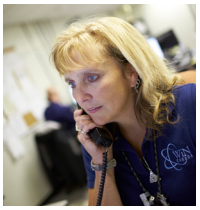
OPG WRITTEN SUBMISSION

In Support of the Renewal of
Darlington's Power Reactor Operation Licence



PROVIDING SAFE, RELIABLE, CLEAN GENERATION

CMD 15-H8.1 | PART 1 HEARING | AUGUST 19, 2015

ONTARIO POWER GENERATION

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Executive Summary

Ontario Power Generation (OPG) is appearing before the Canadian Nuclear Safety Commission (CNSC) on the matter of renewal of the Darlington Nuclear Generating Station (NGS) Power Reactor Operating Licence. The current licence for Darlington NGS expires on December 31, 2015. OPG is requesting renewal of the Darlington NGS operating licence for a term of approximately 13 years to December 1, 2028.

Safety is a core value of OPG's operations at its nuclear stations. OPG's priority is to continue to safely operate its nuclear facilities in a manner that poses minimal risk to our employees, our community, the public, and the environment. OPG recognizes the responsibility we have to manage our facilities in a way that ensures Ontarians benefit from the electricity we produce at the lowest risk to their health and safety.

The requested licence term will cover the activities that OPG will complete in order to ensure Darlington NGS can continue to provide safe and reliable electricity to Ontarians for many more years. The design of CANDU stations requires a mid-life replacement of key reactor components like the fuel channels. Replacing these critical components and undertaking other replacement and enhancement activities will allow the units to be operated safely for a further 30 years. A 13-year operating licence would cover the duration of this undertaking, referred to as the Darlington NGS "Refurbishment" project, and allow all four reactor units to be refurbished under a consistent set of regulatory requirements. This is the safest way to manage Refurbishment, improving nuclear safety through consistency and configuration management between units.

In parallel with Refurbishment activities, and independent of licence duration, OPG commits to perform a Periodic Safety Review (PSR) for the Darlington station on a 10-year frequency in accordance with regulatory requirements. This is in line with the international practice of longer licence terms, up to and including lifetime duration.

The information presented in this Commission Member Document (CMD) summarizes performance in the CNSC's 14 Safety and Control Areas (SCAs) and provides information about OPG's plans and readiness to safely undertake Refurbishment.

OPG is committed to fostering a healthy safety culture, which underpins high levels of safety and performance. Most recently, a station-wide nuclear safety culture assessment conducted at Darlington in February 2015 concluded that there was a healthy nuclear safety culture and that nuclear safety is not compromised by production priorities.

OPG has conducted comprehensive safety analysis to demonstrate the likelihood of a serious accident remains very low. OPG continues to invest to further improve safety at its nuclear facilities as demonstrated by OPG's post Fukushima actions and the implementation of Emergency Mitigating Equipment and Safety Improvement Opportunities. These physical improvements to the plant have been incorporated into the Darlington NGS Probabilistic Safety Assessment (PSA), which concludes there is low and continued reduction in public risk.

In order to demonstrate OPG's emergency response capability, Darlington maintains an extensive Emergency Preparedness drill and exercise program. Furthermore, OPG executed "Exercise Unifed Response" in March 2014, which successfully demonstrated the preparedness of OPG and federal, provincial, and municipal government agencies to respond to a simulated nuclear emergency at the Darlington station. OPG has also developed a strategy in coordination with municipal agencies for the pre-distribution of Potassium Iodide (KI) pills, which will be implemented by the end of 2015.

OPG has demonstrated the safety case for extending the design life of the fuel channels to 235,000 Equivalent Full Power Hours. Periodic inspections of the major components, including the fuel channels, will continue to demonstrate on-going fitness for service.

With respect to refurbishment, OPG completed the required comprehensive assessments in accordance with regulatory requirements, and is investing in plant and infrastructure improvements for continued operation for an additional 30 years beyond refurbishment.

OPG does not take public trust and confidence for granted; we welcome and seek the opportunity to talk with people about nuclear power and to answer questions about our operations, especially refurbishment of the Darlington station. To facilitate public engagement, OPG conducted information sessions on issues related to Darlington station operation and refurbishment. Over 3,500 members of the public attended open house sessions, which included a tour of the Darlington refurbishment training mock-up facility. OPG has also made publically available on its website www.OPG.com key documents and information related to Darlington refurbishment and this licence renewal application.

OPG remains committed to ensuring that the high performance levels demonstrated over the previous licence periods will continue during the next licence period. Specifically, Darlington NGS has established robust programs that meet or exceed regulatory requirements in all of the SCAs. In CNSC staff's most recent assessment of Canadian nuclear power plant performance, and for the seventh straight year, Darlington NGS received an overall integrated station rating of Fully Satisfactory. Furthermore, Darlington NGS has consistently been recognized by industry peers as having excellent performance, most recently in a 2014 peer review where Darlington was rated as one of the top performing stations in the world from the World Association of Nuclear Operators (WANO). In 2012, Darlington also received a similar evaluation from WANO.

OPG has demonstrated that it is qualified to operate Darlington NGS and has made provisions 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. On the basis of this CMD, and associated documentation, OPG is confident that a 13-year operating licence is safe, compliant with all regulatory requirements, and appropriate for one of the best operating nuclear stations in the world.

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1.0 INTRODUCTION

1.1 Background

Darlington Nuclear Generating Station (NGS) is owned and operated by Ontario Power Generation (OPG), a corporation incorporated under the Business Corporations Act (Ontario) with its head office located at 700 University Avenue, Toronto, Ontario, M5G-1X6. OPG, which is wholly owned by the Province of Ontario, operates a diverse mix of flexible, affordable, clean generation and nuclear waste management facilities for the Province.

Nuclear power is an important part of Ontario's clean, reliable and affordable generation mix, and one of the lowest greenhouse gas emitting electricity sources worldwide. With a 3,500 MW electrical output, the Darlington station produces approximately 20 per cent of Ontario's electricity.

