary Meeting of the Convention on Nuclear Safety on the sharing of lessons learned and actions taken by contracting parties in response to the Fukushima Daiichi nuclear accident.</i></p> <p>In keeping with its international commitments, the CNSC will continue to cooperate with other regulators and industry representatives in the implementation of the <i>IAEA Action Plan on Nuclear Safety</i>, promote global nuclear safety through the use of IAEA standards, and continue to support the Convention on Nuclear Safety and the International Emergency Centre.</p> <p>As Competent Authorities for the Convention on Notification of a Nuclear Accident, Health Canada and the CNSC have strengthened their standard operating procedures for communicating with the IAEA, and have practised these in recent exercises. Health Canada has implemented a statement of intent with the United States Department of Energy that includes arrangements for bilateral notifications of a nuclear emergency.</p> <p>Health Canada, as Competent Authority for the <i>Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency</i>, is actively engaged with the IAEA on activities to strengthen these arrangements. Canada has also registered biodosimetry assets under the IAEA's Response and Assistance Network, and continues to identify additional assets that can be registered to support international assistance.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Enhances emergency response and enhances international collaboration. • Verification is integrated into licensing and compliance processes. <p>No outstanding actions.</p>
3.11	<i>There is a need to improve consultation and sharing of information among States on protective</i>	<p>CNSC action:</p> <p>This lesson is directly addressed in the <i>CNSC Integrated Action Plan</i>:</p> <p>C.1.6 <i>The CNSC is to enhance collaboration with international peers through active participation at various international forums to</i></p>

LL#	IAEA lesson	CNSC action and assessment
	<i>actions and other response actions.</i>	<p><i>exchange communications best practices and lessons learned from the Fukushima crisis.</i></p> <p>This action item is complete. Canada provided significant resources in support of the IAEA report on the Fukushima Daiichi accident.</p> <p>Health Canada is an active participant in the IAEA International Radiation Monitoring Information System (IRMIS), whose objective is to share national real-time radiation monitoring data with Competent Authorities of other IAEA Member States during normal and emergency situations.</p> <p>Canada has also contributed to the development of the IAEA's assessment and prognosis function.</p> <p>Finally, Health Canada has put in place a statement of intent with the United States Department of Energy, which includes provisions for the sharing of information during a nuclear emergency.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> <li>• Enhances emergency response and enhances international collaboration. <li>• Verification is integrated into licensing and compliance processes. <p>No outstanding actions.</p>

Phase 2: Assessment of radiological consequences and post-accident recovery

Table 2 reproduces the lessons learned identified in sections 4 and 5 of the DG-IAEA Report and provides information about Canada's actions related to each lesson. The lessons are numbered based on the section of the DG-IAEA Report in which they appear.

Table 2: Assessment of sections 4 and 5

LL#	IAEA lesson	CNSC action and assessment
Section 4. Radiological consequences		
4.1	<p><i>In case of an accidental release of radioactive substances to the environment, the prompt quantification and characterization of the amount and composition of the release is needed. For significant releases, a comprehensive and coordinated programme of long term environmental monitoring is necessary to determine the nature and extent of the radiological impact on the environment at the local, regional and global levels.</i></p>	<p>CNSC action:</p> <p>Boundary monitoring is directly addressed in the <i>CNSC Integrated Action Plan</i>:</p> <p>A.5.3 <i>Licensees should install automated real-time station boundary radiation monitoring systems with appropriate backup power and communications systems.</i></p> <p>Health Canada's fixed monitoring sites provide additional capabilities for real-time data. This data is available in real time to emergency response authorities through Health Canada's web-enabled mapping tool, EMAP. Health Canada is also an active participant in the IAEA International Radiation Monitoring Information System (IRMIS), whose objective is to share national real-time radiation monitoring data with Competent Authorities of other IAEA Member States during normal and emergency situations.</p> <p>Arrangements for comprehensive, long-term environmental monitoring are described in federal and provincial emergency response plans, which include fixed and mobile capabilities as well as centralized laboratories for radiological analysis of various environmental media. In addition to provincial authorities, several federal organizations contribute to this comprehensive capability, including Health Canada, Natural Resources Canada and Atomic Energy of Canada Limited / Canadian Nuclear Laboratories. The CNSC has provided and continues to provide support in terms of technical expertise.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Enhances emergency response/preparedness. <p>No outstanding actions.</p>
4.2	<p><i>Relevant international bodies need to develop explanations of the principles and criteria for radiation protection that are understandable for non-specialists in order to make their application clearer for decision makers and the public. As some protracted protection measures were disruptive for the affected people, a</i></p>	<p>CNSC action:</p> <p>Annex C of the <i>CNSC Integrated Action Plan</i> encompasses a series of actions related to improving communication with the public:</p> <ul style="list-style-type: none"> • Enhancement of social media tools such as Facebook and YouTube to ensure the CNSC website provides, in plain language, information to the public, including information on the safety aspects of nuclear facilities and measures to deal with nuclear emergencies. • Development of a crisis website that can be activated in the event of a nuclear emergency in Canada. • Enhancement of the existing educational resources section on the CNSC website by targeting a broader audience. CNSC Online is a

LL#	IAEA lesson	CNSC action and assessment
	<p><i>better communication strategy is needed to convey the justification for such measures and actions to all stakeholders, including the public.</i></p>	<p>Web-based educational tool that presents highly technical concepts (such as the nuclear fuel lifecycle and nuclear safety) in plain language to Canadians. Where practicable, this interactive tool has made effective use of animated graphics and illustrations.</p> <ul style="list-style-type: none"> • Exploration of partnerships with science-based media organizations to provide media training to specialists and subject-matter experts (with greater emphasis on crisis communications) so they can better convey information in plain language. • Development of a graphic that clearly illustrates to the public the sequence of potential events during and immediately following an extreme accident at a Canadian nuclear power plant. <p>In terms of specifics, a series of items have been developed and posted on the CNSC website about concepts related to emergencies that the public should understand. These include fact sheets on managing doses to the public during a nuclear emergency and a fact sheet on reference levels. Several YouTube videos have also been created, including a series of “ask the expert” videos that address various emergency-related topics.</p> <p>Under the <i>Nuclear Safety and Control Act</i>, one of the CNSC’s objectives is to disseminate objective scientific, technical and regulatory information to the public concerning the Commission’s activities and how both the environment and Canadians’ health and safety are affected by the development, production, possession and use of nuclear substances and prescribed equipment.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Enhancing communications and public education. • Communication strategies and means are continuously improved at the CNSC as new information/technologies become available. <p>No outstanding actions.</p>
4.3	<p><i>Conservative decisions related to specific activity and activity concentrations in consumer products and deposition activity led to extended restrictions and associated difficulties. In a prolonged exposure situation, consistency among international standards, and between international and national standards, is beneficial, particularly those associated with drinking water, food, non-edible consumer products and deposition activity on land.</i></p>	<p>CNSC action:</p> <p>The CNSC agrees that consistency among international standards – and between international and national standards – is beneficial.</p> <p>In Canada, controls on foodstuffs (including milk) are established by Health Canada and guidelines are presented in the <i>Canadian Guidelines for the Restriction of Radioactively Contaminated Food and Water Following a Nuclear Emergency</i>. These guidelines are being revised as part of Health Canada’s broader revision of its protective action guidelines for nuclear emergencies. The CNSC subscribes to Health Canada’s guidelines on drinking water.</p> <p>The CNSC will also address this lesson when establishing post-emergency recovery guidelines for consumer products. Both the CNSC and Health Canada have begun discussions on developing a framework for post-accident issues, which will include criteria for a range of recovery strategies.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Improves the CNSC regulatory framework/processes and

LL#	IAEA lesson	CNSC action and assessment
		<p>emergency preparedness.</p> <p>Work is ongoing under the CNSC and Health Canada with completion planned by 2017.</p>
4.4	<p><i>Personal radiation monitoring of representative groups of members of the public provides invaluable information for reliable estimates of radiation doses and needs to be used together with environmental measurements and appropriate dose estimation models for assessing public dose.</i></p>	<p>CNSC action:</p> <p>The CNSC agrees with this lesson learned. This effort would be carried out collaboratively by a number of government organizations and others. For example, Health Canada has instruments and expertise that can be used to carry out personal dose estimates. Health Canada's National Dosimetry Services, which provides emergency dosimetry services for emergency responders, can provide personal dosimetry for representative members of the public on request of a province or territory. Expertise is also found within the CNSC, applicable provincial authorities and many commercial organizations. There are currently provisions in place to allow for both the calculation and measurement of dose. However, details in terms of guidance material specific to this topic are needed and should be addressed as part of the recommendations for the post-recovery phase of the emergency.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Improves the CNSC regulatory framework/processes and emergency preparedness. <p>Work is ongoing under the CNSC and Health Canada with completion planned by 2017.</p>
4.5	<p><i>While dairy products were not the main pathways for the ingestion of radioiodine in Japan, it is clear that the most important method of limiting thyroid doses, especially to children, is to restrict the consumption of fresh milk from grazing cows.</i></p>	<p>CNSC action:</p> <p>Provisions to restrict the consumption of foodstuffs such as milk are currently covered in the <i>Canadian Guidelines for the Restriction of Radioactively Contaminated Food and Water Following a Nuclear Emergency</i>. These guidelines are being revised as part of Health Canada's broader revision of its protective action guidelines for nuclear emergencies.</p> <p>During an emergency, the provincial decision maker responsible for emergency response would lead in the restriction of local food and water consumption. The Canadian Food Inspection Agency (CFIA) and Health Canada would be involved in the testing of food and water samples, with the CFIA taking any necessary regulatory actions, such as product recalls, to ensure food safety.</p> <p>Provincial plans also include provisions for longer-term ingestion and assurance monitoring to ensure appropriate restrictions are put in place following an emergency. Health Canada and the CFIA work with the provincial authorities to manage these restrictions.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Improves Canada's regulatory framework/processes and emergency preparedness. <p>No outstanding actions.</p>
4.6	<p><i>A robust system is necessary for monitoring</i></p>	<p>CNSC action:</p> <p>The CNSC agrees with this lesson learned. This lesson is also partly</p>

LL#	IAEA lesson	CNSC action and assessment
	<p><i>and recording occupational radiation doses, via all relevant pathways, particularly those due to internal exposure that may be incurred by workers during severe accident management activities. It is essential that suitable and sufficient personal protective equipment be available for limiting the exposure of workers during emergency response activities and that workers be sufficiently trained in its use.</i></p>	<p>addressed through the following action items in the <i>CNSC Integrated Action Plan</i>:</p> <p>A.8.1.1 <i>The CNSC will prepare and consult on a discussion paper on potential amendments to the Radiation Protection Regulations which will include proposed amendments to the emergency provisions in the regulations.</i></p> <p>A.8.1.3 <i>The CNSC will review results of consultation and prepare final amendments to the Radiation Protection Regulations and propose them to the Commission for enactment.</i></p> <p>Canada's <i>Radiation Protection Regulations</i> require licensees to ascertain and record the magnitude of effective dose and equivalent dose received by and committed to all workers, including during severe accident management activities. Workers' radiation doses must also be monitored to ensure they are below Canada's regulatory dose limits and maintained as low as reasonably achievable (ALARA), social and economic factors taken into account.</p> <p>The CNSC has drafted revised regulations on emergencies and emergency dose limits for Canada's <i>Radiation Protection Regulations</i>, which will be submitted for consultation in the <i>Canada Gazette</i>, Part I. These amendments are based on international benchmarking on the control and minimization of doses to persons in accordance with the severity of an emergency. They also address requirements related to pregnant workers, keeping doses ALARA and when a dose limit is exceeded in the context of an emergency.</p> <p>As for the availability of adequate radiation personal protective equipment (PPE) and sufficient training to persons on the use of such equipment, plans are in place. The CNSC has verified licensees' adequacy for PPE and instruments and found them acceptable.</p> <p>Health Canada provides services to support the monitoring and recording of occupational radiation doses. Health Canada's National Dosimetry Services will provide dosimeters to emergency workers to support external dose control. Health Canada also maintains the National Dose Registry for recording and tracking the occupational doses of all workers in Canada. In response to a recent national exercise in Canada, a multi-jurisdictional working group has been established to better define roles, responsibilities, resources and a concept of operations for emergency worker protection.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Improves Canada's regulatory framework and processes. <p>No outstanding actions.</p>
4.7	<p><i>The risks of radiation exposure and the attribution of health effects to radiation need to be clearly presented to stakeholders, making it unambiguous that any increases in the occurrence of health</i></p>	<p>CNSC action:</p> <p>See LL #4.2 above concerning public communication initiatives. Greater efforts on risk communication are ongoing. As one example, this lesson links very closely with the CNSC's development of quantitative health objectives. These objectives will be communicated to the public so that the health risk associated with a possible emergency (for example) is better understood.</p>

LL#	IAEA lesson	CNSC action and assessment
	<i>effects in populations are not attributable to exposure to radiation, if levels of exposure are similar to the global average background levels of radiation.</i>	<p>CNSC assessment:</p> <ul style="list-style-type: none"> • Work is ongoing under continuous improvement. <p>No outstanding actions.</p>
4.8	<i>After a nuclear accident, health surveys are very important and useful, but should not be interpreted as epidemiological studies. The results of such health surveys are intended to provide information to support medical assistance to the affected population.</i>	<p>CNSC action:</p> <p>The CNSC will be involved in a health survey (in the case of a nuclear emergency) and will ensure the purpose and limitations of such a survey are clear.</p> <p>Health Canada has produced the <i>Canadian Guide on Medical Management of Radiation Emergencies</i>, which includes some guidance for longer-term follow-up health surveys. Although the roles and responsibilities for these surveys still need to be clarified, they will likely include provincial health authorities as well as, at the federal level, the Public Health Agency of Canada and Health Canada. Health surveys will be included in the recovery framework currently being discussed by the CNSC and Health Canada.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Enhances domestic and international cooperation. <p>No outstanding actions.</p>
4.9	<i>There is a need for radiological protection guidance to address the psychological consequences to members of the affected populations in the aftermath of radiological accidents. A Task Group of the ICRP has recommended that "strategies for mitigating the serious psychological consequences arising from radiological accidents [should] be sought."</i>	<p>CNSC action:</p> <p>Although addressing the psychological consequences of a nuclear accident is not within the CNSC's mandate, some elements of this lesson will be covered as part of the CNSC's development of a post-emergency strategy. Provisions for managing psychological consequences are included in some provincial health emergency response plans, such as the <i>Radiation Health Response Plan</i> produced by the Ontario Ministry of Health and Long-Term Care. Health Canada has produced the <i>Canadian Guide on Medical Management of Radiation Emergencies</i>, which includes guidance for managing psychological consequences.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Improves Canada's regulatory framework/processes and guidance during radiological emergencies <p>No outstanding actions.</p>
4.10	<i>Factual information on radiation effects needs to be communicated in an understandable and timely manner to individuals in affected areas in order to enhance their understanding of protection strategies, to</i>	<p>CNSC action:</p> <p>In times of emergency, the ability to think logically is greatly hampered by fear. As such, the majority of the effort should be on communication and education during non-emergency periods. (For more details, see LL #4.2 concerning public communication initiatives.)</p> <p>Additionally, this issue is being addressed as part of the CNSC's development of a post-emergency strategy.</p> <p>Under the <i>Federal Nuclear Emergency Plan</i>, the Technical Assessment</p>