The Darlington NGS Power Reactor Operating Licence (PROL) 13.01/2015 expires on December 31, 2015. On December 13, 2013, OPG submitted an application to the Canadian Nuclear Safety Commission (CNSC) for renewal of the operating licence for a licence term to December 1, 2028. This period spans the refurbishment of the four Darlington reactor units and completion of regulatory scope outlined in the Integrated Implementation Plan (Revision 2) submitted to CNSC staff on April 27, 2015.

In 2014 the current PROL was renewed for a one year term to allow additional time for completion of the following activities related to licence renewal.

- Resolution of issues identified by CNSC staff related to the Integrated Implementation Plan

- Publication by CNSC of Regulatory Document REGDOC-2.3.3, *Periodic Safety Reviews*, which sets out the requirements for Nuclear Power Plant life extension and longer term operating licences

- Public posting of a summary report for the Darlington probabilistic risk assessment 2015 version.

- Consistent with OPG's public disclosure policy, OPG has made available information and documentation to facilitate public review and for improved public engagement and more meaningful participation in the hearing process

These activities have each been addressed. The final item, posting the public summary of the DARA update, will be complete prior to the Part 1 hearing.

In December 2014, OPG reaffirmed its request for a renewed term to December 1, 2028.

Throughout this Commission Member Document (CMD), "the licence period" covers the previous and the current licence period (March 1, 2013 to December 31, 2015). Darlington NGS is located on the north shore of Lake Ontario in the Township of Darlington, in the Municipality of Clarington, in the Regional Municipality of Durham, in the Province of Ontario (see Figures 1-1 and 1-2 below).

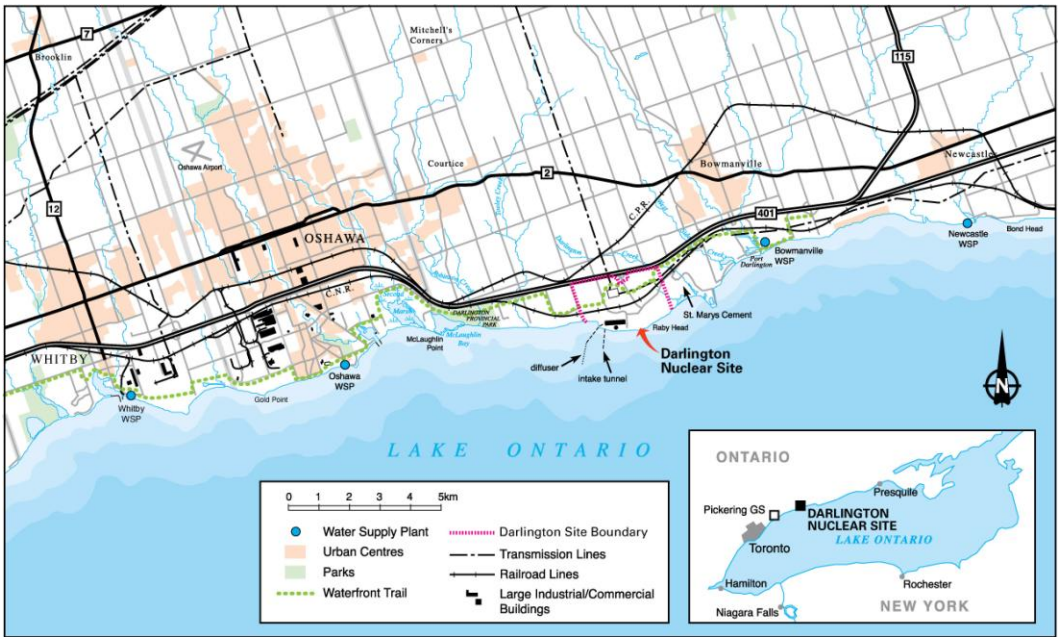


Figure 1-1
Darlington NGS Site Location

Figure 1-2
Darlington NGS Site Aerial View

The station is comprised of four CANDU nuclear reactors, four turbine generators, and associated equipment, services and facilities.

Number of Operational units	4
Net Electrical Output	4 x 881 MW(e)
Maximum thermal power from fuel	2776 MW(t) to yield 934 MW(e) (gross)
Nuclear steam supply system	CANDU pressurized heavy water reactor
Containment structure	Reinforced concrete
In-service dates	
Unit 1	November 14, 1992
Unit 2	October 9, 1990
Unit 3	February 14, 1993
Unit 4	June 14, 1993
Tritium Removal Facility	October 31, 1988

Table 1-1
Summary Data – Darlington NGS

As a component of the licensed facility, within the protected area and included in the operation of the Darlington NGS, is the Tritium Removal Facility (TRF) housed inside the Heavy Water Management Building. The TRF plays an important role in controlling tritium levels in the heavy water systems of the Province's nuclear generating stations. See Section 4.3 for more information about the TRF.

1.2 Darlington Performance Highlights

OPG's operations at Darlington NGS continue to result in some of the best performance in Canada and amongst all nuclear power plants worldwide.

Nuclear practices and processes are regularly benchmarked and evaluated against top performing nuclear facilities around the world. In 2012, Darlington NGS was recognized by an international industry peer evaluation as being one of the top performing stations in the world. In 2014, a subsequent international industry peer evaluation confirmed that high performance had been sustained and that Darlington NGS continues to be a top performing station.

In CNSC staff's most recent assessment of Canadian nuclear power plants, and for the seventh straight year, Darlington NGS received an overall integrated station rating of Fully Satisfactory.

Section 3 of this CMD provides a summary of Darlington's performance in the CNSC's fourteen Safety and Control Areas (SCAs).

Safety as a Core Value

Safety is a core value of OPG's operations at its nuclear stations. OPG's priority is to continue to safely operate its nuclear facilities in a manner that poses minimal risk to our employees, the public, and the environment.

At OPG, we are committed to maintaining a safe work environment for our employees and have been recognized as a leader in promoting workplace safety. We are proud of our safety record and became the first employer in Ontario to receive the ZeroQuest® platinum award from the Infrastructure Health and Safety Association in 2012. The award considered OPG's safety performance, safety management systems, and safety culture.