LL#	IAEA lesson	CNSC action and assessment
	<i>alleviate their concerns and support their own protection initiatives.</i>	<p>Group includes a “support to communications” function whose task is to formulate technical information into plain language for decision makers and the public. As follow-up to a recent national exercise, Health Canada is also working with its partners to provide plain-language training for designated officials.</p> <p>CNSC assessment:</p> <p>Work is ongoing under the CNSC and Health Canada with completion planned by 2017.</p>
4.11	<i>During any emergency phase, the focus has to be on protecting people. Doses to the biota cannot be controlled and could be potentially significant on an individual basis. Knowledge of the impacts of radiation exposure on non-human biota needs to be strengthened by improving the assessment methodology and understanding of radiation-induced effects on biota populations and ecosystems. Following a large release of radionuclides to the environment, an integrated perspective needs to be adopted to ensure sustainability of agriculture, forestry, fishery and tourism and of the use of natural resources.</i>	<p>CNSC action:</p> <p>To inform regulatory oversight, CNSC staff will continue to monitor the research being conducted at Fukushima and Chernobyl to understand the large-scale consequences of radioactive contamination in the environment on populations, communities and the general ecosystem. Based on the information to date, the CNSC’s current approach to assessing radiological effects on non-human biota from nuclear accidents (e.g., as part of environmental assessments) remains valid.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Continuous monitoring of international activities to ensure all elements being considered by international peers are reflected in the Canadian review scope. <p>No outstanding actions.</p>
Section 5. Post-accident recovery		
5.1	<i>Pre-accident planning for post-accident recovery is necessary to improve decision making under pressure in the immediate post-accident situation. National strategies and measures for post-accident recovery need to be prepared in advance in order to enable an effective and appropriate overall recovery</i>	<p>CNSC action:</p> <p>The CNSC is currently drafting post-accident recovery guidelines that address these issues.</p> <p>The CNSC and Health Canada are discussing approaches for developing a broader recovery framework involving all relevant partners.</p> <p>Additionally, the CNSC Commission has powers under sections 46 and 47 of the <i>Nuclear Safety and Control Act</i> to make decisions regarding contaminated lands and to take any measures necessary to protect human health during emergencies.</p> <p>In a post-accident situation, Health Canada will work with its partners to provide analysis and communication of radiological analysis of various environmental media. This approach is currently being followed to manage</p>

LL#	IAEA lesson	CNSC action and assessment
	<p><i>programme to be put in place in case of a nuclear accident. These strategies and measures need to include the establishment of a legal and regulatory framework; generic remediation strategies and criteria for residual radiation doses and contamination levels; a plan for stabilization and decommissioning of damaged nuclear facilities; and a generic strategy for managing large quantities of contaminated material and radioactive waste.</i></p>	<p>ongoing concern from the public about the potential contamination of Canadian ocean waters due to the Fukushima accident.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Guidelines for food and water controls are currently in place as part of provincial and federal emergency offsite planning. <p>Work is ongoing under the CNSC and Health Canada with completion planned by 2017.</p>
5.2	<p><i>Remediation strategies need to take account of the effectiveness and feasibility of individual measures and the amount of contaminated material that will be generated in the remediation process.</i></p>	<p>CNSC action:</p> <p>This issue will be considered in the development of post-accident recovery guidelines.</p> <p>CNSC assessment:</p> <p>Work is ongoing under the CNSC and Health Canada with completion planned by 2017.</p>
5.3	<p><i>As part of the remediation strategy, the implementation of rigorous testing of and controls on food is necessary to prevent or minimize ingestion doses.</i></p>	<p>CNSC action:</p> <p>This issue has been considered in the development of post-accident recovery guidelines.</p> <p>In a post-accident situation, Health Canada will work with its partners to provide analysis and communication of radiological analysis of various environmental media. This approach is currently being followed to manage ongoing concern from the public about the potential contamination of Canadian ocean waters due to the Fukushima accident.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Guidelines for food and water controls are currently in place as noted previously. <p>Work is ongoing under the CNSC and Health Canada with completion planned by 2017.</p>

LL#	IAEA lesson	CNSC action and assessment
5.4	<i>Further international guidance is needed on the practical application of safety standards for radiation protection in post-accident recovery situations.</i>	<p>CNSC action:</p> <p>The CNSC agrees with this lesson and is monitoring the work of the international community.</p> <p>CNSC assessment:</p> <ul style="list-style-type: none"> • Continuous monitoring of international activities to ensure all elements being considered by international peers are reflected in the Canadian review scope. <p>No outstanding actions.</p>
5.5	<i>Following an accident, a strategic plan for maintaining long term stable conditions and for the decommissioning of accident-damaged facilities is essential for on-site recovery. The plan needs to be flexible and readily adaptable to changing conditions and new information.</i>	<p>CNSC action:</p> <p>The CNSC agrees with this lesson. This kind of strategic plan would be integrated and aligned with licensees' already established preliminary decommissioning plans and radiation protection programs in accordance with Canada's <i>Radiation Protection Regulations</i>.</p> <p>CNSC assessment:</p> <p>No outstanding actions.</p>
5.6	<i>Retrieving damaged fuel and characterizing and removing fuel debris require solutions that are specific to the accident and special methods and tools may need to be developed.</i>	<p>CNSC action:</p> <p>Retrieving damaged fuel and developing special tools fall under the licensee's responsibilities. (See the response to LL #5.7 below.)</p> <p>CNSC assessment:</p> <p>No outstanding actions.</p>
5.7	<i>National strategies and measures for post-accident recovery need to include the development of a generic strategy for managing contaminated liquid and solid material and radioactive waste, supported by generic safety assessments for discharge, storage and disposal.</i>	<p>CNSC action:</p> <p>The safety assessment should include characterization of contaminated waters resulting from potential incidents related to CANDU reactors and taking into account the siting guidelines for Canadian NPPs. Based on the results, the safety assessment should address how contaminated waters will be safely managed to protect the environment. This may include addressing storage capacity and location, treatment technology and monitoring.</p> <p>As part of the <i>Nuclear Substances and Radiation Devices Regulations</i>, the CNSC has unconditional and conditional clearance criteria for the disposal of solid material. The act of remediation differs from decommissioning in that it is done outside of lifecycle planning. Regulatory oversight of the remediation activities must be clear, fair and commensurate with the risks involved.</p> <p>The International Commission on Radiological Protection (ICRP) has developed the concept of "reference levels" to address the decision-making challenges associated with regulating accidents. The CNSC will be incorporating remediation as a topic in an upcoming discussion paper on waste management and decommissioning, planned for publication in 2016.</p>

LL#	IAEA lesson	CNSC action and assessment
		<p>CNSC assessment:</p> <ul style="list-style-type: none"> This topic will be covered in a discussion paper on waste management and decommissioning. Development of the discussion paper is currently in progress. <p>No outstanding actions.</p>
5.8	<p><i>It is necessary to recognize the socioeconomic consequences of any nuclear accident and of the subsequent protective actions, and to develop revitalization and reconstruction projects that address issues such as reconstruction of infrastructure, community revitalization and compensation.</i></p>	<p>CNSC action:</p> <p>Addressing this issue is beyond the CNSC's mandate. It is a government policy.</p> <p>CNSC assessment:</p> <p>No outstanding actions.</p>
5.9	<p><i>Support by stakeholders is essential for all aspects of post-accident recovery. In particular, engagement of the affected population in the decision making processes is necessary for the success, acceptability and effectiveness of the recovery and for the revitalization of communities. An effective recovery programme requires the trust and the involvement of the affected population. Confidence in the implementation of recovery measures has to be built through processes of dialogue, the provision of consistent, clear and timely information, and support to the affected population.</i></p>	<p>CNSC action:</p> <p>The CNSC has established policies and practices that optimize openness, transparency and stakeholder engagement, including stakeholder involvement in the decision-making process. However, the importance of stakeholder involvement has been recognized and is addressed in the draft document on post-emergency recovery, with further development to be based on best practices from the cleanup of other contaminated sites.</p> <p>As stated in this lesson, confidence in the implementation of recovery measures has to be built through processes of dialogue with the affected population. This dialogue must take place before an accident happens (i.e., while there is no state of panic or fear-mongering by interested parties).</p> <p>The CNSC and Health Canada are currently discussing approaches for developing a broader recovery framework involving all relevant partners and stakeholders.</p> <p>CNSC assessment:</p> <p>Work is ongoing under the CNSC and Health Canada with completion planned by 2017.</p>

Annex 9 (c)

Public Information Programs of NPP Licensees

The public information and disclosure programs of Canadian NPP licensees are required to have the following elements:

- objectives
- identification of target audience(s)
- tracking of public and media opinion
- public information strategy and products
- public disclosure protocol
- public disclosure notification to the CNSC
- program evaluation and improvement process
- documentation and records
- contact information

The public information strategies and products within the licensees' programs typically consist of:

- community newsletters mailed directly to households in the region
- advertising in local newspapers
- regular updates provided to local politicians at the municipal, provincial and federal levels
- an interactive visitors' centre
- annual open houses on operational performance
- an Aboriginal affairs program
- communication with employees
- an informative website and social media channels
- regular information sessions on topics identified as areas of public interest
- public polling and focus groups to gather information on public opinion
- media releases

These programs are supported by disclosure protocols that outline the type of information on the facility and its activities that will be shared with the public (e.g., incidents, major changes to operations, periodic environmental performance reports) and how that information will be shared.

For illustration, some examples of the public outreach undertaken by Bruce Power and by OPG during the reporting period are described below.

During the reporting period, Bruce Power:

- consulted with Aboriginal groups and communities whose treaty or Aboriginal rights may be directly affected by the NPP's operation
- implemented a new Aboriginal Scholarship Program to assist students as they further their studies at post-secondary institutes
- launched the Bruce Power site summer bus tour program for visitors
- posted to its website an electronic version of its monthly newsletter
- invested in support programs in the local community (e.g., health and wellness, youth development)

- conducted regular provincial and regional public opinion polling to scientifically measure support in a number of key areas
- hosted telephone town hall meetings so that the Bruce Power Chief Executive Officer could engage the local population in an open conversation regarding key issues involving the NPP and the surrounding community

At Darlington, OPG:

- distributed a community newsletter, *Darlington Neighbours*, three times per year to more than 100,000 households and businesses in Clarington and Oshawa
- provided regular updates (through letters and briefings) to Durham Regional Council and Clarington and Oshawa municipal councils
- provided regular updates to existing community committees (Durham Nuclear Health Committee, Darlington Community Advisory Council) and other stakeholders
- held information-sharing events with First Nations and Métis communities to discuss the implementation of its Aboriginal relations policy
- distributed to the local community a new nuclear safety guide to provide information about what to do in the unlikely event of a nuclear emergency
- provided support to community initiatives through its Corporate Citizenship Program
- provided information to the public through its website and social media program, with more than 27,000 visitors annually to its website and more than 5,000 Twitter followers
- hosted two “open doors” sessions to more than 3,500 members of the public, which included a tour of the Darlington refurbishment training mock-up facility

In addition to the typical public information programs for existing NPPs, OPG and Bruce Power also conducted comprehensive outreach programs focused on the pre-distribution of iodine thyroid blockers (i.e., potassium iodide pills) in 2015. More details can be found in subsection 16.1(d).

Annex 10 (a)

Safety Policies at the Nuclear Power Plants

Nuclear power poses unique hazards due to the enormous energy in the reactor core, radioactive material and decay heat produced by the fuel. Nuclear safety involves the protection of workers, the public and the environment from these hazards. Therefore, as stated in article 10, each NPP licensee in Canada has given due priority to safety as part of its management system.

Each licensee has adopted a different style of demonstrating its priority to safety, with some choosing to state high-level safety principles as part of a distinct nuclear safety policy for their organization.

Ontario Power Generation

The OPG nuclear safety policy states 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.

This policy identifies the Chief Nuclear Officer as being accountable to the Chief Executive Officer and the Board of Directors to establish a management system that fosters nuclear safety as the highest priority.

Bruce Power

Ensuring a healthy nuclear safety culture is an objective for the Bruce Power management system and a means to high standards of excellence. Bruce Power states its commitment to safety within its nuclear safety policy:

Individuals at all levels of the organization consider nuclear plant safety as the overriding priority. Their decisions and actions are based on this priority, and they follow up to verify that nuclear safety concerns receive appropriate attention. The work environment, the attitudes and behaviours of all individuals reflect and foster such a safety culture. Bruce Power shall ensure that reactor safety is the overriding priority in its business decisions and activities, and as the operator of a nuclear power plant accepts that its fundamental reactor safety objective is to protect the public, site personnel and the environment from harm, by establishing and maintaining effective defences against radiological hazards.

This policy provides additional elaboration related to the protection of safety margins, maintenance of defence in depth, and safety analysis.

Hydro-Québec

For Gentilly-2, the Hydro-Québec policy on nuclear safety has a similar statement of high-level values and goals, with a set of supporting principles:

Management, Nuclear Production, has assigned its highest priority to nuclear safety at Gentilly-2. This commitment is supported by the following statements:

- Each employee is personally responsible for safety.
- Managers must demonstrate their commitment to safety.
- Confidence and transparency prevail in the organization.

Decisions made reflect the priority assigned to safety.
Nuclear technology is recognized as special and unique.
A questioning attitude is valued.
Continuous improvement is sought by the organization.
Safety is continuously under review.
Employees, partners and suppliers respect all safety related requirements.

NB Power

The *Nuclear Management Manual*, the highest-level document governing the operations of Point Lepreau, has the following as the first point of the management commitment:

NB Power is committed to the safe, reliable and efficient operation of Point Lepreau Generating Station.

The organization's mission is stated as follows:

To operate the Point Lepreau Generating Station to provide electricity safely...

The first of the core values of the organization is stated as follows:

Safety First – We recognize and take seriously the unique safety requirements of the nuclear core. We are committed to employee and public safety.

In addition, the *Nuclear Management Manual* is introduced by the following statement:

Our Management System is a combination of the culture and interrelated activities that are used to direct and carry out work. It includes the management and support of personnel to enable them to implement the documented processes established within the Management System so that the performance objectives are achieved safely, consistently and efficiently.

Employee responsibilities are stated in the NB Power management system and are also stated in the *Station Instruction on Operations Expectations and Practices* for Point Lepreau.

Annex 11.2 (a)

Details Related to Training and Numbers of Workers

Improvements to licensees training programs

The following provides examples of how NPP licensees have improved their training programs during the reporting period.

Fuel handling: Bruce Power

Bruce Power has developed a full-scale fuel handling simulator to assist with fuel handling training for all necessary staff (e.g., fuel handling control room operators, shift managers, control room shift supervisors, non-licensed operators, nuclear power school trainees). The simulator provides real-time simulation of any on-power fuelling machine action and is enhanced with a graphic display for the development of mental models, which provides a solid understanding of plant design and system interrelationships.

The fuel handling simulator is unlike any other in the world. The system was modelled with a degree of precision (± 0.1 mm) previously unachieved. The integration of high-fidelity physics models with an already high-fidelity reactor model is also the first of its kind in the nuclear industry; it paves the way for training that until now was not even considered.

The fuel handling equipment and environment have been modelled using state-of-the-art, real-time physics models that make the behaviour of the models precisely match the response of the NPP. Key physical properties such as mass, inertia and centre of mass are all built into the models. More importantly, interaction properties are also included (e.g., friction, stiffness, stiction) and can be easily manipulated through instructor controls. Allowing simulator instructors to cause virtually any key component to stick, seize or break free lets them recreate virtually any historical event as well as conduct training for new failure scenarios.

The fuel handling simulator's scope encompasses the entire fuel route: loading new fuel into the head from the new fuel room, fuelling the reactors and discharging irradiated fuel in the primary irradiated fuel bay.

Dynamic learning activities: Bruce Power

Bruce Power has incorporated the use of dynamic learning activities (DLAs) into its training programs. Every six months, staff members demonstrate that they can apply human performance tools in a challenging situation. DLAs ensure workers know how to apply these tools in order to reduce the frequency of workplace errors and minimize the impact of errors that do occur. The expectation is that all full-time and support staff complete a DLA relevant to their workgroup every six months. Bruce Power has built a "Murphy's Alley" trailer that is used for human performance DLAs. The trailer has two areas at either end that mimic a contamination control area, and a large middle section that features various pieces of equipment, including valves, gauges and mechanical and electrical components. As part of the DLA, workers demonstrate proper use of the human performance tools appropriate for the situation.

The DLAs are typically timed to be completed ahead of scheduled maintenance outages (during which workloads are typically the highest). During the reporting period, Bruce Power conducted two DLAs each year. Recent DLAs included maintenance DLAs focused on foreign material exclusion; operations and work management DLAs focused on job site reviews; chemistry and

environment DLAs focused on procedure use and adherence; radiation protection and industrial safety DLAs focused on contaminated control area behaviours; and an engineering DLA focused on technical pre-job briefs. Errors are embedded into the DLAs so workers can demonstrate all human performance tools to get their DLA credit.

Dynamic learning activities: Ontario Power Generation

OPG has developed and implemented DLAs to sustain and continually improve radiation protection performance at Darlington and Pickering. The DLAs provide an opportunity for participants to interact with a worker in a simulated radioactive work area, complete with state-of-the-art instrumentation and equipment that simulates radiation hazard conditions. This provides station leaders with the opportunity to demonstrate their skills in a realistic work environment without exposure to occupational radiation hazards, using instrumentation virtually identical to that used in the plant.