Darlington's safety performance continues to be within the Canadian Electricity Association (CEA) top quartile for comparable industries for the past four years. This performance has resulted from OPG's focus on proactive Musculoskeletal Disorders reporting for ergonomic solutions and improvements in material handling, training, and procedures.

OPG reactors and waste storage facilities are designed, operated and maintained in such a way to ensure the public is protected at all times. OPG recognizes the responsibility we have to manage our facilities in a way that ensures Ontarians benefit from the electricity we produce at the lowest risk to their health and safety. Additionally, to ensure the consequences of any potential event are low, OPG works with federal, provincial and municipal authorities to ensure that the highest standard of emergency response capability is always available. OPG has continued to take a leadership role in Canada in key areas such as chairing the development of the new Canadian Standards Association

(CSA) standard N1600, *General Requirements for Nuclear Emergency Management Programs*, providing ongoing support for Emergency Management Ontario and Durham Region's Emergency Management response capabilities, and facilitating rigorous training across the sector.

OPG led the planning and execution of the Exercise Unified Response that was successfully completed in May 2014. More than 1000 participants (including the CNSC) from 54 federal, provincial, municipal and non-government agencies participated over the course of the 3-day exercise. The results show that there are robust emergency plans in place at all levels to deal with a nuclear event. Further enhancements to these plans are being implemented as part of the lessons learned.

OPG operates Darlington NGS in a manner that ensures the potential for harm arising from our radiological emissions always remains low. During the licensing period, there were no radiation exposures to employees at Darlington NGS that exceeded regulatory limits or our more stringent administrative dose limits. External and internal dose performance at Darlington NGS continues to be among the best in the CANDU industry. The radiation dose to the public from Darlington has been a fraction of 1% of regulatory limits for the entire licensing period.

Fukushima Action Plan

OPG has been recognized for its achievements in operational and management excellence in its response to the Fukushima Daiichi accident. OPG has confirmed that its stations are safe and that systems and procedures are in place to deal with significant emergencies. OPG has taken the key lessons learned from the Fukushima event and incorporated changes to further enhance the safety of its nuclear facilities. All items in the CNSC's Fukushima Action Plan have been closed.

Social Responsibility

OPG recently received two important honours in the area of corporate social responsibility. The company received the 2014 Social Responsibility Award from the CEA for its achievements in building productive and successful relationships with First Nations and Métis communities. The award is part of the CEA's Sustainable Electricity Program that recognizes companies for their exceptional sustainable development performance.

OPG was also named by Corporate Knights Inc. to both the 2014 and 2015 list of Best 50 Corporate Citizens in Canada. The "Best 50" list is considered the corporate sustainability "ranking of record" in Canada. OPG was noted by Corporate Knights Inc. for its commitment to environmental, social and community values.

Community Support

We are proud of our contribution to our local communities and value the relationships we have built with them. OPG does not take public trust and confidence for granted; it is

something that has to be earned not only by safe plant operation, but also by maintaining open and transparent communications, and by being an active member of the community.

We welcome and seek the opportunity to talk with people about nuclear power and to answer questions about our operations. OPG regularly and proactively provides information to the public on our on-going activities, public and environmental impacts, and we consult with key stakeholders and the public on future planned activities.

To facilitate public engagement, OPG conducted information sessions with key organizations on the licence renewal process and issues related to Darlington station operation and refurbishment. Over 3,500 members of the public took advantage of two open doors sessions which included a tour of the Darlington refurbishment training mock-up facility. OPG has also made publically available on its website www.OPG.com key documents and information related to Darlington refurbishment and this licence renewal application.

1.3 Refurbishment Overview

The requested licence term will cover the activities that OPG will complete in order to ensure Darlington NGS can continue to provide safe and reliable electricity to Ontarians for many more years.

The design of CANDU stations requires a mid-life replacement of key reactor components like the fuel channels. Replacing these critical components and undertaking other replacement and enhancement activities will allow the units to be operated safely for a further 30 years.

In 2007, OPG began planning and preparation for the refurbishment of the Darlington station. Darlington's record of safe and reliable operation together with the strong nuclear safety culture and the commitment to continuous improvement, are the foundation for extending the life of the station. Building on this foundation, OPG embarked on assessments which considered both Canadian and international modern codes and standards, to identify the incremental activities that will ensure OPG meets its commitment to continued safe and secure long-term operations.

Further details on refurbishment are provided in Section 4.1 of this CMD.

Refurbishment Planning Process

In October 2010, OPG and the CNSC signed a protocol that set out the administrative process between OPG and CNSC staff to manage the regulatory interactions for the assessments and licensing submissions required to support life extension as described by CNSC Regulatory Document RD-360, *Life Extension of Nuclear Power Plants*, February 2008. RD-360 sets out the following expectations that the licensee must demonstrate:

- The technical scope of the project is adequately determined through an Integrated Implementation Plan (IIP) that takes into account the results of an Environmental Assessment (EA), where required, and an Integrated Safety Review (ISR);

- Programs and processes that take into account the special considerations of the project are established; and

- The project is appropriately planned and executed.

OPG carried out the comprehensive assessments in accordance with RD-360 to systematically identify the enhancements to our programs and the station design that provide the additional assurance for long-term safe operations. The assessments build on the well-established programs that OPG follows to ensure current safe operations. The assessments are forward looking, and establish the additional work that is associated with planning and executing a life extension project. These additional work activities are presented in the IIP.

Environmental Assessment

OPG undertook an EA under the Canadian Environmental Assessment Act to assess the effects on the environment as a result of the refurbishment of the four Darlington reactors and the operation of the reactors for approximately 30 years following refurbishment.

The EA concluded that refurbishment and continued operation of Darlington NGS, taking into account identified mitigation measures, is not likely to cause significant adverse environmental effects. This conclusion was confirmed through the CNSC public hearing process in 2012 and documented in the Record of Proceedings, including Reasons for Decision issued by the Commission.

Following the issuance of the Record of Proceedings and Reasons for Decision, four intervenors before the Commission sought judicial review of the Decision in the Federal Court of Canada. The application for judicial review was dismissed by the Federal Court in November 2014, and the intervenors have appealed that decision to the Federal Court of Appeal. The Attorney General of Canada and OPG are both responding to the appeal. The parties are following the Court's process and timelines for the appeals. The Court has not yet scheduled the hearing of the appeal, but it is anticipated that the hearing will occur by the end of 2015, with the Court of Appeal's decision likely being released sometime in the first half of 2016.