All OPG station leaders have participated in interactive DLAs to improve the quality of oversight and mentoring of workers during radioactive work execution. Station leaders have also participated in DLAs to improve pre-job briefings given prior to radioactive work execution and to maintain internal dose as low as reasonably achievable (ALARA) during work in areas where airborne radiation hazards are present. Operating and maintenance staff have participated in DLAs related to handling tritiated fluids and contamination control. A dedicated facility has been established for the delivery of DLAs in a small group environment to maximize learning opportunities and hands-on involvement of participants. These DLAs are delivered at both NPPs to ensure alignment across the fleet.

Dynamic learning activities: NB Power

NB Power has developed an integrated DLA to address the application and use of human performance tools and techniques by all NPP staff. The activity incorporates three tasks: strainer cleaning in a field environment, performing manipulations in a radiation area requiring a radiation exposure permit, and doing calculations in an office. These tasks are done simultaneously and then integrated to solve a common goal when successful. Successful completion of tasks requires “engaged, thinking workers” effectively using the organization’s human performance tools.

All NPP staff, starting with the site vice-president and station directors, are required to complete the DLA, including contract staff joining the organization to support outages (a total of up to 1,400 staff members). To date, approximately half of the personnel supporting the unplanned outage have completed the DLA. Staff learning is observed by their peers, supervisors and managers when they return to work activities, and alignment is achieved with expectations, critical steps and observation and coaching methodologies. Personnel use the tools in the same manner as the training they completed before an outage.

Operations and maintenance training creates and maintains job performance capability. This training normally includes classroom instruction, workshops, on-the-job instruction, full scope simulator exercises, supervisory coaching and informal briefings. The majority of staff members are also trained to a radiation protection level that qualifies them to be responsible for their own protection, able to sponsor supplemental staff and provide radiation protection oversight.

Refurbishment training facility: Darlington Energy Complex

OPG staff and contractors who will be working on the replacement of fuel channels and feeders at Darlington will be trained in a refurbishment training facility referred to as the Darlington Energy Complex. This will allow ample time for staff to perform a full “dress rehearsal” of the intricate work in an environment that replicates the actual reactor vault, before and during project execution. The purpose of the mock-up is to have the work teams determine best working techniques before the Darlington refurbishment begins. Mock-up buildings have been an integral part of previous major projects including refurbishments at Point Lepreau, Wolsong (Korea) and Bruce Power. Industry best practice and lessons learned have shown that training on realistic mock-ups results in significantly more efficient field execution.

The mock-up reactor is designed and built to accurately represent the size and space within the real reactor vaults and identify all interferences (e.g., lighting in access areas) that will be encountered during the work.

The mock-up equipment in the training centre includes:

- full-scale reactor mock-up with critical target components, interferences, vault cranes, fueling machine bridge and fueling machine pits
- numerous fuel channel and feeder mock-ups of the target components for those replacements

The mock-ups have been precisely constructed. There are 480 pressure tubes to be extracted and inserted in each reactor. As the mock-up does not include the calandria, workers will be able to see the new tubes sliding into position. Also due for replacement and part of the mock-up are the 960 feeder tubes – one at each end of each fuel channel assembly.

In addition to practicing replacement activities, trainees will also demonstrate understanding of overall evolution and critical hold points from a radiation protection ALARA perspective by participating in mock-up rehearsal or “just-in-time” training for the project to replace fuel channels and feeders.

Requirements and guidance for qualification and numbers of workers

A hierarchy of laws, regulations, licence conditions and regulatory documents specify the requirements for the number of workers to be present at an NPP as well as the qualifications and training of personnel who perform critical safety-related activities.

The NSCA and its regulations provide the legislative basis for the number of workers and the qualification, training, examination and certification of personnel. Specifically, the *General Nuclear Safety and Control Regulations* state that the licensee shall:

- (a) ensure the presence of a sufficient number of qualified workers to carry on the licensed activity safely and in accordance with the NSCA, its regulations and the licence
- (b) train the workers to carry on the licensed activity in accordance with the NSCA, its regulations and the licence

The *Class I Nuclear Facilities Regulations* require each applicant for a licence to construct, operate or decommission a Class I nuclear facility to provide details about the qualifications, training and experience of any worker involved in the NPP’s operation or maintenance.

The licensing basis for NPPs include the following requirements related to numbers of workers, qualifications and training:

- A minimum staff complement (sufficient qualified personnel) must be in attendance at all times to ensure safe operation of the NPP. This includes a sufficient number of qualified personnel to ensure adequate emergency response capability. The minimum staff complement is specified in licensee documents that are submitted as part of the application for a licence see (subsection 11.2(a)).
- A sufficient number of the following certified positions must be in attendance at all times at an NPP. These will vary depending upon the design of the NPP:
 - authorized nuclear operator/control room operator (all NPPs are required to have an authorized nuclear operator in direct attendance at each unit's main control room panels at all times)
 - Unit 0 control room operator (Bruce A, Bruce B, Darlington)
 - control room shift supervisor and shift manager for multi-unit NPPs
 - shift supervisor for single-unit NPPs
- A certified responsible/senior health physicist must be appointed.
- Certified personnel must meet the relevant certification requirements applicable to their positions, as specified in CNSC regulatory document RD-204, *Certification of Persons Working at Nuclear Power Plants*.
- CNSC guidance document G-323, *Ensuring the Presence of Sufficient Qualified Staff at Class I Nuclear Facilities – Minimum Staff Complement*, describes CNSC staff's expectations of key factors that must be considered to ensure the presence of a sufficient number of qualified staff at Class I nuclear facilities.

Annex 11.2 (b)

Workforce Planning Processes

All licensees have assessed the nature of the work performed by staff, the training and qualifications required, and the existing capacity to do that work. Details on how Bruce Power has done this are provided in annex 11.2(b) of the sixth Canadian report.

All licensees also have processes to ensure adequate resources and facilities are always available for responding to planned activities and contingencies. The following is an example of Bruce Power's processes to plan and optimize its workforce.

The workforce planning process is reviewed annually as part of Bruce Power's business planning cycle. The process includes a talent segmentation exercise that analyzes the requirements for various positions and the available staff. It identifies the specific criticality levels of all jobs across the company, as well as the normal complement (e.g., requirements) for those positions. This information is then applied as business assumptions for future staffing level planning activities.

Several business assumptions are also applied against actual headcount and job level targets to mitigate risks to critical positions. An attrition model forecasts future retirements and staff movements across the site, based on historical retirement and staff movement trends, retirement surveys, available skills within and outside the organization, and a risk assessment/environmental scan of internal and external factors. In addition, the lead time (e.g., recruitment and training) is identified for all critical positions (including certified staff) and serves as a basis for "pre-hiring" before an incumbent actually leaves his or her position. This ensures mission-critical knowledge can be captured and transferred to a new hire, and that Bruce Power maintains an adequate level of employees in positions required to safely manage the NPP.

Bruce Power's workforce planning process allows for continuous adjustments to the workforce plan, as it is considered a living document that must meet business requirements. Senior managers also review the status of Bruce Power's planned staffing efforts and other critical reports semi-monthly.

This experience, knowledge and continual review are now applied to execute a gap analysis between current staffing levels and the optimal future state. During yearly business planning sessions, executives and senior managers reconcile current work program requirements and Bruce Power's long-term workforce model to develop appropriate staffing levels across the site for each year of the planning horizon. Consequently, Bruce Power has a system in place to ensure that current programs are managed, while implementing improvement strategies to reach its future workforce model and staffing levels.

Annex 12 (a)

Responsibilities and Accountabilities for Human Performance at NPPs

Each licensee incorporates, in its management system, an organizational and management philosophy that uses a hierarchical method to account for human performance:

- The primary responsibility for human performance rests with each individual.
- First-line managers are accountable for monitoring and correcting human performance issues.
- Management provides the necessary expectations, facilities and tools to aid human performance.
- Non-line organizations provide independent oversight of human performance.

The priority to safety of each licensee and the focus on safety culture (as discussed in article 10) are critical to this hierarchical approach. Clear lines of authority and communication are established, so that individuals throughout the organization are aware of their responsibilities toward nuclear safety. At the individual level, the emphasis is on personal dedication and accountability for each individual engaged in an activity that affects the safety of the NPP. An individual's recognition and understanding of this responsibility, as well as a questioning and self-checking attitude, are essential for minimizing human errors.

Human performance tools for workers are used to anticipate, prevent and detect errors before they cause harm to people, plant, property or the environment. Although these tools can be used by any employee in a wide range of situations, they are particularly useful to front-line workers and their managers, who touch plant equipment and are capable of altering its status. Human performance tools help workers maintain positive control of a work situation, ensuring the job is done correctly the first time.

Errors by knowledge workers, especially engineers, potentially have the greatest adverse impact on NPP safety. "In-process" errors are often more subtle than front-line active errors committed by operators and maintainers on plant equipment, in that they tend to create latent errors that, if undetected, become embedded in the physical configuration of the plant equipment or documentation. Additionally, latent errors may go unnoticed for very long periods. Human performance tools for knowledge workers assist them in anticipating, preventing and catching most errors related to their work. Knowledge worker tools provide a defensive barrier against latent errors that can affect plant safety or production later.

Management's roles and responsibilities to aid in human performance include:

- clearly communicating performance expectations through policies and procedures
- establishing an effective organization with well-defined and understood responsibilities, accountabilities and authorities
- ensuring an operational safety focus
- hiring sufficient numbers of properly qualified workers
- developing sound procedures to clearly define safety-related tasks
- continuously enhancing the procedures by incorporating lessons learned

- providing the necessary training and education to emphasize the reasons behind established safety practices and procedures, together with the consequences of safety shortfalls in personal performance
- providing sufficient and proper facilities, tools and equipment, and support staff
- conducting self-assessments to promote continuous improvement
- ensuring that human factors issues are systematically considered in any new design or modification to an existing facility
- providing additional levels of oversight, independent of the line organization, to evaluate human performance
- ensuring the use of operating experience feedback

Each level of management is also vested with a specific level of authority as defined in their operating policies and principles (OP&Ps; see subsection 9(b) and subarticles 19(ii) and 19(iii)) and other management system documents. Managers should have a clear understanding of what they can approve versus what they must refer to a higher authority. Errors are minimized by requiring anyone who approves a document or activity to verify consistency and compliance with:

- the individual's limits of authority
- the applicable external requirements (e.g., laws, regulations and the licence) and internal boundaries (e.g., OP&Ps, safety reports and quality assurance manuals)
- operating and maintenance practices
- design assumptions and intent

First-line managers are accountable for monitoring and correcting human performance issues. The primary method is direct observation of pre-job planning and preparation, work execution and post-job wrap-up activities. The flow of information and the communication of problems both up and down the line, including identification of human errors, are key to human error detection and correction.

A formal observation and coaching program assists managers and supervisors in directing their observation activities in those areas where the most significant impact will be achieved. The program also provides guidance on effective non-confrontational approaches to interacting with employees when delivering coaching feedback on performance that met or did not meet the requirements.

Annex 12 (e)

Human Factors Engineering in NPP Design and Modification

In the Canadian nuclear power industry, human factors engineering (HFE) is applied in new designs from the conceptual design phase to the final detailed design, installation and commissioning phases. In operating NPPs, HFE considers operational, maintenance and aging management factors – and is integrated in the development of procedures as well as change control processes when any modifications are made.

A rigorous HFE approach is used in the areas of human system interface components, equipment layouts, control room habitability, control room display design, panel design and annunciation design.

A systematic process is defined, documented and implemented to integrate human factors into the design process. HFE activities are identified and documented for each design and incorporated into the design plan and/or human factors plan. The plans are based on the regulatory requirements, international standards and best practices, as well as experience derived from the application of HFE to previous CANDU design projects throughout the evolution of CANDU technology. The plans are then implemented to ensure that the resulting design is compatible with human capabilities and limitations and that the systems and equipment can be safely and effectively operated and maintained for all postulated system states and operating conditions. HFE summary reports are produced to document the results of the process. All licensees and Candu Energy Inc. perform periodic self-assessments of their HFE programs to confirm they are fully implemented and effective.

The HFE program plan for design aspects of a nuclear project, including refurbishment and new build, covers 11 elements based on the USNRC document NUREG-0711, *Human Factors Engineering Program Review Model*:

- HFE program management
- operating experience review
- functional requirements analysis and function allocation
- task analysis
- staffing and qualification
- human reliability analysis
- human-system interface design
- procedure development
- training program development
- human factors verification and validation
- design implementation (integration)

CSA standard N290.12-14, *Human factors in design for nuclear power plants*, was published in December 2014. This standard includes elements of NUREG-0711. All NPP licensees are in the process of implementing the CSA standard; full implementation is expected during the next reporting period.

In addition to providing input about the design itself, human factors are also addressed as part of the constructability, operability, maintainability and safety review as well as in the development of procedures, instructions and training. Also, human factors considerations and human

performance tools are used throughout a nuclear facility to address installation and commissioning of the design as well as the operability, maintainability and safety of NPPs during operation and shutdown.

Annex 14 (i) (c)

Details on Deterministic Safety Analysis

Content of the safety analysis reports for existing NPPs

NPP licensees maintain deterministic safety analyses as documented in their safety analysis reports. Deterministic safety analysis demonstrates that the radiological consequences of postulated initiating events – which involve a single process failure – and events involving a single process failure in conjunction with a failure in one of the special safety systems do not exceed the accident-dependent reference public dose limits specified in the design requirements.

The typical safety analysis report covers the following main areas as given below.

Introduction and site description, which include the following characteristics:

- general description
- geography and land use for recreation and commerce, as well as information such as population distribution
- meteorology
- hydrology
- geology and seismology

Systems and components, which provide sufficient detail for understanding the interaction of the systems and for use in following the accident analysis details. The elements typically covered include:

- safety design philosophy
- design criteria
- structures
- reactor
- reactor process systems
- special safety systems and safety-related systems
- instrumentation and control
- electrical power systems
- turbine/generator and auxiliaries
- fuel and fuel handling
- auxiliary systems
- radiation protection
- waste management

Deterministic safety analysis summaries, which provide the detailed description of the accident analysis for the NPP. This presents the analysis of all the design-basis accidents to demonstrate that the safety design objectives of all postulated accidents are met. The elements typically covered include:

- identification of initiating events
- fuel handling system failures
- electrical system failures
- control failures
- small loss-of-coolant accidents

- large loss-of-coolant accidents
- loss-of-coolant accident outside containment
- feedwater system failures
- steam supply system failures
- shutdown cooling system, shield cooling system and moderator system failures
- support system failures
- common mode incidents:
 - design-basis earthquake
 - turbine breakup
 - design-basis tornado
 - design-basis rail-line blast
 - spurious closure of the heat transport loop interconnect valves
 - toxic corrosive chemical rail-line accident
 - internal fires
- event classification
- description of major computer models

Examples of improvements to deterministic safety analyses

The NPP licensees continually update safety analyses that included the effects of aging of the primary heat transport system. The effects are due primarily to the diametric creep of the pressure tubes. Safety analyses have been performed to demonstrate adequacy of safety margins in the scenarios most affected by aging. As provided in CNSC regulatory document REGDOC-2.6.3, *Aging Management*, an important aspect of life management is the impact of aging on facility safety, including safety margins, as determined through an updated deterministic safety analysis. This analysis requires a systematic and integrated approach to aging management.

Revised safety analyses are being conducted in the context of the licensees' implementation of CNSC regulatory document REGDOC-2.4.1, *Deterministic Safety Analysis*, which was published in 2014. The following describes the work being carried out by each licensee to implement REGDOC-2.4.1.

Ontario Power Generation

OPG is currently implementing the requirements of REGDOC-2.4.1 by performing several sets of safety analyses under the new framework. These analyses also incorporate the effects of primary heat transport aging. Pilot analyses have been completed for loss-of-reactivity control scenarios and loss of moderator heat sink scenarios. OPG has also performed safety analyses for loss of flow, small-break loss-of-coolant accidents, and neutron overpower protection accident scenarios to demonstrate adequacy of safety margins with aged primary heat transport conditions.

Bruce Power

Bruce Power has embarked on a three-year safety report improvement project, scheduled to be completed by December 31, 2017, to upgrade the safety analysis summaries section of its safety report. Bruce Power is adding a common mode failure appendix (not currently included in the Bruce A and B safety reports) and aligning its safety report framework with REGDOC-2.4.1.

Through this project, Bruce Power intends to improve and enhance the Bruce A and B safety reports.

Bruce Power will develop an approach for deterministic analyses in support of seismic events, fire and floods, drawing from post-Fukushima assessments and probabilistic safety assessments performed in compliance with CNSC regulatory standard S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*.

NB Power

During the reporting period, NB Power completed its event identification and classification in accordance with REGDOC-2.4.1 and performed a clause-by-clause and event-specific gap assessment against the requirements of REGDOC-2.4.1. It applied a graded approach to determining the analysis of anticipated operating occurrences (AOOs), which identified that no further AOO analysis was required at that time. However, based on the REGDOC-2.4.1 gap assessment, NB Power chose to perform an AOO analysis for fast loss-of-reactivity control accidents to confirm the findings of the graded approach. Additional AOO analysis may be identified depending on the outcome of the fast loss-of-reactivity control analysis. NB Power has performed recent analyses that comply with REGDOC-2.4.1 requirements, including for postulated large-break loss-of-coolant accidents with coincidental loss of emergency core cooling. Ongoing safety analysis work that complies with REGDOC-2.4.1 includes analysis of high-energy line breaks. NB Power will initiate safety analysis work to evaluate the consequences of small loss-of-coolant analysis, which includes addressing aging effects. All new analysis will be reflected in future updates to the safety report.

Annex 14 (ii) (b)

Aging Management Programs at Each Nuclear Power Plant

CNSC regulatory document REGDOC-2.6.3, *Aging Management*, establishes the regulatory requirements and provides guidance for integrated and component-specific aging management programs at NPPs.

Along with the aging management programs required by REGDOC-2.6.3, Canadian licensees have developed a series of periodic inspection programs and plans that expand the minimum inspection and testing program requirements to address operational and safety issues. The most significant of these programs and plans are described below.

Feeder Pipe Lifecycle Management Plan

This plan establishes an inspection and maintenance strategy to mitigate risks related to feeder aging and degradation mechanisms. Specific program inspection and maintenance activities are described to mitigate degradation caused by bend thinning, bend cracking, localized flaws adjacent to welds and weld cracking. A visual inspection program is included to detect any localized feeder fretting due to contact with components and structures in close proximity. This plan also documents the strategy for determining whether feeder replacement is needed.

Fuel Channel Lifecycle Management Plan

This plan presents strategies for ensuring that the effects of fuel channel aging are monitored (with inspections conducted per CSA standard N285.4, *Periodic inspection of CANDU nuclear power plant components*) and managed effectively. It also discusses degradation mechanisms – including pressure tube dimensional changes due to service conditions (axial and diametral expansion, wall thinning and tube sag), deuterium uptake, fracture toughness changes, pressure tube to calandria tube contact and the potential for blister growth, as well as re-fuelling-related service-induced damage to inside surfaces. Degradation mechanisms for fuel channel annulus spacers are also discussed along with plans to ensure their fitness for service. Research results are used to guide the inspection plans.

Flow-accelerated Corrosion Program

This program identifies susceptible systems and monitors and manages degradation related to flow-accelerated corrosion and other degradation mechanisms (such as erosion), mainly in secondary-side (non-nuclear) and certain primary-side (nuclear) piping systems. The program is based on the Electric Power Research Institute (EPRI) program. It uses the Chexal-Horowitz Engineering Corrosion (CHECWORKS) software as a guide in identifying and selecting inspection locations and processing measured data to determine thinning rates and acceptability for continued service. For piping that cannot be modelled using CHECWORKS due to geometrical constraints or thinning mechanisms (such as small-bore piping or thinning due to an erosive mechanism), manual calculations are used to evaluate the thinning rate and acceptability for continued service.

Steam Generator Lifecycle Management Plan

This plan establishes the inspection and maintenance strategy used to control risks related to steam generator aging and degradation mechanisms, and includes measures to detect, record, trend and mitigate these mechanisms. Program elements include tube wall inspections and inspections of other internal components (e.g., moisture separators, tie rods, feedwater boxes, and nozzles), water chemistry management, and primary- and secondary-side deposit management and removal (via water lancing, internal tube blasting, blow-down practices during operation and occasional chemical cleaning).

Containment

Requirements for the design, construction, commissioning and in-service inspection of concrete containment structures are contained in CSA standard N287.7, *In-service examination and testing requirements for concrete containment structures for CANDU nuclear power plants*. Licensees perform periodic in-service inspection and testing of the containment at specified intervals, to ensure structural integrity and leak-tightness are maintained. As specified by regulatory requirements, licensees submit the periodic inspection and testing results, as well as their evaluations, to the CNSC for review. If inspection results indicate an adverse trend, the CNSC may require the licensee to increase the frequency of the inspection and/or provide compensatory measures.

Additional inspection requirements for containment components are specified in CSA standard N285.5, *Periodic inspection of CANDU nuclear power plant containment components*.

Component replacement

The Canadian nuclear industry continues to take initiatives to prevent and manage problems with acquiring replacements for equipment that is no longer available from the original manufacturer. COG has an Emergency Spares Assistance Process that obtains spare parts from other utilities to meet the needs of CANDU NPPs. As well, a number of replacement components (including gaseous fission product detectors, 48-volt indicating fuses, heavy water leak-detection systems, potentiometers, shut-off rod motors and digital control computers) were acquired through COG on behalf of several CANDU NPPs. The Canadian industry has also developed some capability, within an appropriate quality assurance program, to reverse-engineer and manufacture replacement parts that are no longer available.

Example of Integrated Plant Life Management Plan

Bruce Power is evolving its approach to managing the aging and health of key structures, systems or components in alignment with evolving regulatory requirements, best practice, and operating experience. Bruce Power's asset management approach is an example of the implementation of an integrated NPP licensee aging management program to support key assets in reaching their target lifetimes for reliable operations. The asset management approach utilizes Bruce Power's existing processes by integrating engineering practices for monitoring system and component health, periodic inspection, equipment reliability and aging management, thus continuously gathering data in a "plan-do-check-act" cycle. A number of initiatives and strategies are underway to achieve or exceed target lifetimes.

The program's scope and process has been developed with consideration for nuclear industry regulatory requirement documents, along with best practice and guidance documents such as:

- CNSC regulatory document REGDOC-2.3.3, *Periodic Safety Reviews*
- CNSC regulatory document REGDOC-2.6.3, *Aging Management*
- CNSC regulatory standard S-98, *Reliability Programs for Nuclear Power Plants*
- IAEA safety guide NS-G-2.12, *Ageing Management for Nuclear Power Plants*

Annex 15 (a)

Detailed Requirements and Guidance for Control of Radiation Exposure of Workers and the Public

The *Radiation Protection Regulations* incorporate many of the International Commission on Radiological Protection recommendations for dose limits (ICRP 60, 1991) as well as its recommendations on occupational exposure to radon progeny (ICRP 65, 1994). The regulations address the following:

- implementation and requirements of licensee radiation protection programs
- requirements for ascertaining and recording doses
- definition of action level and the actions to be taken when an action level has been reached
- requirement for informing workers of the risks associated with radiation to which the worker may be exposed and of effective and equivalent dose limits
- requirement for when to use licensed dosimetry services to ascertain dose
- effective and equivalent dose limits for nuclear energy workers, pregnant nuclear energy workers and persons who are not nuclear energy workers
- dose limits that apply during the control of emergencies
- actions to be taken when a dose limit is exceeded and the process for authorizing return to work
- requirements for licensed dosimetry services
- requirements for labelling containers and devices
- requirements for posting radiation warning signs

The CNSC has developed a number of regulatory documents to assist licensees in matters related to radiation protection and environmental protection. CNSC regulatory guide G-129, *Keeping Radiation Exposures and Doses “As Low As Reasonably Achievable” (ALARA)*, describes measures licensees can take to keep all doses to persons ALARA, social and economic factors being taken into account. Elements that the CNSC considers to be essential in the approach to ALARA are:

- demonstrated management commitment to the ALARA principle
- implementation of the ALARA principle through a licensee’s management of radiation protection (including provision of dedicated resources, training, documentation and other measures)
- programs that control exposures to workers and the public
- planning for unusual situations
- development of performance goals and regular operational reviews

CNSC regulatory guide G-228, *Developing and Using Action Levels*, is intended to help licence applicants to develop action levels in accordance with paragraph 3(1)(f) of the *General Nuclear Safety and Control Regulations* and section 6 of the *Radiation Protection Regulations*. G-228 provides guidance on the types of parameters that can be used in developing action levels, requirements for monitoring these parameters and appropriate responses when an action level is reached.

Licensees must use a CNSC-licensed dosimetry service to measure and monitor radiation doses of nuclear energy workers who have a reasonable probability of receiving an effective dose

greater than 5 mSv in a one-year dosimetry period. CNSC regulatory standard S-106, *Technical and Quality Assurance Requirements for Dosimetry Services*, contains accuracy, precision and quality assurance requirements for dosimetry services licensed by the CNSC. The requirements in S-106 meet, and in some instances exceed, the requirements of IAEA safety guides RS-G-1.2, *Assessment of Occupational Exposure Due to Intakes of Radionuclides*, and RS-G-1.3, *Assessment of Occupational Exposure Due to External Sources of Radiation*. Licensed dosimetry services must file the dose results of each nuclear energy worker to the Canadian National Dose Registry, which is maintained by Health Canada.

Summary of doses to NPP workers during the reporting period

Workers at NPPs are restricted to dose limits of 50 mSv in a one-year dosimetry period and 100 mSv in a five-year period. The data in the tables on the following page show the collective dose from routine operations and outages, as well as the total collective dose and maximum individual effective dose received by a worker at Canadian NPPs during the reporting period. As indicated, no worker exceeded the annual dose limit of 50 mSv. In addition, no worker exceeded the five-year dose limit of 100 mSv.

Table 1: Occupational dose summary for Canadian NPPs, 2013–2015

NPP	Year	Number of reactors	Collective dose from routine operations (person-mSv)	Collective dose from outages, (including forced outages) (person-mSv)	Total collective dose (person-mSv)	Maximum individual effective dose (mSv)
Bruce A and B	2013	8	859	6,092	6,951	13.63
	2014	8	914	8,017	8,931	20.17
	2015	8	882	6,541	7,423	15.40
Darlington	2013	4	382	4,067	4,449	14.15
	2014	4	391	1,813	2,204	11.13
	2015	4	329	2,311	2,640	9.78
Gentilly-2*	2013	1	0	52	52	2.26
	2014	1	0	109	109	7.85
	2015	1	0	7	7	1.46
Pickering	2013	6	682	3,764	4,446	14.50
	2014	6	721	4,685	5,406	14.50
	2015	6	747	4,802	5,549	15.38
Point Lepreau	2013	1	178	47	225	6.59
	2014	1	148	397	545	10.20
	2015	1	144	76	220	6.6

* The Gentilly-2 reactor was shut down during this period.

Table 2: Maximum five-year individual effective dose to workers at each Canadian NPP, 2011–2015*

Station	Maximum individual effective dose (mSv)
Bruce A and B	74.4
Darlington	42.6
Gentilly-2	12.3
Pickering	57.8
Point Lepreau	18.7

* Data provided by the National Dose Registry. Regulatory limit is 100 mSv for the five-year period of January 1, 2011 to December 31, 2015.

Table 3: Total collective dose at all Canadian nuclear power plants, 2013–2015

Year	Number of operating reactors	Collective dose (person-Sv)
2013	19	16.12
2014	19	17.19
2015	19	15.84

Annex 15 (b)

Radiological Emissions from Canadian NPPs

All NPPs release small quantities of radioactive materials, in a controlled manner, into both the atmosphere (as gaseous emissions) and adjoining water bodies (as liquid effluents). This annex reports the magnitude of these releases for each operating NPP in Canada for the years 2013 to 2015. This annex also indicates how these releases compare with the derived release limits (DRLs) imposed by the CNSC. In the majority of cases, the levels of gaseous and liquid effluents from all operating NPPs were below 1 percent of the values authorized by the CNSC.

Table 1: Gaseous emissions released from Canadian nuclear power plants, 2013–2015

Year	Tritium oxide (TBq)	Carbon-14 (TBq)	Noble gases (TBq-MeV)	Iodine-131 (TBq)	Particulates (TBq)
Bruce A¹					
DRL, 2009–2013	1.35E+05	1.05E+03	4.75E+04	1.18E+00	3.10E-01
Since 2014	1.98E+05	6.34E+02	1.12E+05	1.14E+00	1.73E+00
2013	5.04E+02	2.53E+00	6.66E+01	4.94E-05	4.94E-06
2014	7.51E+02	1.64E+00	5.30E+01	3.94E-04	3.13E-06
2015	7.05E+02	3.15E+00	5.62E+01	5.15E-05	1.06E-05
Bruce B¹					
DRL, 2009–2013	2.71E+05	1.08E+03	1.06E+05	9.15E-01	7.42E-01
Since 2014	3.16E+05	7.56E+02	2.17E+05	1.35E+00	3.61E+00
2013	2.63E+02	1.10E+00	3.71E+00	4.04E-05	1.86E-05
2014	4.13E+02	1.26E+00	5.25E+01	4.02E-05	1.53E-05
2015	3.74E+02	1.16E+00	5.25E+01	4.01E-05	1.63E-05
Darlington					
DRL	5.9E+04	3.5E+02	4.5E+04	1.4E+00	6.7E-01
2013	2.07E+02	1.03E+00	3.16E+01	1.40E-04	2.90E-05
2014	2.71E+02	1.30E+00	4.61E+01	1.63E-04	3.13E-05
2015	2.54E+02	1.34E+00	2.22E+01	1.43E-04	3.45E-05
Gentilly-2					
DRL	8.58E+04	1.99E+02	7.70E+04	3.25E-01	1.21E+00
2013	1.14E+02	7.49E-01	9.96E-04	ND	6.26E-07
2014	1.19E+02	4.83E-01	3.15E-03	ND	2.92E-07
2015	1.07E+02	3.80E-01	ND	ND	1.34E-06
Pickering Units 1–4					
DRL	1.2E+05	2.2E+03	3.2E+04	9.8E+00	4.9E-01
2013	1.83E+02	7.75E-01	1.21E+02	8.44E-06	3.74E-06
2014	2.48E+02	9.13E-01	1.13E+02	1.12E-05	4.13E-06
2015	2.36E+02	1.05E+00	9.25E+01	1.38E-05	5.48E-06
Pickering Units 5–8					
DRL	1.9E+05	2.0E+03	4.7E+04	8.9E+00	7.2E-01
2013	2.42E+02	9.07E-01	6.48E+00	4.35E-06	4.97E-06
2014	2.83E+02	9.06E-01	1.05E+01	5.19E-06	3.81E-06
2015	2.99E+02	1.01E+00	1.64E+01	4.64E-06	1.60E-05
Point Lepreau					
DRL	2.8E+05	6.8E+03	1.2E+05 TBq	6.0E+01	1.8E+00
2013	9.1E+01	8.0E-02	3.58E+00	ND	ND
2014	6.6E+01	8.4E-02	3.3E+00	ND	ND
2015	1.4E+02	8.4E-02	4.8E+00	ND	ND

Note 1: DRLs revised on licence renewal in 2014

ND = not detected

Table 2: Liquid effluent released from Canadian nuclear power plants, 2013–2015

Year	Tritium oxide (TBq)	Gross beta-gamma (TBq)	Carbon-14 (TBq)
Bruce A¹			
DRL, 2009–2013	2.13E+06	1.00E+02	2.61E+03
Since 2014	2.30E+06	4.58E+01	1.03E+03
2013	1.96E+02	2.12E-06	9.95E-04
2014	1.94E+02	1.02E-03	1.13E-03
2015	2.20E+02	9.17E-04	2.45E-03
Bruce B¹			
DRL, 2009–2013	2.27E+06	1.07E+02	2.78E+03
Since 2014	1.84E+06	5.17E+01	1.16E+03
2013	4.19E+02	3.95E-03	4.90E-03
2014	6.42E+02	1.99E-03	8.06E-03
2015	6.72E+02	1.53E-03	9.07E-03
Darlington			
DRL	5.3E+06	7.1E+01	9.7E+02
2013	1.09E+02	2.75E-02	3.20E-04
2014	1.74E+02	2.99E-02	5.51E-03
2015	2.41E+02	4.86E-02	7.29E-03
Gentilly-2²			
DRL, 2013-2014	1.16E+07	1.75E+02	2.40E+03
Since 2015	1.44E+07	2.23E+01	3.06E+02
2013	2.14E+02	1.84E-03	1.67E-01
2014	3.56E+02	2.86E-04	5.28E-02
2015	1.51E+02	5.28E-04	3.00E-01
Pickering Units 1–4			
DRL	3.7E+05	1.7+00	3.2E+01
2013	1.17E+02	6.71E-03	Note 3
2014	1.02E+02	8.98E-03	Note 3
2015	9.82E+01	4.87E-03	Note 3
Pickering Units 5–8			
DRL	7.0E+05	3.2E+00	6.0E+01
2013	1.89E+02	2.61E-02	1.72E-03
2014	2.42E+02	2.33E-02	1.47E-03
2015	2.74E+02	1.69E-02	2.80E-03
Point Lepreau			
DRL	4.6E+07	3.9E+01	3.3E+02
2013	2.9E+02	1.40E-07	4.30E-03
2014	3.2E+02	6.80E-05	6.60E-03
2015	1.4E+02	1.15E-03	1.00E-02

Note 1: DRLs revised on licence renewal in 2014

Note 2: DRLs revised through licence amendment in 2015

Note 3: The carbon-14 releases in liquid effluent from Pickering Units 1–4 are reported in the carbon-14 releases in liquid effluent from Pickering Units 5–8

Annex 16.1 (b)

Onsite Emergency Plans at Canadian Nuclear Power Plants

Bruce Power Nuclear Emergency Plan

The Bruce Power Nuclear Emergency Plan is a corporate-level plan that serves as the common basis of site-specific nuclear emergency preparedness and response arrangements. It describes concepts, structures, roles and processes needed to implement and maintain Bruce Power's radiological emergency response capability. It also represents a basis for controlling changes and modifications to the Bruce Power emergency preparedness capability.