An EA follow-up program was developed that will verify the accuracy of the EA and determine the effectiveness of the mitigation measures. The actions to implement the program are contained in the IIP.

The EA follow-up program activities associated with the pre-refurbishment phase have begun, including the effluent characterization, benthic invertebrate community study, and monitoring of fish eggs, larvae and invertebrates entrained by the cooling water intake structure. The entrainment study is planned prior to the start of the refurbishment outage.

Design enhancements committed through the EA will further increase safety margins and reduce plant risk. These design enhancements are included in the IIP. Each of these projects has been initiated and has progressed to the engineering and procurement activities stage. More details are provided below as well as in Section 4.2.

Integrated Safety Review

An ISR is a systematic assessment of plant design, condition and operation to determine the extent to which the nuclear power plant conforms to modern codes and standards and practices, that the licensing basis will remain valid over the extended operating life, and that arrangements are in place to maintain plant safety for long-term operation. The ISR identifies the reasonable and practical activities that can be implemented to enhance the safety of Darlington NGS to allow for long-term operation. These activities are also included in the IIP.

The Darlington NGS ISR was carried out in accordance with the methodology described in a CNSC approved basis document. The review considered the design, plant condition and operation of the station against 17 safety factors, 103 modern codes and standards as well as current and historic licensing issues.

The ISR completed for Darlington NGS demonstrated that the current state of the plant and its operational performance complies closely with modern codes and standards and utilizes industry best practice.

CNSC staff review of the Darlington ISR, including the addenda produced to address CNSC staff comments, concluded that the ISR met the applicable requirements of RD-360.

Global Assessment

The Global Assessment used the results of the EA and ISR and examined them in an integrated manner. It assessed the strengths, opportunities for improvement, and actions to address the opportunities for improvement and to provide an overall risk judgment on the acceptability of continued operation. The Global Assessment further assessed the adequacy, and implementation timing of the actions arising from the EA and ISR that are identified to extend the life of the plant.

The Global Assessment recognized Darlington NGS as a top performing nuclear power plant, which results from a robust design; solid engineering, operations and maintenance programs; processes that incorporate continuous improvement; and staff who are committed to nuclear safety as a core value of nuclear operations.

The Global Assessment included a detailed assessment of Darlington NGS's defence in depth against the requirements for new Nuclear Power Plants in CNSC Regulatory Document RD-337, *Design of New Nuclear Power Plants*. It was determined that these requirements are met at Darlington NGS and that the defence in depth barriers will be further strengthened as a result of the implementation of the IIP.

The results of the Global Assessment demonstrate that Darlington NGS is a safe and reliable nuclear power plant today, and that implementation of the improvements in the IIP will result in Darlington NGS being an even safer and more reliable supplier of clean electrical power to the Province of Ontario for another 30 years.

Integrated Implementation Plan

The Darlington IIP contains the activities resulting from the EA and ISR. Enhancements that support the long-term safe operation of Darlington NGS in the IIP contain the following key activities:

- Replacement of fuel channels, feeders, calandria tubes, and end fittings
- Replacement of liquid relief valves on the Heat Transport System

- Implementation of safety-related recommendations from component condition assessments, including refurbishment or replacement of components
- Design and installation of a Containment Filtered Venting System (CFVS)
- Provision of Shield Tank Overpressure Protection (STOP)
- Enhancements to the Powerhouse Steam Venting System (PSVS)
- Installation of a third Emergency Power Generator (EPG3)
- Provision of an alternate, independent supply of water as an Emergency Heat Sink
- Installation of additional independent fire water pumps
- Installation of two auxiliary shutdown cooling pumps in each unit
- Completion of the EA follow up program
- Implementation of a transient/fatigue monitoring program

The first version of the IIP (Revision 0) was submitted to the CNSC in December 2013 along with the Global Assessment of Darlington NGS. CNSC feedback was incorporated into Revision 1 of the IIP in October 2014. In April 2015, IIP Revision 2 was submitted to the CNSC with further enhancements and clarifications. IIP Revision 1 and 2 were accepted by CNSC staff in December 2014 and June 2015 respectively.

Timeline for Execution of the IIP

The activities identified in the IIP include programmatic activities as well as unit specific refurbishment activities and enhancements. As with all work within the nuclear station, the timing for performance of the work activities depends on the safety significance of the work, the availability of resources to perform the work, and whether the work can be carried out at power or requires the unit to be in an outage state. Certain work activities planned during the refurbishment of the reactors requires not just that the units be in an outage state, but that they are in a defueled state.

Figure 1-3 illustrates the Darlington Refurbishment timeline, including the windows during which the IIP scope of work will be completed. It is based on current planning assumptions and is subject to change. The period of the new licence requested is also included to show how it brackets the Refurbishment work.