As discussed in the sixth Canadian report, Bruce Power has updated its emergency plan in response to lessons learned from the Fukushima accident. As well as its response to design-basis events, the plan now takes into account requirements for supporting a sustained response to a beyond-design-basis multi-unit event resulting in an extended loss of offsite power for up to 72 hours without assistance. Bruce Power's emergency response capability is consistent with the onsite planning basis and process of determining shift minimum complement. This process involved a review and justification of the staffing requirements required for dealing with the spectrum of events that could require both operational and emergency response.

The province of Ontario Nuclear Emergency Response Plan (PNERP; see annex 16.1(d)) provides the offsite basis for nuclear emergency planning, preparedness and response, with the primary aim of ensuring public safety in the event of a nuclear emergency. In the context of the Bruce Power Nuclear Emergency Response Plan, a nuclear emergency is any emergency that poses a radiation hazard to people or property offsite.

The Bruce Power plan defines a station emergency as a sudden, unexpected occurrence of unusual radiological conditions with the potential for accidental exposure to staff or the public exceeding regulatory limits. A station emergency can also be declared for a non-radiological event requiring protection of onsite personnel and activation of Bruce Power's emergency response organization.

The emergency plan is consistent with the corresponding Bruce Power safety analysis and reports that were provided to the CNSC.

Security (or hostile action) response is addressed through separate provisions. However, the provisions regarding potential releases of radioactive materials also apply to security incidents (e.g., the need for offsite notification, situation updates or confirmation of any radioactive releases). Emergency response related to transportation of nuclear substances is addressed by a separate plan.

To implement its emergency plan, Bruce Power has developed specific nuclear emergency preparedness and response arrangements. In the event of an onsite nuclear emergency at the Bruce Power site, staff would immediately classify the nuclear emergency in accordance with criteria specified in the station emergency procedure. Should this emergency have offsite implications, staff would further categorize it according to criteria contained in the PNERP. To simplify this step, many events have been categorized according to the province of Ontario's notification designations.

Emergency drills and exercises are an integral part of Bruce Power's overall program assessment process. These exercises are conducted periodically at Bruce Power A and B, in cooperation with other organizations and jurisdictions that have a role in nuclear emergency preparedness and response.

Bruce Power maintains emergency public response capabilities within various communications departments, including employee communications, investor and media relations, government relations and community relations. The primary targets of Bruce Power's nuclear emergency public information program are people who live or work near Bruce A and B as well as certain Bruce Power employees and contacts who would need to be informed of an emergency. In the event of a nuclear emergency involving Bruce A and B, Bruce Power's emergency response procedures and agreements require the corporation to coordinate its public information efforts and activities with those of other participating jurisdictions or organizations, such as provincial agencies operating within the framework of the PNERP.

Bruce Power's communications response in a given emergency will depend upon the related circumstances. For events that are not severe enough to warrant activation of the PNERP but may be of interest to neighbours and other stakeholders, Bruce Power would issue news releases or verbal briefings to the local media, with copies provided to provincial and municipal officials. If the situation warrants, Bruce Power may activate its local media centre for briefing or interview purposes.

More severe events may require activation of the PNERP and the province of Ontario's Joint Emergency Information Centre, which is located in the Toronto offices of Emergency Management Ontario. Pending activation and operation of the centre, Bruce Power's emergency response organization would, on an interim basis, communicate relevant information to the public and the media. With the Emergency Information Centre in operation, the provincial government would assume control of information regarding the offsite response. The Municipality of Kincardine would establish a local emergency information centre at its offices. Bruce Power would assist the municipality with preparing information for the local public by ensuring its accuracy. Emergency-related information prepared at local and provincial emergency information centres would be jointly scrutinized for accuracy by all three parties prior to its release.

Ontario Power Generation Consolidated Nuclear Emergency Plan

The OPG Consolidated Nuclear Emergency Plan is a corporate-level plan that serves as the common basis of site-specific nuclear emergency preparedness and response arrangements at OPG's Darlington and Pickering Nuclear Generating Stations. It describes concepts, structures, roles and processes to implement and maintain an effective OPG response to radiological emergencies that could endanger onsite staff, the public or the environment. It provides a framework for interaction with external authorities and defines OPG commitments under the PNERP.

Similar to Bruce Power, the OPG Consolidated Nuclear Emergency Plan defines a station emergency as a sudden unexpected occurrence of unusual radiological conditions with the potential for accidental exposure to staff or the public exceeding regulatory limits. The OPG plan focuses on the release of radioactive materials from fixed facilities and on OPG interfaces with the PNERP (see annex 16.1(d)). The formal scope of the plan excludes hostile (security) action incidents at OPG nuclear plants, as these incidents are dealt with in detail in other OPG

documents. However, the plan's provisions regarding potential releases of radioactive materials also apply to security incidents. These include the requirements for offsite notifications, situation updates and confirmation of any radioactive releases.

The emergency plan is consistent with the corresponding OPG nuclear safety analyses and reports provided to the CNSC.

To implement its nuclear emergency plan, OPG has developed site-specific nuclear emergency preparedness and response arrangements for its NPPs. In the event of an onsite nuclear emergency at an OPG NPP, OPG staff would immediately classify the nuclear emergency in accordance with criteria specified in emergency procedures. Should this emergency have offsite implications, OPG staff would further categorize it according to criteria contained in the PNERP. PNERP categorization criteria are referenced in procedures to ensure alignment. Offsite notifications would be made following categorization, within required time limits.

Emergency drills and exercises are an integral part of OPG's overall process of program assessment. Exercises are conducted regularly at all OPG NPPs, in cooperation with other organizations and jurisdictions that have a role in nuclear emergency preparedness and response. Five drills or exercises are conducted at each OPG NPP annually to test the effectiveness of the emergency plans and procedures, facilities, equipment and training effectiveness. Included in these drills are multi-unit severe accidents to validate OPG's severe accident management guidelines and the deployment of emergency mitigating equipment.

OPG maintains emergency public response capabilities within its nuclear public affairs department. The primary audiences for OPG's nuclear emergency public information program are those who live or work near OPG NPPs. In the event of a nuclear emergency involving an OPG NPP, OPG emergency response procedures and agreements require the corporation to coordinate its public information efforts and activities with those of other participating jurisdictions or organizations, such as provincial agencies operating within the framework of the PNERP.

The OPG public affairs response in a given emergency would depend upon the related circumstances. For events that are not severe enough to warrant activation of the PNERP but that may be of interest to neighbours and other stakeholders, OPG would issue news releases or verbal briefings to the local media, with copies provided to provincial and municipal officials. Should the situation warrant, OPG may activate its onsite or near-site local media centre for briefing or interview purposes.

More severe events may require activation of the PNERP and provincial and municipal emergency information centres. OPG may also communicate relevant information within its jurisdiction to the public and media.

Gentilly-2 Nuclear Emergency Plan

The Hydro-Québec *Plan des mesures d'urgence* describes its arrangements to cope with actual or potential nuclear emergencies at Gentilly-2. That publication and various supporting documents define the Gentilly-2 nuclear emergency preparedness and response plan in detail, including application criteria, roles and responsibilities, requirements for coordination, classification of emergency alerts, notification of offsite authorities, communications with the media and the public, emergency procedures, response logistics, technical and equipment support and emergency training and drills.

The plan stipulates that abnormal onsite events that increase the risk (radiological or conventional) to employees, the public or the environment shall be announced by the declaration of an appropriate level of alert, indicating the severity or potential severity of the incident. Gentilly-2 has four alert levels:

1. An **area alert** indicates a dangerous or potentially dangerous situation within a limited area of the NPP.
2. A **station alert** indicates a dangerous or potentially dangerous situation within an important area of the NPP.
3. A **local alert** indicates:
 - significant radioactive materials were released or potentially released to the environment
 - low risk to the population and environment
 - no protective measures are required for the population
 - the event has been declared by Gentilly-2 authorities
4. A **general alert** indicates:
 - significant radioactive materials were released or potentially released to the environment
 - significant risk to the population and the environment
 - protective measures are recommended for the population near Gentilly-2
 - the event has been declared by public authorities of the province of Quebec

Emergency drills are conducted at Gentilly-2 at least once per year. The NPP also participates in externally organized drills in cooperation with offsite authorities. Gentilly-2 managers, staff and workers receive both basic and specialized instruction in nuclear emergency preparedness and response, on an as-required basis.

Gentilly-2 provides emergency preparedness services according to a well-defined process that includes:

- treatment of information and requests related to the process
- determination of risks (conventional or radiological), activation criteria and alert-level criteria
- documentation of emergency response (framework and response procedures)
- determination of emergency response organization (mission and responsibilities)
- determination of emergency resources (staff, installations and equipment)
- development of interfaces with offsite authorities
- maintenance and development of communication and public relations framework
- training
- drills and exercises
- emergency preparedness implementation (risk assessment, alert declaration, emergency response organization activation, notification of offsite authorities, management intervention, accident assessment, staff protection, recommendation of protection measures to the population, end of alert and return to normal)
- evaluation of the emergency preparedness process

The emergency preparedness process comprises these major outputs:

- policy and framework documents
- emergency procedures
- collaboration and agreements with offsite authorities
- emergency response organization
- emergency installations and equipment
- tested emergency plans

Point Lepreau Nuclear Emergency Response Plan

The NB Power Nuclear Emergency Response Plan is an all-hazards, onsite emergency plan for Point Lepreau. This plan serves as the basis for event preparedness, prevention, mitigation, response and recovery at the station. The plan outlines hazards, command structure, roles and responsibilities, and processes required to implement and maintain NB Power's emergency response capability.

The Nuclear Emergency Response Plan is built on the basis of protecting the NPP, public, personnel and environment during any event which may occur. The events covered within this framework include radiological, fire, medical, hazmat, severe weather, natural events, security and severe accidents.

Although security events are captured within the plan, security response to hostile actions is dealt with through separate provisions. However, the provisions regarding potential release of radioactive materials also apply to security incidents.

To support the Nuclear Emergency Response Plan, Point Lepreau has a full suite of response procedures that are integrated into the station's management system. These procedures and response guidelines allow the emergency response organization to affectively respond to and manage any event which may occur.

The onsite emergency plan is consistent with the corresponding NB Power safety analysis and reports provided to the CNSC.

Emergency drills and exercises are an integral part of Point Lepreau's overall emergency management program. Exercises are conducted regularly with the station's emergency response organization, and are done in cooperation with other organizations and jurisdictions that have a role in nuclear emergency preparedness and response.

In response to the Fukushima accident, Point Lepreau has made significant enhancements that provide additional depth to its response capacity during severe accidents. These enhancements include emergency mitigating equipment that provides backup power and water to the station, training on-shift staff on the deployment and operation of the equipment and integrating the equipment into emergency procedures.

The New Brunswick Emergency Measures Organization (NBEMO), an agency of the provincial government, is responsible for actions to protect the public. As such, NBEMO manages the Point Lepreau offsite emergency plan, including the development and testing of its capabilities. NB Power has a direct partnership with NBEMO, and supports the offsite plan in all aspects. This includes the mass decontamination plan, which details requisite monitoring and decontamination in the event that a nuclear emergency requires evacuation of local area residents.

Annex 16.1 (d)

Provincial Offsite Emergency Plans

Province of Ontario

The province of Ontario possesses the most commercial power reactors (18 operating reactors) of any jurisdiction in Canada. In addition, a research reactor is located at Chalk River and six U.S. nuclear facilities lie within 80 km of Ontario. As a result of these hazards, a nuclear emergency plan – the Province of Ontario Nuclear Emergency Response Plan (PNERP) – has been in place since 1986. This plan has never been activated (in full or partially), although events have occurred that resulted in formal notifications to the province. These events were monitored until it was determined that they posed no risk to the public or environment.

The provincial *Emergency Management and Civil Protection Act* governs emergency preparedness and response in Ontario. This legislation requires the provincial government to formulate a plan for emergencies arising in connection with nuclear facilities. It also permits the province to designate municipalities that must plan for nuclear emergencies. The Office of the Fire Marshal and Emergency Management administers the PNERP on behalf of the province and coordinates nuclear emergency preparedness and response in Ontario.

The PNERP defines a nuclear emergency as an actual or potential hazard to public health, property or the environment from ionizing radiation whose source is a major nuclear facility within or immediately adjacent to Ontario. The hazard may be caused by an accident, malfunction or loss of control involving radioactive material. The plan defines a radiological emergency as an actual or potential hazard to public health, property or the environment from ionizing radiation resulting from sources other than a major nuclear facility.

The aim of the plan is to safeguard the health, safety, welfare and property of the province's inhabitants and to protect the environment. The PNERP, as the lead provincial document for offsite nuclear emergency preparedness and response, details the support and coordination of the activities of provincial ministries, nuclear facilities, the Government of Canada (including the CNSC) and designated municipalities in order to meet the plan's objectives.

The PNERP details the arrangements in place for nuclear emergency planning, preparedness and response in Ontario. The plan covers various components, including:

- aim and guiding principles
- hierarchy of emergency plans and procedures
- description of the hazard
- planning basis
- protective actions
- concept of operations
- emergency organization
- operational policies
- emergency information
- public education
- detailed responsibilities of the various participants
- provincial and municipal committee oversight

Full-scale exercises focusing on nuclear or radiological emergencies are conducted regularly with the participation of the licensees and different levels of government.

The Office of the Fire Marshal and Emergency Management is currently updating the PNERP, including a review of the planning basis for nuclear emergency response in Ontario. This review is being undertaken in light of the lessons learned from the Fukushima accident and involves numerous subject matter experts from multiple jurisdictions and organizations. A full public consultation on the new draft plan will be undertaken in late 2016.

Province of Quebec

Within the province of Quebec, under the *Civil Protection Act*, municipalities are responsible for emergency measures on their territory. In the event their capacity to respond is or is likely to be exceeded, the Ministère de la sécurité publique would coordinate responses and additional support from the Government of Quebec. It is to this end that the Organisation de la sécurité civile du Québec (OSCQ) was established. The OSCQ is responsible for emergency planning and response to all hazards, including offsite nuclear emergencies. The *Plan national de sécurité civile du Québec* provides the terms of reference for all emergencies. The nuclear component of the OSCQ plan is described in the *Plan des mesures d'urgence nucléaire externe à la centrale nucléaire Gentilly-2* (PMUNE-G2).

The PMUNE-G2 clearly defines the responsibilities of government departments and agencies in a nuclear emergency at Gentilly-2, with the objectives of minimizing consequences, protecting the public and providing support to municipal authorities. In effect since 1983, the PMUNE-G2 is updated regularly. In 2002, response procedures and support programs were revised and subsequently implemented. These are updated on a regular basis.

Under the PMUNE-G2, Hydro-Québec and the OSCQ have separate but complementary responsibilities for emergency planning and response to an accident at Gentilly-2. As part of this response, with respect to PMUNE-G2, the OSCQ would open the government operations centre to coordinate the actions of the various government departments and organizations in Quebec and to maintain a link with federal institutions. The regional response centre in Trois-Rivières would coordinate local responses and provide support to the affected municipalities.

The province of Quebec has special detection and analysis equipment capable of characterizing the environment and the food chain. The PMUNE-G2 master plan was abandoned as of May 26, 2016 due to the reduced offsite risk. The province has indicated that it will now use the *Plan national de sécurité civile du Québec* should there be the need to respond to a nuclear emergency at Gentilly-2 or anywhere in the province.

Another specific plan from the OSCQ is the offsite nuclear emergency plan for Chalk River Laboratories (referred to as PMUNE-CSF). It is expected to be adopted in late 2016.

Province of New Brunswick

The provincial nuclear emergency program is governed by a partnership between NB Power and the New Brunswick Department of Public Safety. The primary agencies for emergency management and public security in New Brunswick are the:

- New Brunswick Emergency Measures Organization (NBEMO), which is the provincial lead agency for emergency management and business continuity, including radiological-nuclear contingencies
- New Brunswick Security Directorate, which is the provincial lead agency for security and critical infrastructure protection

The Government of New Brunswick has consolidated public safety and security responsibilities (including the provincial nuclear emergency program) under the mandate of the New Brunswick Department of Public Safety, in conjunction with the following enhancements to emergency preparedness in New Brunswick:

- strengthening the prevention of and preparedness and response for all hazards, including the integration of crisis and consequence management apparatus under a single emergency management system
- investing significantly in provincial government Internet infrastructure to make it more reliable and fault-tolerant and to improve its capacity
- updating and strengthening operational capability at the NBEMO Provincial Emergency Operations Centre, which includes enhancing the business process and investments in infrastructure to improve connectivity and collaboration among federal and provincial intervening organizations, with more focus on operational readiness
- developing a training and exercise strategy for major scenarios, including nuclear response, so that NBEMO is exercised annually rather than every three years (as in the past)
- replacing the inventory of potassium iodide pills, updating demographic information for the emergency planning zone and improving communications systems linking the Offsite Emergency Operations Centre (owned and maintained by NB Power) and the Provincial Emergency Operations Centre

New Brunswick Emergency Measures Plan

Under New Brunswick's *Emergency Measures Act*, NBEMO has the lead responsibility to develop provincial emergency action plans and to direct, control and coordinate emergency responses.

The New Brunswick Emergency Measures Plan, prepared by NBEMO, defines an emergency as any abnormal situation requiring prompt action beyond normal procedures to limit damage to persons, property or the environment. The aim of the plan is to designate responsibility for actions to mitigate the effects of any emergency, other than war, in the province.

The plan defines the lead responsibilities of the New Brunswick Department of Public Safety and the supporting roles of some 23 departments, agencies or organizations. Representatives of these stakeholders make up the Provincial Emergency Action Committee, which directs controls and coordinates provincial emergency operations and assists and supports municipalities as required. NBEMO has recently updated the committee's handbook, which includes all the tasks the different departments are responsible for when there is an event.

The Provincial Emergency Action Committee maintains two states of readiness. The standby state requires representatives of departments to be available (on call). An emergency state requires action from NBEMO or other departments. During an emergency state, departmental representatives are called to the Provincial Emergency Operations Centre and briefed on the corresponding emergency.

The province is divided into six regions that are overseen by the emergency measures organization. In each region, emergency management coordinators support the development and refinement of emergency planning by municipalities and provide advice and assistance on the development of emergency plans. They coordinate the use of provincial resources to deal with emergency situations in rural areas and urban municipalities. To accomplish this, regional emergency committees are formed to provide assistance to municipalities and the population of unincorporated areas. These committees consist of representatives from the provincial Departments of Environment, Health, Justice, Natural Resources, Social Development and Transportation, as well as local governments.

Local authorities are responsible for emergency planning and response within their physical boundaries and, in some cases, for certain areas outside their boundaries. Communities may assist each other in accordance with mutual aid agreements. However, when an emergency arises in which the resources of a community (or group of communities) are insufficient, the province will provide assistance through the regional emergency committee. Regional emergency operations centers are located in government facilities.

Point Lepreau Offsite Emergency Plan

NBEMO developed the Point Lepreau Offsite Emergency Plan in accordance with the framework described above. This plan delineates the immediate actions to be taken by those involved if an incident at Point Lepreau results in an offsite emergency, outlining their roles and responsibilities. The plan goes through an annual review to ensure the information contained within it is accurate.

Should it be necessary to alert the public to an offsite emergency, wardens would oversee designated areas to ensure residents were appropriately informed of any actions required. An automated telephone and email notification system has been established to send messages to all residents. Radio, television and wardens would also be used to advise the public of the need for any protective actions. Arrangements are in place to help individuals who might require physical assistance should evacuation prove necessary.

The Government of New Brunswick utilizes the Incident Management System, an organizational structure based principally on the United States' National Incident Management System and a suite of information management and decision support tools. The emergency organization and tools are designed around the requirement for interoperability with provincial and local emergency management partners, as well as with federal agencies such as Public Safety Canada, Health Canada, the Public Health Agency of Canada and the Department of National Defence.

NBEMO maintains a multi-year emergency exercise program that allows regular exercises and training to take place, fully supported by NB Power through their partnerships. This includes exercises at the Offsite Emergency Operations Centre (which would be operated and supported during an event by representatives from both organizations).

Annex 16.1 (e)

Details of Federal Emergency Provisions

Detailed provisions of the *Federal Nuclear Emergency Plan*

Health Canada administers the *Federal Nuclear Emergency Plan* (FNEP). The latest version of the plan was endorsed by the Deputy Ministers' Emergency Management Committee in October 2012. Within the FNEP, a nuclear emergency is defined as an event that has led or could lead to the uncontrolled release of radioactive material or exposures to uncontrolled sources of radiation, which pose or could pose a threat to public health and safety, property and the environment.

The FNEP contains:

- an outline of the Government of Canada's aim, authority, emergency organization and concept of operations for dealing with the response phase of a nuclear emergency
- a description of the framework of federal emergency preparedness policies, the planning principles on which the FNEP is based and the links with other specific documents of relevance to the FNEP
- a description of the specific roles and responsibilities of participating organizations that are involved in the planning, preparedness or response phases of a nuclear emergency
- provincial annexes that describe interfaces amongst federal and provincial emergency management organizations, as well as the arrangements for a coordinated response and the provision of federal support to provinces affected by a nuclear emergency

Five nuclear emergency event categories are defined in the FNEP, according to the potential scope of impacts on Canada and Canadians:

- **Category A:** an emergency at an NPP in Canada
- **Category B:** an emergency at an NPP in the United States or Mexico
- **Category C:** an emergency involving a nuclear-powered vessel in Canada
- **Category D:** other serious radiological emergencies or potential threats in Canada that require a multi-departmental or multi-jurisdictional response
- **Category E:** a nuclear emergency outside of North America

The scope of the FNEP excludes the following situations:

- emergencies that pose only a limited radiological threat over a localized area and are not anticipated to exceed the capabilities of regulatory, local or provincial/territorial authorities to respond, including but not limited to:
 - events at licensed nuclear facilities with no radiological offsite impacts or involving only non-radiological hazards to the personnel at the facilities, the public or the environment
 - transportation accidents involving regulated quantities of radioactive material on Canadian lands or in Canadian territorial waters
- management and coordination of the Government of Canada's actions during the recovery phase

The FNEP includes response levels that escalate as a result of specific triggers. As an event evolves, the coordinated response to the emergency will be scaled according to the scope of the emergency and associated triggers. During routine operations, FNEP notification and alerting capabilities are provided by a 24/7 FNEP duty officer, who monitors situations of interest, conducts internal reporting, and responds to drills, exercises and requests for information. These

activities are managed by Health Canada's Radiation Protection Bureau with input from specific partners when required, and include normal preparedness activities.

The occurrence of a radiological or nuclear emergency would lead to a sequence of response actions and technical support functions focused on managing the event, mitigating its effects and protecting the public and environment from actual or potential radiological impacts. The extent of coordinating arrangements described in the FNEP and occurring between individual departments and agencies would depend on the nature, magnitude and location of the event, the responsibilities within federal jurisdiction and the level of assistance requested. The Government of Canada would conduct emergency operations within the federal mandate and would provide, in accordance with prior arrangements or at the request of a provincial government, national support services and resources through the National Emergency Response System and provisions of the FNEP or a provincial annex in the FNEP.

Under the FNEP, a multi-departmental Technical Assessment Group would be convened to provide federal-level technical assessment of the threat and risk associated with the radiological hazard, as well as associated protective action recommendations, as required, for mitigating the radiological consequences to health, safety, property and the environment. The FNEP Technical Assessment Group would establish task teams or experts within its operations to undertake specific technical assessment functions, such as risk assessment and prognosis, environmental-pathways modelling, radiological assessment, field-based monitoring and surveillance, and human monitoring.

As the Fukushima and Chernobyl accidents demonstrated, a severe nuclear emergency at an NPP that is distant from Canada would have a limited effect within Canada. Although small quantities of radioactive material might reach Canada, they would be unlikely to pose a direct threat (e.g., from exposure to fallout) to Canadian residents, property or the environment. Consequently, Canada's response under the FNEP to a nuclear emergency occurring outside North America would likely focus on:

- controlling food imported from areas near the accident
- assessing the impact on Canadians living or travelling near the accident site
- assessing the impact on Canada and informing the public
- coordinating responses or assistance to foreign jurisdictions and organizations (national or international)

The potential severity of other serious radiological emergencies or potential threats, as defined in the FNEP, would depend on case-specific factors. For fixed facilities and materials in transit, appropriate responses to possible emergencies can be planned in some detail. In other situations, emergency planning can be complicated by such factors as the potential magnitude and diversity of the radiation threat, the location of the source of the radiation, any impacts on essential infrastructures and the speed at which related circumstances may evolve.

Emergency management recovery phase

Once a nuclear emergency situation is stabilized and immediate actions to protect public health and safety were completed, emergency management of the radiological hazard would shift from the response phase to the recovery phase. FNEP senior officials (from Health Canada and the CNSC), in consultation with the Chair of the FNEP Technical Assessment Group, the Federal Assistant Deputy Minister of the Emergency Management and Regional Operations Branch (Public Safety Canada) and the Federal Coordinating Officer would recommend the return of the

FNEP to a routine reporting level as well as the termination of some or all components of the FNEP not required for the transition to recovery. The Federal Assistant Deputy Minister Emergency Management Committee, in consultation with the Privy Council Office, would approve the transition to recovery and termination of the emergency.

Responsibility for recovery falls primarily within provincial/territorial jurisdiction. If federally assisted recovery actions were required, the responsibility for coordinating recovery operations would be assigned to a specific Minister of the Government of Canada by the Privy Council Office and the Prime Minister.

The FNEP identifies the following federal activities (or support for the provinces) that are recognized as being part of the recovery phase:

- development of a long-term recovery management plan, including reference levels on residual dose from long-term contamination and a strategy for restoration of normal socio-economic activities, including international aspects
- monitoring of contaminated areas, assessment of potential doses to public and workers and assessment of medium- and long-term health hazards
- environmental decontamination and radioactive waste disposal operations
- maintenance of dose registries for emergency workers
- non-radiological recovery operations
- proactive and transparent public information and international communication related to all of the above activities

Provisions of the CNSC in emergency preparedness and response

As the federal nuclear regulatory body, the CNSC participates in nuclear emergency prevention, preparedness, response and recovery activities as part of its responsibilities under Canadian legislation. The CNSC emergency management program is aligned with the *Emergency Management Act*.

Because the CNSC's regulatory obligations extend to a wide range of circumstances, facilities, activities and materials, it must plan for its possible involvement in a similarly diverse range of emergency scenarios. The CNSC maintains an Emergency Operations Centre at its headquarters in Ottawa to enhance its ability to respond to nuclear emergencies. This facility is used during ongoing FNEP and CNSC drills and training exercises, to confirm nuclear emergency preparedness. The CNSC Emergency Operations Centre operates using public electricity but it can also rely on an emergency generator in the event of loss of the electricity grid. The CNSC has an alternate site for emergency staff to assemble should its main headquarters be inaccessible.

To fulfill CNSC regulatory policy P-325, *Nuclear Emergency Management Policy*, and the CNSC Emergency Response Plan, emergency management relies on staff to assess the significance of an emergency and to communicate these findings to senior management, staff, the public, media, the licensee and all levels of government.

The CNSC Emergency Response Plan is the document that describes the strategies and guidelines the CNSC would follow to cope with a nuclear emergency. In particular, it describes:

- emergency situations that could require CNSC involvement
- the role of the CNSC in nuclear emergencies

- the role of interfacing parties
- the CNSC's emergency preparedness organization
- the concept of "operations"
- the CNSC's equipment infrastructure
- preparedness and training requirements and exercises

The plan is issued under the authority of the President of the CNSC, in accordance with the objectives of the NSCA and its regulations and the *Emergency Management Act*. The plan is designed to provide a compatible interface with the emergency plans and procedures of CNSC licensees, provincial governments, the Government of Canada and international organizations. It draws upon provisions of the *Packaging and Transport of Nuclear Substances Regulations* and the *Transportation of Dangerous Goods Act, 1992* and associated regulations and includes formal agreements with various organizations and jurisdictions.

Ultimately, the implementation of the CNSC Emergency Response Plan in the event of a declared emergency could involve the following parties:

- the CNSC's emergency organization
- CNSC employees
- CNSC licensees
- transporters, shippers and others involved in or affected by the transport of nuclear substances
- departments and agencies of the Government of Canada
- provincial government departments and agencies
- news media organizations
- the USNRC
- the IAEA

The CNSC Emergency Response Plan is in effect at all times in one of four operating modes:

- In **normal mode**, the CNSC plans, trains and conducts exercises to maintain its emergency preparedness. In this mode, the CNSC also responds to events that do not warrant activation of the emergency organization.
- In **standby mode**, the CNSC alerts responders and monitors the status of events that may require an emergency response at some stage.
- Operations enter the **activated mode** when the CNSC decides that an emergency response is necessary and activates preparations for such a response.
- The **recovery mode** follows the activated mode and consists of activities to restore a non-emergency state, such as the standby or normal modes.

Within the context of the CNSC Emergency Response Plan, a nuclear emergency is any abnormal situation associated with a radiological activity or a CNSC-licensed activity or facility that could require prompt action beyond normal procedures to limit damage to persons, property or the environment.

These nuclear emergencies could be offsite or onsite emergencies. For example, a nuclear emergency could be created by events related to the:

- release (or potential release) of radioactive contaminants or any nuclear substance prescribed in the NSCA from a Canadian or foreign NPP or other CNSC-licensed facility
- loss, theft, discovery or transport of nuclear substances within or outside of Canada

The nature of the CNSC's involvement could range from exchanging ideas and information to coordinating plans, attending training programs, participating in exercises and responding to actual emergencies. The CNSC Emergency Response Plan provides corporate guidelines for employee involvement. Specifically, it defines the CNSC staff members who would participate in the emergency organization (depending upon the nature of the emergency). Responsibilities of CNSC staff members in the event of a nuclear emergency parallel their responsibilities during routine CNSC operations.

As part of the CNSC's Emergency Response Plan, the CNSC has established various technical and administrative arrangements. These include bilateral cooperation agreements with other national and international jurisdictions, as well as a CNSC duty officer program whereby anyone can seek emergency information, advice or assistance 24 hours a day for actual or potential incidents involving nuclear materials or radiation.

Annex 16.1 (f)

Description of Major Emergency Exercises, Training and Other Initiatives

Exercise Unified Response

Exercise Unified Response was a full-scale, national nuclear exercise with participation from all levels of government, including the facility operator, Ontario Power Generation (OPG). It was held May 26–28, 2014. This exercise involved more than 54 participating organizations and more than 2,000 participants, as well as international observers. The last major nuclear exercise of this scope and complexity was CANATEX-3, which was conducted in 1999. Since this last major exercise, and also in response to the 2011 Fukushima accident, the nuclear response plans for the licensees have been revised or updated. Exercise Unified Response provided an excellent mechanism to test at all levels revised plans and processes established since the Fukushima nuclear emergency.

Exercise Unified Response's overall objective was to test the preparedness of OPG, government and non-government agencies, and communities for responding to a nuclear event at Darlington by evaluating current response plans, procedures and capabilities. A specific federal objective was to validate the revised *Federal Nuclear Emergency Plan* (FNEP).

Overall, the CNSC, as regulator, determined that it was able to meet the exercise objectives and demonstrate that its regulatory oversight was delivered in accordance with its mandate, including providing objective information to the public and media. In addition, the CNSC demonstrated its technical capability to assess a severe accident and its potential consequences.