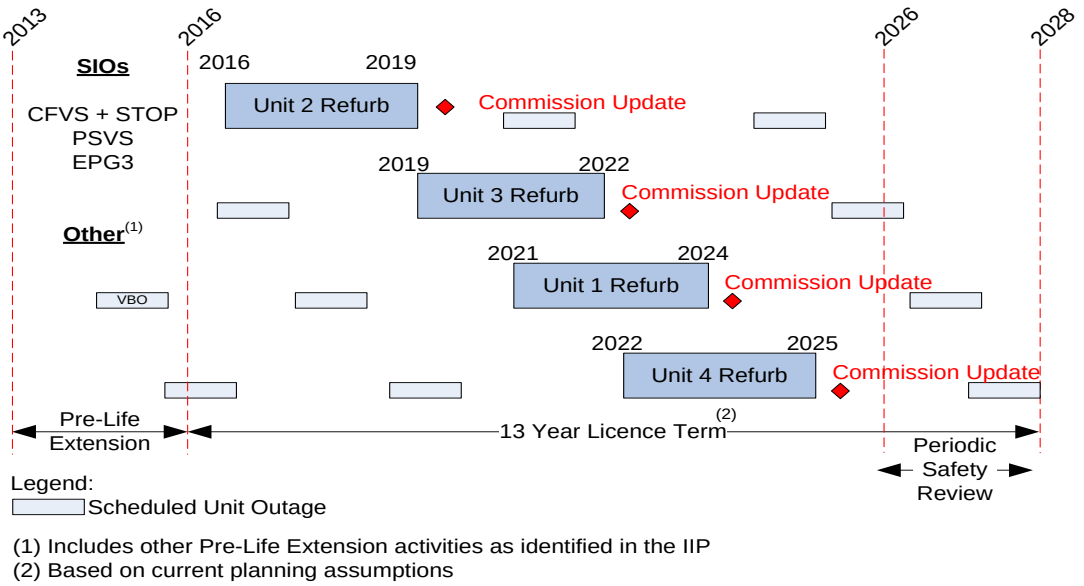


Figure 1-3
Darlington Refurbishment Timeline

In general, IIP work that is unit-specific will be performed during the unit refurbishment outage and the period up to and including the first scheduled maintenance outage post-refurbishment (over an approximate 13 year period).

In accordance with RD-360, OPG has prepared an IIP Change Control procedure that has been accepted by the CNSC staff. While changes to the IIP are not planned there may be instances where minor non-intent changes may be required. In these cases the changes will be managed in accordance with the IIP Change Control Procedure.

Further details of OPG's plan for Darlington Refurbishment are provided in Section 4.1 and 4.2 of this CMD.

1.4 Term of Licence

OPG is requesting a licence term of approximately 13 years, to December 1, 2028, to cover the refurbishment of the four reactor units and completion of the major activities outlined in the Integrated Implementation Plan. OPG concludes that this licence duration is consistent with the nature of the activities to be undertaken during the licence term.

A 13-year licence term is appropriate, acceptable, and desirable for the following reasons:

- A 13-year operating licence is the safest way to manage Refurbishment. It would allow all four Darlington units to be refurbished under the same set of regulatory requirements thus improving nuclear safety through consistency and configuration management between units.

- OPG has already completed comprehensive assessments (the Environmental Assessment and Integrated Safety Review) to cover operations out to 2055. Both studies support long term plant operation well beyond December 2028.

- OPG is investing in safety improvements now which will result in Darlington NGS being an even safer and more reliable plant going forward during and after the licence term. As described in Section 4.2, many of these safety improvements will be completed prior to the start of the refurbishment outages.

- Darlington NGS has for many years been and is today one of the top performing nuclear plants in the world. OPG remains committed to ensuring this will not change during the licence term.
  - Fully Satisfactory CNSC integrated plant rating seven straight years
  - Consistently recognized by international peer evaluations for high performance

- OPG commits to performing Periodic Safety Reviews (PSR) in accordance with CNSC Regulatory Document 2.3.3, *Periodic Safety Reviews*. With a licence term to December 2028, OPG will commence updating the PSR in approximately 10 years (2025) in support of the next licence renewal.

- The international practice is for long term operating licences, typically for the life of the plant, independent of the Periodic Safety Review frequency, as shown in Table 1-2. A 13-year licence is much shorter than the international norm.

- The licence term does not preclude reviews and ongoing public scrutiny of plant performance before the Commission. OPG commits to providing the Commission formal updates following the refurbishment of each unit that would be in addition to regular public meetings on a range of nuclear topics including OPG's attendance at the CNSC Annual Report public meeting. OPG anticipates being before the Commission several times throughout the licence term. This will provide ample opportunity for public and Commission engagement as refurbishment progresses.

- OPG recognizes that the length of the licence term does not impact the effectiveness of the compliance program established by CNSC staff or the authority of the Commission to suspend, revoke or replace the licence, including establishing new licence conditions. Furthermore, regulatory hold points have been established for key stages of unit start-up following refurbishment which require prior approval of the Commission or person authorized by the Commission.

- OPG has internal processes under its management system which ensure performance is maintained at a high standard. As part of this management system, self assessments and independent audits are conducted on a regular basis. Results are documented in the OPG internal Station Condition Record (SCR) system which is accessible by CNSC site staff at any time.

- A 13-year term provides improved regulatory certainty for our shareholder, the Province of Ontario, and rate payers.

Country	Operating Licence Term	PSR Frequency
Belgium	Lifetime Terms	Every 10 years
Czech Republic	Lifetime Terms	Every 10 years
Finland	5 - 20 year Terms	Every 10 years
France	Lifetime Terms	Every 10 years
Germany	Lifetime Terms	Every 10 years
Hungary	Lifetime Terms	Every 10 years
Japan	Lifetime Terms	Every 10 years
Mexico	30 year Terms	Every 10 years
Netherlands	Lifetime Terms	Every 10 years
South Korea	Lifetime Terms	Every 10 years
Spain	10 year Terms	Every 10 years
Sweden	Lifetime Terms	Every 10 years
Switzerland	Lifetime Terms	Every 10 years
United Kingdom	Lifetime Terms	Every 10 years
United States	40 years + 20 year renewals	Not a USNRC Requirement

* USNRC – United States Nuclear Regulatory Commission

Table 1-2
International Practice for Nuclear Power Plant Operating Licence Terms and for Frequency of Periodic Safety Reviews (Reference: CMD 15-M12.1)

2.0 BUSINESS PLAN

Darlington's vision is to be the best performing nuclear plant in the world. The objective for the business plan is to continue Darlington's "Journey of Excellence" while positioning the station for refurbishment and beyond. Continuing focus areas include:

- Safety
- Integration and alignment with the refurbishment project
    - Fuel Handling reliability
    - Aging Life Management Investments
- Equipment reliability
- Leadership behaviours/Human Performance

Darlington Performance Overview

Darlington remains focused on continuous improvement plans which are grouped into four cornerstones: Safety, Equipment Reliability, Value for Money, and Human Performance.

In March 2014, Darlington received another excellent safety and performance evaluation from an industry peer review, recognizing Darlington as one of the best performing nuclear stations in the world.