The offsite response organizations – including municipal, provincial and federal agencies – demonstrated their ability to work in an integrated manner to effectively respond to a low-probability nuclear emergency.

OPG's emergency preparedness and response programs, which had been approved by the Commission, were found to be robust and compliant with regulatory requirements. The licensee effectively responded to the emergency scenario – for example, in addressing safety shutdown systems and continued cooling, or providing necessary information and support to offsite authorities.

Although issues were identified, the participating organizations demonstrated that they can respond effectively to a severe accident in order to protect the public, infrastructure and the environment. Exercise Unified Response successfully validated the FNEP, demonstrating that its governance structure and concept of operations are sound. The exercise also served as a means to validate the FNEP's Ontario annex. The findings from the federal interdepartmental portion of the exercise were summarized into 45 recommendations that were tracked in a management action plan, along with corrective actions, most of which were implemented by the end of March 2016.

In the spirit of continuous improvement, all participating organizations performed a self-evaluation. The lessons learned from Exercise Unified Response are being used to further strengthen and improve onsite and offsite emergency response plans.

Exercise Intrepid

NB Power and the provincial authority, the New Brunswick Emergency Measures Organization, conducted a full-scale emergency exercise called Exercise Intrepid on November 17–18, 2015. This exercise was the largest full-scale emergency exercise ever conducted for NB Power and the province, and fully exercised the onsite and offsite emergency plans.

The exercise involved more than 1,000 people across 35 agencies participating through local, municipal, provincial and federal levels of the government, including CNSC staff from headquarters as well as the site office at Point Lepreau.

Exercise Intrepid simulated an event at the station that progressed into a severe accident with offsite implications, and was the first full-scale exercise for Point Lepreau utilizing emergency mitigating equipment and other Fukushima-related modifications. There was also a proactive evacuation of the community conducted with volunteers requiring the deployment of offsite resources. The response required full activation of both onsite and offsite emergency response organizations, including the Provincial Emergency Operations Centre, the Royal Canadian Mounted Police, Horizon Health, Ambulance NB, the Red Cross, the CNSC Emergency Operations Centre, the Health Canada Emergency Operations Centre and the Federal Nuclear Emergency Plan Technical Assessment Group.

In the scenario, Point Lepreau was faced with a series of challenges that included loss of Class IV onsite power, which occurred as a result of a severe weather system. This necessitated deploying emergency mitigating equipment to provide backup power. Simulated failure of plant components required a planned venting of the reactor building, later challenged by an unplanned release. During the scenario, there was also a contaminated casualty sent to the Saint John Regional Hospital via ambulance, which allowed for testing of this emergency plan component.

The lessons learned will be used to further strengthen and improve both the onsite and offsite emergency response plans.

Human monitoring table-top exercise

To further investigate specific issues that were not fully tested in Exercise Unified Response, Health Canada worked with its stakeholders to organize a table-top exercise on human monitoring. The objectives of this exercise, held in November 2015, were to evaluate concepts of operation for triaging exposed and unexposed individuals, test policies and concepts of operations for the human monitoring aspects of nuclear events, and test the interoperability between first responders/receivers and federal, provincial and municipal emergency response organizations. The exercise used a variety of exposure scenarios. Participants demonstrated their broad ranges of expertise and knowledge and responded positively and collaboratively to practising a collective response during the exercise.

IAEA participation in Canadian exercises

Exercise Unified Response included an international component, specifically notification to the IAEA by the national competent authorities (i.e., the CNSC and Health Canada) and notification through the International Nuclear Event Scale (INES) by the CNSC. Several action items were identified and resolved as a result of this exercise. During Exercise Intrepid, the new IAEA

assessment and prognosis function, as well as joint procedures between Health Canada, the CNSC and the IAEA Incident and Emergency Centre, were tested. Canada is among the earliest countries to test this function. Several recommendations have been identified to improve these procedures.

IAEA Convention Exercise series

Between 2013 and 2015, Health Canada took part in 14 exercises of the IAEA Convention Exercise (ConvEx) series. The most comprehensive was the December 2015 exercise: a scenario that involved a simulated illicit radiological source placed inside the international departure lounge of the Mexico City international airport. The source affected both Canadians and international travellers departing for Canada. This was an event that involved a simulated international transboundary incident, testing the capabilities and roles for both international and domestic response using the IAEA's Unified System for Information Exchange in Incidents and Emergencies (USIE) site.

METER training and RN-Med-Prep

The Medical Emergency Treatment for Exposures to Radiation (METER) course is delivered to train medical professionals who respond to the medical aspects of a radiological or nuclear emergency. This course is periodically offered by Health Canada at various locations across Canada. During the reporting period, five METER sessions were delivered to over 200 trainees.

The Radiological/Nuclear Medical Emergency Preparedness and Response (RN-Med-Prep) project was a two-and-a-half year initiative to expand the METER training package and further enhance the Canadian medical community's state of readiness in facing a radiological or nuclear emergency. This project divided the course offerings into multi-level training options, including an eLearning module covering radiation basics, radiation biology and protection strategies. RN-Med-Prep gained accreditation from the College of Family Physicians of Canada in New Brunswick in 2014.

Radiological assurance monitoring training

On request from the provinces and territories, Health Canada and FNEP partners will provide support for field operations during a nuclear emergency. The role of the FNEP field team is to perform field radiation monitoring and surveillance and to provide assurance monitoring in the zones where the population is being maintained. Regular offsite training is organized for the Health Canada field team and FNEP partners. The objectives of this training are to maintain readiness and expand operational capacity, comply with health and safety practices, and "train the trainer." During the reporting period, four training sessions were organized and many federal, provincial/territorial and municipal organizations participated.

Canada benchmarking project

Health Canada, as lead for the FNEP, led a project to benchmark all of the tools intended to be used by the various federal and provincial emergency response organizations to estimate offsite radiological doses during a nuclear emergency. This benchmarking project was initiated to address areas for improvement identified during Exercise Unified Response in May 2014: the need to develop improved interorganizational exchanges of information related to dose projections during a nuclear emergency, and the need to improve communications to decision

makers on uncertainties and limitations inherent in the tools currently used in Canada (and the rationales behind the use of alternate scenarios).

The objectives of this benchmarking project were to:

- provide an overview of tools currently used by the various nuclear emergency response organizations in Canada (including the Accident Reporting and Guidance Operational System, which is the primary tool used by Health Canada to generate dose projections in a nuclear emergency) and to improve understanding of their interoperability
- benchmark tools against each other by running a standardized scenario and analyzing the results such that the uncertainties and limitations of various tools are better understood
- provide recommendations for managing multiple results produced by these tools in the event of a nuclear emergency in Canada

The project was completed and a final report was published in March 2016.

International benchmarking project

Health Canada and the CNSC participated in an international benchmarking project sponsored by the Organisation for Economic Co-operation and Development (OECD) Nuclear Energy Agency (NEA) that focused on software tools for modelling the nature and quantity of radioactive materials that could be released during accidents at NPPs. The project's objective was to benchmark software tools used to estimate consequences of accidents at nuclear facilities and to help identify strengths and weaknesses of the tools used for source-term and dispersion modelling. Health Canada's Accident Reporting and Guidance Operational System was one of the software programs analyzed. Health Canada contributed by modelling a scenario involving an accident at Point Lepreau. The NEA published the final project report in December 2015.

Exercise Huron Challenge – Trillium Resolve

Exercise Huron Challenge – Trillium Resolve, a major nuclear exercise at Bruce A and B, will take place in October 2016. Bruce Power and the Province of Ontario are involved to the fullest extent with designing and participating in this exercise. At the federal level, elements of the FNEP will be tested.

Annex 18

Supporting Details Related to CNSC Design Requirements and Design Assessments

Design requirements in CNSC regulatory document REGDOC-2.5.2

CNSC regulatory document REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants*, sets out technology-neutral expectations (to the extent possible) for the design of new, water-cooled NPPs. REGDOC-2.5.2 includes direction on:

- establishing safety goals and objectives for the design
- utilizing safety principles in the design
- applying safety management principles
- designing structures, systems and components (SSCs)
- interfacing engineering aspects, NPP features and facility layout
- integrating safety assessments into the design process

REGDOC-2.5.2 describes five levels of defence in depth:

- preventing deviation from normal operation as well as failures of SSCs
- detecting and intercepting deviations from normal operation to prevent anticipated operational occurrences from escalating to accident conditions and to return the NPP to a state of normal operation
- minimizing accident consequences by providing inherent safety features, fail-safe design, additional equipment, and mitigating procedures
- ensuring radioactive releases from severe accidents are kept as low as practicable
- mitigating the radiological consequences of potential releases of radioactive materials during accident conditions

In general terms, the dose acceptance criteria in REGDOC-2.5.2 follow from the postulate that the risks due to a new technology should not be significant contributors to existing societal risks. The dose acceptance criteria must also be sufficient to ensure that very few accidents will require protective measures. The safety goal for large-release frequency is expressed in terms of the release of cesium-137 that could require long-term relocation of the local population to mitigate potential health effects. The safety goal for small-release frequency is expressed in terms of the release of iodine-131, which would require temporary evacuation to mitigate health effects. To achieve a balance between prevention and mitigation, a third goal is defined to limit the frequency of severe core damage. This ensures the designer does not place too much reliance on reactor containment. The actual safety goals are shown in subsection 14(i)(d).

REGDOC-2.5.2 stipulates that SSCs important to safety are of proven design and are designed according to appropriate modern standards. Where a new SSC design, feature or engineering practice is introduced, adequate safety is proven using a combination of supporting R&D programs and an examination of relevant experience from similar applications. A qualification program is established to verify that the new design meets all applicable safety expectations. New designs are tested before entering service and are then monitored in service to verify that their expected behaviour is achieved. REGDOC-2.5.2 stipulates that the NPP design draws on operating experience in the nuclear industry as well as on relevant research programs.

REGDOC-2.5.2 also contains requirements related to reliability, operability and human factors (as they relate to design).

The requirement in REGDOC-2.5.2 to design for reliability includes considering common-cause failures and allowances for equipment outages. There are design requirements related to single-failure criteria for safety groups and fail-safe designs for SSCs important to safety. There are also special considerations for shared instrumentation among safety systems and the sharing of SSCs between reactors.

REGDOC-2.5.2 sets a requirement for various safety actions to be automated so that operator action is not necessary within a justified period of time from the onset of anticipated operational occurrences or design-basis accidents. Appropriate and clear distinction between the functions assigned to operating personnel and to automatic systems is facilitated by the systematic consideration of human factors and the human-machine interface. The need for operator intervention on a short time scale is kept to a minimum.

REGDOC-2.5.2 requires a human factors engineering (HFE) program that facilitates the interface between operating personnel and the NPP by utilizing proven, systematic analysis techniques to address human factors. The program must promote attention to plant layout and procedures, maintenance, inspection and training, as well as the application of ergonomic principles to the design of working areas and environments. The NPP's design must facilitate diagnosis, operator intervention and management of the NPP's condition during and after anticipated operational occurrences, design-basis accidents and beyond-design-basis accidents. This facilitation is achieved by adequate monitoring instrumentation and plant layout, and suitable controls for the manual operation of equipment.

The HFE program should:

- reduce the likelihood of human error as much as is reasonably achievable
- provide means for identifying the occurrence of human error and methods by which to recover from such error
- mitigate the consequences of error

Human factors verification and validation plans are established for all appropriate stages of the design process to confirm that the design adequately accommodates all necessary operator actions.

REGDOC-2.5.2 also stipulates that the human-machine interfaces in the main control room, the secondary control room, the emergency support centre and the plant provide operators with necessary and appropriate information in a usable format that is compatible with the necessary decision and action times. Design requirements are established for both the main control room and emergency support centre to provide a suitable environment for workers under all possible conditions, taking ergonomic factors into account.

Vendor pre-project design review

The CNSC process for vendor pre-project design review is divided into three distinct phases.

Phase 1: The CNSC confirms that submissions for the specific design demonstrate that the vendor understands Canadian regulatory requirements and expectations. The scope of submissions is fixed by the CNSC.

Phase 2: The CNSC confirms that submissions for the specific design demonstrate that the proposed design complies with REGDOC-2.5.2 and related documents. The scope of the review is fixed by the CNSC and usually involves assessment in 16 specific topical areas:

- defence in depth, SSC classification, dose acceptance criteria
- reactor core nuclear design
- means of shutdown
- fuel design
- emergency core coolant and emergency feedwater systems
- reactor control system
- containment
- pressure boundary of the primary heat transport system
- severe accident prevention and mitigation
- fire protection
- radiation protection
- quality assurance program
- human factors
- out-of-core criticality
- robustness, safeguards and security
- safety analysis

Phase 3: Based on feedback received from the CNSC in phase 2, the vendor may discuss, in more depth, resolution paths for any design issues identified in phase 2. The scope of submissions is fixed by the vendor.

The review does not include non-technical considerations such as:

- design costs
- completion of design
- scheduling factors relative to the review of a licence application
- capacity factors
- design changes that could be required as a result of future findings

The following activities had been completed related to vendor pre-project design reviews:

- The Phase 2 review of the Westinghouse AP1000 reactor was completed in June 2013.
- The Phase 3 review for Candu Energy Inc.'s Enhanced CANDU 6 (EC6) reactor was completed in June 2013.
- The Phase 1 review of the ATMEA reactor was completed in June 2013.

Annex 18 (i)

Details Related to Assessing and Improving Defence in Depth

This annex describes the NPP licensees' work to continuously improve safety of their facilities. In terms of design aspects relevant to lessons learned from the Fukushima accident, the designs of Canada's NPPs (all of which are CANDU reactors) include several features that prevent accidents and can help mitigate impacts should an accident occur. These were described in annex 18(i) of the sixth Canadian report.

At the time of the Fukushima accident, reassessment of protection against external hazards had already occurred for some of the NPPs subject to integrated safety reviews (ISRs) for refurbishment projects. During the previous reporting period, various activities were completed to assess specific external hazards: these were described in the sixth Canadian report. Enhancements to defence in depth were completed in various categories and continued in the recent reporting period.

This annex provides an update of the improvements made during the reporting period with respect to defence in depth.

Although the risk of an accident is very low, NPP operators have implemented modifications to improve their NPPs' ability to withstand severe external events and other challenges, such as a prolonged loss of power or the loss of all heat sinks. In addition to modifications already described in the sixth Canadian report, Point Lepreau installed a water-tight, manually operated flood door for the reactor building personnel airlock to withstand beyond-design-basis accident (BDBA) conditions (such as a reactor building flood resulting from prolonged emergency water injection). Also, OPG has installed flood barriers at Darlington and Pickering to provide additional protection for standby and emergency power generators.

Besides the consideration of specific hazards, the licensees have systematically verified the effectiveness of, and supplemented where appropriate, the existing NPP capabilities in BDBA and severe accident conditions. In particular, they have addressed:

- makeup capabilities for steam generators, primary heat transport system and connected systems, moderator, shield tank and irradiated fuel bays
- overpressure protection of main systems and components
- control capabilities for hydrogen and other combustible gases
- containment integrity to prevent unfiltered releases of radioactive products
- design requirements for the self-sufficiency of a site (e.g., availability and survivability of equipment and instrumentation following a sustained loss of power, capacity to remove heat from a reactor)
- control facilities for personnel involved in accident management
- emergency mitigating equipment (EME) and resources that could be stored onsite (separate from the protected area) or stored offsite and brought onsite if needed

The licensees have evaluated means to provide additional coolant makeup from alternate sources. Some modifications are completed or already in progress. Canadian NPP licensees have procured additional EME and developed procedures for its deployment.

The deployment of EME is being implemented by NPP licensees. As an example, OPG is deploying its EME in two phases. The scope of the implementation of EME Phase 1 was for accident mitigation with the objective to cool and contain the reactor core using passive water inventories in situ as well as portable pumps, generators, and portable uninterruptible power supplies. Phase 2 addresses containment pressure, water recovery and hydrogen mitigation strategies. In addition, Phase 2 will result in the re-powering of plant equipment required to mitigate containment pressure rise and that recover the water from the sump while introducing strategies to mitigate hydrogen buildup and ensure irradiated fuel bay cooling is maintained. Work is still under development for the implementation of EME Phase 2.

The licensees have also evaluated the structural response of the irradiated fuel bay to seismic events and elevated temperatures (up to boiling). They have implemented enhancements to improve coolant makeup capacity to the irradiated fuel bay.

In addition, OPG plans to install permanent fire water pumps at Darlington to augment the existing emergency service water system for supply to the firewater system. OPG will also install permanent piping from the emergency service water system to allow the new firewater pumps to supply emergency makeup water to the heat transport system.

To address the topic of overpressure protection of the main systems and components, the licensees demonstrated that the installed relief valves on the bleed condenser provide sufficient relief capacity and mitigate pressure boundary failure due to overpressure. Licensees are still assessing existing margins-to-failure and investigating potential design changes for shield tank and calandria vault pressure relief. For example, Darlington is installing additional overpressure protection in all four units to prevent potential shield tank failure in the extremely unlikely event of total and sustained loss of heat sink to any unit. This allows for optimal design and effective operation of the containment filtered venting system described below by protecting the shield tank from potential failure, thus precluding a challenge to the containment system.

All Canadian NPPs have installed passive autocatalytic recombiners (PARs) – in some cases, as part of refurbishment projects prior to the Fukushima accident – for protecting against hydrogen buildup in the containment and detonation that might cause structural damage and consequently the uncontrolled release of radioactivity to the environment. NPP licensees are continuing to perform confirmatory assessments demonstrating the efficacy of PARs for severe accidents, and have determined that PARs are not needed in the irradiated fuel bay areas.

During its refurbishment, Point Lepreau had installed an emergency containment filtered venting system. Licensees other than Point Lepreau are evaluating the means to prevent containment system failures and, to the extent practicable, unfiltered releases of radioactive products in BDBAs, including severe accidents. The options being considered include emergency filtered containment vents. For example, OPG is installing a containment filtered venting system at Darlington to prevent containment system failure from over-pressurization following the unlikely event of a multi-unit severe accident. The system will limit radioactive releases of fission products to the environment through the use of high-efficiency dry metal fiber filter modules using the Westinghouse technology.

NPP licensees have established special measures for obtaining information on which to base recovery actions for the period when batteries have become exhausted but portable diesel-powered generators have not yet been installed. The licensees have identified practicable upgrades to extend the duration of power supplies to instrumentation and control equipment.

Licenses evaluated the installation of generators to provide backup power for instrumentation, as well as additional battery-powered instrument readout devices.

For example, Bruce Power installed a third emergency power generator at Bruce B to allow refurbishment of the existing two emergency power generators while maintaining the emergency power system's reliability. A third emergency power generator is being installed at Darlington to improve the availability and reliability of the emergency power system. Once installed, prior to the start of the first unit refurbishment outage, there will be three emergency power generators that are fully capable of providing power to key equipment on all four Darlington units for fuel cooling and monitoring.

The licenses are demonstrating that the equipment and instrumentation necessary for severe accident management – and essential to the execution of the SAMGs – will perform their function for the duration for which they are needed. In addition, licenses have evaluated the habitability of control facilities under conditions arising from BDBAs and severe accidents. In fact, through COG, the Canadian nuclear power industry developed a generic methodology in 2014 with which to evaluate the habitability of control facilities during a severe accident, including non-radiological hazards.

The licenses have also assessed options for water and temperature monitoring from a safe location in the case of a loss of cooling inventory. They are procuring emergency equipment (e.g., power supplies, pumps) that could be stored onsite or offsite and used to provide backup services during a BDBA.

The following are additional examples of design changes made at Canadian NPPs during the reporting period that were not associated with refurbishment projects or the response to the Fukushima accident. They are examples of enhancements to defence in depth that are routinely made (e.g., during maintenance outages). They address requirements for design-basis accidents as well as conditions predicted for BDBAs and severe accidents:

- Bruce Power and OPG modified the 37-element fuel bundle design to improve safety margins for certain anticipated operational occurrences and design-basis accidents at Bruce A, Bruce B and Darlington. This minor design change was achieved by reducing the diameter of the centre fuel element and creating more coolant flow area in the vicinity where fuel dry-out first occurs during accidents. This re-optimization resulted in heat transfer performance improvement and delayed dryout, without adverse impact on online fuelling systems.
- Bruce Power upgraded the delayed neutron monitoring system at Bruce A. This system allows for the quick detection of fuel defects such that the defect fuel can be removed from the reactor during on-line fuelling.
- OPG modified the powerhouse steam venting system at Darlington to increase overall system availability and reliability through the installation of additional control units on each unit. The system automatically activates vent panels on sensing either high temperature or high pressure (indicative of a steam piping failure) to protect the powerhouse by venting steam.

During the reporting period, Bruce Power implemented the following safety improvements that were identified through the PSA. Specifically, the licensee:

- installed emergency mitigating equipment at both Bruce A and B, which includes makeup water to the boilers, heat transport system and moderator system

- made improvements at Bruce A to enable automatic isolation of the calandria shield tank
- enhanced the robustness of containment for multi-unit events
- improved the reliability of Group 2 equipment at Bruce B
- upgraded apparatuses for very early smoke detection at Bruce A and B

Annex 19 (i)

Conduct and Regulatory Oversight of Commissioning Programs

Before an NPP is commissioned, several CNSC staff members are located at the NPP site to observe and report on the commissioning and start-up processes and activities.

CNSC staff members do not attempt to follow all aspects of a licensee's commissioning program. Rather, reliance is placed on the licensee's internal review process, which is mandated by the commissioning quality assurance program. Detailed commissioning specifications define the acceptance criteria to be used in inspections and tests performed as part of the commissioning program. Typically, the licensee's procedures require the designers to approve commissioning specifications for a particular system or component, to verify that:

- the program is checking the right items
- the acceptance criteria being used are appropriate to prove that the equipment can perform the safety functions intended in the design

In some cases, partial tests are done if complete tests are not practical (as in the case of commissioning tests of emergency core cooling systems). For example, in the past, while commissioning tests were done that involved injection of emergency coolant into the reactor core, tests in which cold water is injected into a hot core were not attempted, because such tests could lead to high stresses in the primary coolant system components. The components are designed to withstand these stresses during a limited number of emergencies, but exposing them to such high stresses simply for testing purposes could not be justified.

The commissioning quality assurance program also requires the process of approving the specifications and results to be documented. Any failure to meet the acceptance criteria must be referred back to the design organization, which will decide which, if any, design changes are required. CNSC staff can perform inspections, at any time, to confirm that procedural requirements are being complied with and that appropriate decisions are made.

Direct involvement of CNSC staff in commissioning concentrates on a few major tests, such as those that check the overall NPP response to specific events (e.g., a loss of normal electrical power supplies). CNSC staff members also witness major commissioning tests of special safety systems, such as functional tests of the shutdown systems where the reactor is actually tripped and the rate of power reduction is measured (and compared to the rate assumed in safety analyses).

When reviewing commissioning, CNSC staff members concentrate on these major tests because they are considered particularly important to safety. These tests check the overall performance of an NPP's safety features and can reveal problems that tests of individual components would not detect. CNSC staff members also review test proposals, including detailed commissioning specifications, which are examined to confirm that the tests' acceptance criteria are consistent with the system's safety design requirements (as defined in the licence application). When tests are completed, CNSC staff members review the test results and commissioning reports.

The CNSC requires the licensee to submit commissioning completion assurances prior to first loading of fuel, prior to leaving reactor guaranteed shutdown state, and upon completion of approach to critical, low-power tests and high-power tests.

Commissioning completion assurances are written certifications with the following statements:

- Commissioning has been completed according to the process described in the licence application.
- Commissioning results were acceptable.

The completion assurance statements may contain lists of tasks not yet completed, such as the completion of commissioning reports that are not prerequisites for the approvals being sought. This helps to ensure that these tasks are not subsequently overlooked.

Typically, the licensee holds a series of commissioning completion assurance meetings to review the work done on particular systems. CNSC staff members at the site attend some of these meetings.

Annex 19 (iv)

Severe Accident Management Guidelines

In 2002, the Canadian NPP licensees, in coordination with COG, formed a working group on severe accident management (SAM). Its objective was to formulate severe accident management guidelines (SAMGs) for CANDU reactors based on international best practices. The emergency operating procedures at that time addressed a number of accident situations well beyond design-basis accidents. However, they tended to focus on the use of equipment and systems within the scope of their intended purpose and within the constraints of normal operating rules. The objective was to extend the scope of SAM beyond these procedures in the event that significant core damage occurs or is imminent, ensuring all reasonable measures are taken, with any available equipment, to mitigate core damage and releases from containment. The goal was to provide better guidance for control room staff to manage and exit severe accidents.

In parallel with the first phase of the COG SAMG project, the CNSC published regulatory guide G-306, *Severe Accident Management Programs for Nuclear Reactors*, in 2006. This guide was superseded in 2015 with the publication of CNSC regulatory document REGOC-2.3.2, *Accident Management, Version 2*, which incorporates enhancements resulting from lessons learned from the Fukushima accident.

The first phase of the COG SAMG project concluded early in 2007. It adapted the Westinghouse Owners Group approach to SAM for use in CANDU reactors, producing a set of generic guidelines applicable to all operating CANDU models along with a more focused set of guidance documents for each CANDU models (CANDU-6, Pickering and Bruce/Darlington). COG extended the project to overseas members, providing the opportunity for all CANDU-6 reactor operators to participate in and benefit from information developed during the project.

The licensees adapted the generic SAMG strategies and guides to each NPP. The second phase of the project, also coordinated by a COG working group, dealt with implementing project documents, adapting SAMG strategies and guides to each specific site and operating organization, interfacing the SAMGs with control room emergency operating procedures, validating the SAMG documentation against a wide variety of scenarios and providing the emergency response organization with the training necessary to implement SAMG strategies during emergencies.

Exercises to verify the effectiveness of the developed strategies and documentation focused initially on potential core damage scenarios, identified by probabilistic safety assessments as constituting the highest residual risk. This implementation phase commenced in 2007, and all licensees have completed exercises and drills to test and validate their emergency organization response to SAMG events.

Following the Fukushima accident and in response to the CNSC Action Plan, a joint project coordinated by COG was formed to examine the work necessary for extending SAMGs based on lessons learned and to provide the Canadian nuclear industry with additional support. The COG joint project has also been opened to interested international members who wish to take advantage of the work. The scope of the COG joint project includes:

- extension of SAMG programs to encompass the shutdown/low-power states
- extension of SAMG programs to more fully consider multi-unit events
- development of SAMGs for irradiated fuel bay events

- development of a methodology for assessment of equipment and instrument survivability following severe accidents
- verification of strategies for maintaining containment integrity during severe accident conditions
- verification of strategies for in-vessel retention to prevent calandria failure and corium-concrete interaction
- development of a methodology for assessment of control facility habitability

Following completion of the above elements, individual licensees are expected to implement the findings or apply the methodologies and then take remedial actions, if necessary.

In addition to extending the SAMG framework, Canadian licensees have procured portable diesel generators and portable water pumping capability to augment defence-in-depth capabilities should all AC power be lost and heat sink capability be compromised following an extreme external event. Deployment of this emergency mitigating equipment would be triggered from appropriate emergency operating procedures as a measure to prevent a severe accident and would also be incorporated into SAMG procedures to mitigate severe accident progression, if needed.

The following summarizes the progress of SAMG implementation for each NPP licensee.

Bruce Power

During the reporting period, Bruce Power issued updated SAMG implementing documents: it also initiated training for operations and emergency response staff. A validation exercise was completed in 2015 at Bruce A and a major exercise will be conducted in 2016 at Bruce B. Bruce Power also completed the implementation of a SAMG program for Bruce A and B for both single and multi-unit events.

The key elements of this program include:

- a user's guide
- two control room guidelines
- a diagnostic flow chart
- a severe challenge (hazard) status tree
- seven severe accident guidelines
- four severe challenge guidelines
- six computational aids
- two severe accident exit guides

Implementing these elements included a number of enabling procedures and minor design changes. Training of the operations and emergency response crews is completed, and SAMG drills are performed on a periodic basis.

Bruce Power also worked in conjunction with Ontario Power Generation (OPG), through COG, on implementing multi-unit SAMG provisions. The COG project defined the generic requirements for multi-unit response and updated the SAMG technical basis document using insight from the Fukushima event as well as recent analyses from various PSA studies. This work was completed during 2015. Bruce Power has completed SAMGs for the irradiated fuel bays. Training of staff for the irradiated fuel bay SAMGs is ongoing and will be complete in mid-2016.

Ontario Power Generation

OPG has undertaken a four-phase approach to SAMG implementation:

1. **Phase 1**, or emergency response organization implementation, focused on developing NPP-specific guidance, including:
 - a user's guide
 - control room guidelines
 - a diagnostic flow chart
 - a severe challenge (hazard) status tree
 - severe accident guidelines
 - severe challenge guidelines
 - computational aids
 - severe accident exit guides

Training programs, including a SAMG overview and an in-depth SAMG user program, were developed and delivered to key members of the emergency response organization. The full suite of SAMG documentation has been made available in emergency response organization facilities. SAMG drills specific to Darlington and Pickering were conducted at the OPG corporate emergency operations facility to verify the effectiveness of the developed strategies and documentation. Phase 1 implementation was completed by the end of 2010 and OPG has assembled a SAMG technical team to join the emergency response organization duty roster.

2. **Phase 2**, or NPP implementation, involved the integration of SAMGs with the existing NPP emergency operating procedures, further development of enabling instructions and site-specific SAMG documents, and training of operations staff. Phase 2 was completed for all OPG NPPs at the end of 2011.
3. **Phase 3** addressed improvements identified during Phase 2. These included improving and validating the enabling instructions for field staff, ensuring SAMG strategies reflect the most current and accurate technical information, conducting training for emergency response organization and plant staff, and including the use of emergency mitigating equipment in SAMG strategies (this equipment was procured after the Fukushima accident for use in the event of a station black-out). Additional training of field staff in the use of SAMG and enabling instructions was carried out in 2013. Table-top drills were performed for each OPG site, using the site-specific SAMGs, and onsite drills were carried out in 2013. The onsite drills involved plant staff using site simulating activities to cope with a SAMG scenario. Phase 3 was completed by the end of 2013.
4. **Phase 4** was completed by the end of 2015 and involved updating the SAMGs, followed by table-top drills and onsite drills. The focus of Phase 4 was to include multi-unit and irradiated fuel bay response in the SAMG strategies. OPG is working in conjunction with Bruce Power, through COG, on implementing multi-unit SAMG provisions.

NB Power

Point Lepreau completed implementation of its SAMG program in late 2011, following extensive drills of the emergency response organization as a proof of concept that the SAMG procedures could be appropriately enacted if a severe accident occurs. Further drills are being considered to more fully train operating staff on enabling instructions. The requirement for

SAMG drills and ongoing training of the emergency response organization has been incorporated in the emergency preparedness program and included as part of an overall, five-year emergency exercise plan with offsite emergency response organizations.

As an outcome of a COG joint project, Point Lepreau staff have completed implementation of SAMGs for the irradiated fuel bay along with the requisite staff training. New SAMG guidance has also been implemented for severe accidents that could occur in the shutdown or low-power state and to address possible severe radiation events involving the dry fuel storage canisters and spent radioactive waste management facility.

Other SAMG implementation measures include the following:

- Assessments consistent with the COG joint project methodology related to survivability of equipment and instrumentation during severe accident conditions have been completed. These assessments also evaluated plant habitability to provide a high degree of assurance that an accident can be managed from control facilities and that mitigating actions can be carried out.
- Compensatory measures and design modifications have been identified as appropriate and are being progressed.
- The majority of Fukushima-related design modifications have been implemented at Point Lepreau with the exception of providing external water to the calandria for moderator water makeup as part of an enhanced in-vessel retention strategy. It is expected that design modification will be completed during the next reporting period. Implemented design modifications include:
 - portable backup power and connection points to critical plant loads, the onsite emergency management facility, information technology infrastructure and the switchyard for control of auxiliaries
 - connection points for external water supply to key heat sinks for accident prevention and mitigation
 - portable equipment including *in-situ* refuelling capability and deployment vehicles (stored in a hardened structure)
 - a radiation boundary monitoring system that provides real-time radiation measurements to the emergency response organization
- SAMG and other procedures have been revised to ensure that emergency mitigating equipment can be deployed reliably within a time frame defined by critical performance objectives derived from severe accident analysis timing and other assessments.
- Training and drills have been performed to verify that the equipment can be deployed with confidence within required time frames.

Gentilly-2

Gentilly-2 was shut down at the end of 2012, and no plans were made to further develop SAMGs for the NPP. However, Hydro-Québec completed the development and implementation of a specific program for the irradiated fuel bay during the reporting period.