OPG has been a world leader in its response to the Fukushima accident, resulting in a safer plant. Emergency Mitigating Equipment (EME), mobile and flexible means of providing cooling water to the reactor, has been implemented and is fully available for use at the station following a beyond design basis event or severe accident.

Following refurbishment, Darlington will continue to be a safe, low cost, reliable, top performing plant. Figure 2-1 shows Darlington's 2015-2017 Business Plan Vision. The Vision summarizes Darlington's high level improvement plans and focus area initiatives that are part of our Journey of Excellence.

Safety	Reliability
• Tritium emission reduction • Work protection program effectiveness • Fuel defect reduction	• Equipment reliability improvements • Maintenance backlog reduction • Fuel handling reliability improvement • Cross functional alignment
Value for Money	**Human Performance**
• VBO planning & execution • Work execution and ownership • Refurbishment integration • "Getting work ready"	• Leadership & supervisory development • Human performance improvements • Contract partner success • Certified operator throughput

Figure 2-1
Darlington 2015-2017 Business Plan Vision

Safety

Safety is a core value and a cornerstone of OPG's operations. OPG is proud of its safety record and works hard to maintain a safe work environment. Safety performance remains strong as Darlington has achieved 4 million hours without a Lost Time Accident and will continue to focus on improving safety and demonstrate that personal safety, nuclear safety and environmental safety are priorities that supersede all others.

Reliability

Ensuring high levels of reliable performance of equipment important to nuclear safety and production will lead to improved station reliability.

Value for Money

Darlington continues to pursue efficiencies to optimize resources and maximize efficiency. This has resulted in an increased commitment to the long term health of the station through a strong portfolio of project new starts and completions, as well as refurbishment integration and alignment. Best practices have been developed to minimize refurbishment cost and maximize efficient use of resources.

Human Performance

The objective of Darlington's Human Performance program is to reduce Human Performance events and errors by managing defences in pursuit of zero events of consequence. The human performance plan starts with awareness, understanding and commitment by all levels of the organization. Darlington has demonstrated this through the use of an extensive operating experience program, including use of workshops held to learn key lessons from both internal and external industry significant events – a key component of our leadership continuing training.

Darlington Performance Metrics

As Darlington continues on its multi-year journey achieving excellent performance through our business plan, we continue to update our targets in metrics used to measure and drive improved performance. Table 2-1 highlights Darlington's performance targets for the 2015-2017 business planning period. Note that report card indicators for units undergoing refurbishment will be tracked separately. In addition, OPG will continue to strive for excellence in all areas of our business by completing industry peer reviews every 24 to 36 months.

Report Card Metrics - Annual Targets	2015	2016	2017
Safety			
All Injury Rate (#/200k work hours)	0.69	0.69	0.69
Collective Radiation Exposure (person rem/unit) *	73.80	55.00	77.60
Airborne Tritium Emissions (curies) *	4,800	4,000	3,000
Environmental Infractions (#)	7	7	6
Environment Index (%)	80	80	80
Work Protection Level 1 Events	2	2	2
Reliability			
Net Electrical Production (TWh)	24.74	26.03	20.16
Forced Loss Rate (%)	1.00	1.00	1.00
Unit Capability Factor (%) *	82.3	92.0	89.9
BP-Planned Outage Performance (days)	245.6	97.0	101.2
Nuclear Performance Index (%)	88.8	94.3	93.8
On-line Deficient Maintenance Backlog (work orders/unit)*	180	175	175
On-line Corrective Maintenance Backlog (work orders/unit)*	25	25	17
Plant Reliability List (# of work orders completed)	200	200	200
T-15 Scope Survival Critical WO's (%)	80	80	80
Equipment Reliability Index (%)	85	88	88
Dry Storage Containers (#)	60	60	60
Chemistry Performance Indicator (Annual YTD)	1.01	1.01	1.01
Value for Money			
Thermal Performance Indicator (%)	99.5	99.5	99.5
Human Performance			
Training Index (%)	80	80	80
Corrective Action Program - Quality of Significance Level 1&2 Eval's (Out of 3)	2.22	2.22	2.22
Event-Free Day Resets (#)	2	1	1

* Targets based on 3-unit operation following start of Unit 2 refurbishment outage in 2016

Table 2-1
Darlington Performance Targets

3.0 SAFETY AND CONTROL AREAS

3.1 Management System

As shown in Table 3-1 below, CNSC staff have consistently assessed the Management System SCA as meeting relevant regulatory requirements and expectations.

2010	2011	2012	2013	2014
Satisfactory	Satisfactory	Satisfactory	Satisfactory	Satisfactory

Table 3-1
CNSC Ratings for Darlington's Management System SCA

The OPG Nuclear Management System provides a framework that establishes the processes and programs required to ensure OPG achieves its safety objectives, continuously monitors its performance against these objectives, and fosters a healthy safety culture. Monitoring of OPG's performance takes place at several levels, including at the industry level where experts from various utilities worldwide perform a peer review of our nuclear stations. Internally, OPG has a well-established corrective action program, incorporating self-assessments, benchmarking, and independent audits through our Nuclear Oversight division. These elements of the management system, including the organization structure which supports it, are discussed in further detail below.

Nuclear Management System

Darlington NGS is compliant with CSA Standard N286, *Management System Requirements for Nuclear Facilities*. The Nuclear "Charter" establishes the Nuclear Management System for OPG Nuclear. The Charter communicates the Chief Nuclear Officer's (CNO) expectations regarding implementation of the Nuclear Management System.

OPG's Management System ensures high performance...

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

OPG Nuclear Management System effectiveness is reviewed by the Nuclear Executive Committee and CNO as part of ongoing oversight. Each program area owner provides an annual report based on a standardized set of performance criteria. Programs are assessed in the areas of management and leadership, performance execution and continual improvement.

The Programs within the Nuclear Management System undergo extensive external assessment of their performance as well. These assessments include industry peer reviews by organizations such as the World Association of Nuclear Operators (WANO),

independent Nuclear Oversight audits, and reports from the Nuclear Safety Review Board (NSRB). Together, these provide for a wide range of independent, critical and expert perspectives which identify opportunities for improvement and with mechanisms which track corrective actions to address these opportunities.

The Nuclear Management System continues to evolve to support the OPG business model by transfer of several nuclear programs to centre-led business units. This involved careful review and oversight of the changes by the Nuclear Executive Committee to ensure that the roles and accountabilities for meeting the CSA N286 requirements were understood and captured in the centre-led program owner's governance and management systems.

OPG Nuclear is currently transitioning to the 2012 version of CSA N286. A large number of OPG program documents are being revised to reflect this change. The majority of the revisions are complete, with the reminder of the changes being administrative in nature and will be completed by the end of 2015.

Nuclear Safety Policy

OPG's Board of Directors has issued a Nuclear Safety Policy that ensures individuals at all levels of the organization consider safety as the overriding priority over schedule, cost and production. The Policy requires that everyone conduct themselves in a manner consistent with the 10 traits of a healthy Nuclear Safety Culture which is outlined in the Institute of Nuclear Power Operators (INPO) document INPO 12-012, *Traits of a Healthy Nuclear Safety Culture, Rev 1*. The NSRB was established to ensure that the requirements of the Nuclear Safety Policy and Nuclear Management System are being fulfilled. The NSRB is comprised of a Chairman and additional external members who are appointed by the Board of Directors. The NSRB provides the CNO with an annual independent assessment of OPG Nuclear activities at each station that may impact on nuclear safety and performance.

Safety Culture

The mechanisms for fostering and continually strengthening a healthy safety culture cascade throughout the management systems within the Corporation.

OPG periodically evaluates its safety culture to recognize positive attributes and to identify areas for further improvement. External evaluations which help to monitor the overall health of the safety culture include industry evaluations and evaluations by teams such as the NSRB. Internally, Nuclear Oversight Audits, self assessments, industry benchmarking, behavioural observations, the corrective action program and site performance trends are also used.

These process inputs are assessed in an ongoing review of the health of the safety culture, and formal management oversight mechanisms are designed to monitor and assess the health of the safety culture in an integrated fashion. A healthy safety culture underpins high levels of performance in all 14 SCAs.

A station wide nuclear safety culture assessment conducted at Darlington in February 2015 concluded that there was a healthy nuclear safety culture, a healthy respect for nuclear safety, and that nuclear safety is not compromised by production priorities. Station personnel feel they can challenge decisions if needed without fear of retaliation. OPG will continue to periodically conduct these station wide assessments with the goal of constantly improving.

In January 2013, OPG implemented an industry document, Nuclear Energy Institute's NEI-09-07, *Fostering a Healthy Nuclear Safety Culture*, which provides a framework to monitor nuclear safety culture. Implementation included establishment of a Nuclear Safety Culture Monitoring Panel to monitor the process inputs that are indicative of the health of the organization's nuclear safety culture. In doing so, strengths and potential concerns that merit additional attention by the organization are identified and acted upon. This process for monitoring safety culture has been recognized as industry leading and benchmarked by international peers.

Benchmarking and sharing of good practices in Safety Culture monitoring to more quickly assess and respond to potential changes in nuclear safety culture will continue to be a focus for OPG.

Corrective Action Program and OPEX

Darlington NGS utilizes an effective and efficient Performance Improvement process that is aligned with industry best practice. This process results in an organization that has a bias toward preventing events and a culture that is conducive to continuous improvement. Performance Improvement encompasses the Corrective Action Program, Operating Experience (OPEX), and Self Assessment and Benchmarking.

Training and procedure guidance are provided such that personnel assigned to conduct activities associated with the Performance Improvement process have the knowledge and skill required.

OPG's Corrective Action Program ensures adverse conditions are promptly identified, assessed, prioritized and corrected to prevent recurrence. Personnel at Darlington have a healthy culture of identifying and self reporting issues, generating over 10,000 reports each year identifying a wide range of adverse conditions. The vast majority of the reports generated are low level, with minimal safety significance. Actions are taken to correct the issue when required and the reports are analysed for potential trends. A causal analysis or a root cause evaluation is required for the more significant events. The quality of evaluations of significant events is monitored by the Corrective Action Review Board (CARB), which consists of senior managers at Darlington. Effectiveness reviews are performed to ensure that actions taken to resolve significant events have in fact prevented recurrence or mitigated consequences to acceptable levels.

The Corrective Action Program also encompasses the processes to ensure internal and external OPEX is evaluated, distributed to appropriate personnel, and applied to

implement actions that improve plant safety and reliability. OPG consistently contributes its OPEX to the industry.

Self Assessment and Benchmarking

Self assessments and benchmarking are routinely conducted at the divisional and departmental level to ensure continuous improvement in all aspects of our work. Proactive self assessments are scheduled on a yearly basis and provide a method to ensure that Darlington remains self critical. Results are documented and actions taken are tracked using the corrective action process.

OPG participates in a number of industry peer groups, facilitating good opportunities to benchmark other utilities and participate in industry assessments. Similarly, peers from other utilities visit Darlington to gain insights and learn from the best practices of one of the best performing nuclear stations in the world. These relationships are important to ensure OPG continues to gain insight on industry best practices in all areas.

Independent Assessment

Nuclear Oversight

The Nuclear Oversight division provides an independent assessment of OPG's Nuclear Management System, to determine whether the established programs are being effectively implemented by the Nuclear Line of Business organizations. By performing this oversight function, Nuclear Oversight helps to ensure that OPG activities are effectively implementing the requirements of CSA N285 and CSA N286 series standards.

Nuclear Oversight has implemented a 5-Year Audit Plan using a risk based process that identifies when programs supporting the Nuclear Management System are to be audited. The specific scope of the planned audits is determined through a risk analysis performed 26 weeks prior to audit conduct. This ensures that programs are audited at the right time and with the appropriate scope.

Nuclear Oversight identifies performance deficiencies which are documented and reported to the organization with the responsibility to evaluate and resolve the identified deficiencies.

The Nuclear Oversight division's own performance has also been assessed through independent assessments. The 2013 Nuclear Industry Evaluation Program evaluation team determined that OPG independent assessment functions for the Nuclear Oversight division and the NSRB are effective.

The NSRB concluded in 2014 and 2015 that Nuclear Oversight audits are effective in identifying risks to current and improved station performance and that Nuclear Oversight continues to find and report important issues through performance assessments, audits and surveillance activities.

Industry Peer Reviews

Industry peer reviews are periodically performed at all of OPG's nuclear stations. The most recent Darlington peer review was completed in the first quarter of 2014. Feedback from this review was that the Darlington station continues to be one of the top performing stations in the world. Darlington was presented with an award for excellence as shown in Figure 3-1 below. This is a significant honour from an international team of experts and industry peers from nuclear stations worldwide. One of our goals is to continue this high level of industry-recognized performance, while also taking the opportunity to learn from others' best practices and continually improve.

Figure 3-1
OPG Executives Receive 2014 Excellence Award for Darlington NGS

Organization

During the previous licence period, OPG implemented a Business Transformation Program and adopted an integrated organizational model. Under this structure, there are two types of functional organizations: those accountable for delivering "centre-led" fleet-wide support; and those accountable for operations. Drivers for this change included the changing energy market and needs for increased efficiency and agility, while maintaining safety and quality.

Centre-led functions establish one point of accountability for an entire function, to deliver functional support across all business units. This structure requires integration of a function and avoids duplication of work. Examples include Human Resources, Supply Chain, Finance, Training, Environment and Corporate Relations and Communications. Previously, for some functions (e.g. supply chain) OPG had a separate department within each business unit.

OPG provides updates on organizational changes to the CNSC on an annual basis.

3.2 Human Performance Management

As shown in Table 3-2 below, CNSC staff have consistently assessed the Human Performance Management SCA as meeting relevant regulatory requirements and expectations.

2010	2011	2012	2013	2014
Satisfactory	Satisfactory	Satisfactory	Satisfactory	Satisfactory

Table 3-2
CNSC Ratings for Darlington's Human Performance SCA

OPG has developed and implemented processes to ensure a sufficient number of personnel are assigned to all required areas, and have the necessary knowledge, skills, procedures, and tools in place to safely carry out their duties. These processes include specific human performance management and error-prevention programs, taking into account factors affecting fitness for duty, as well as various training programs. Furthermore, initiatives are well underway to address industry demographic challenges in the areas of recruitment, succession planning, and knowledge management. Further details on these areas are outlined below.

Human Performance Program

The objective of the OPG Human Performance Program is to continually reduce the frequency and severity of events, through the systematic reduction of human errors and the management of defences, in pursuit of zero events of consequence.

The Human Performance Program additionally focuses on the requirement to proactively identify and address latent organizational weaknesses, which are hidden deficiencies in management control processes or values creating workplace conditions that can give rise to errors and degrade the integrity of defences.

OPG's human performance programs ensure...

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

Darlington NGS has a Human Performance Strategic Plan which starts with awareness, understanding, and commitment by all levels of the organization. It involves promoting individual and department ownership and accountability regarding human performance best practices. The strategic plan drives multi-faceted initiatives from the front line worker to the leadership level.

The Darlington Human Performance initiatives align with the Fleet Human Performance initiatives to aim for 'Event Free' Operation. The fleet initiatives leverage learning from

both of OPG's nuclear stations to accelerate improvement. OPG recently implemented a Centralized Functional Area Management (CFAM) group in the area of Human Performance to enhance oversight of station activities and to leverage learnings from industry peers. The CFAM manager meets regularly with the industry CFAM peer managers to discuss current industry trends and collaborate on the direction the industry takes for Human Performance initiatives.

Current Human Performance initiatives established at Darlington NGS include:

- Implementation of the revised Observation & Coaching program to improve supervisor interactions with plant staff.

- Effective Human Performance Steering Committee that identifies and evaluates cross functional cognitive trends based on supervisor observations of workers, paired observations that monitor supervisor behaviours, and self assessments.

- Department "Advocates" promote excellence in Human Performance with their peers. Advocates are staff from various departments who have received human performance training by an INPO Human Performance subject matter expert. Subsequent training sessions have been scheduled in 2015 at Darlington to provide training for new Advocates.

- Revised "Manager In The Field" Program
    - Observe work executed in field to validate expectations are being met
    - Assess supervisor coaching quality & assist supervisors who require additional development

- First Line Manager Oral Review Board assessments to gauge supervisory effectiveness on an ongoing basis

- Supervisor Coaching Dynamic Learning Activities for Shift Managers and Control Room Shift Supervisors

- Peer coaching initiative to promote "looking out for one another"

Excellence in human performance depends on alignment of individual and leader behaviours with organizational process and values. The Darlington strategy is to enhance individual behaviours through the use of event-free tools and defenses that minimize and/or mitigate error propagation to attain event-free performance.

<u>Minimum Shift Complement</u>

The Minimum Shift Complement is the minimum number of qualified workers required to be on site to support safe unit operation and to respond to design basis events. Darlington utilizes a computer-based Duty Crew Minimum Shift Complement assurance program that ensures compliance with the requirements and enables the station to maintain historical auditable data.

During the current licensing period, OPG completed validation exercises to confirm minimum shift complement staffing numbers meet CNSC requirements identified in G-278, *Human Factors Verification and Validation Plans* and G-323, *Ensuring the Presence of Sufficient Qualified Staff at Class 1 Nuclear Facilities*.

Fitness for Duty

OPG has procedures in place to document hours of work requirements for employees. Specifically, this procedure sets limits for the number of hours within a specified time period that plant staff can work. The limits, which are in place to guard against fatigue in the workplace, are very strict in comparison to other jurisdictions.

As part of OPG's Fitness for Duty Program, a Continuous Behaviour Observation Program (CBOP) is in place which trains supervisors and managers on how to monitor workers for signs of fatigue or other factors which could adversely impact worker performance.

Training

OPG has rigorous training programs used to systematically develop and maintain competent personnel to safely operate, maintain, and improve plant performance, and to drive continuous improvements in human performance. Through these training programs, station personnel acquire the skills and knowledge commensurate with their individual positions within the organization and the responsibilities of those positions.

Training of Certified Staff

The Certified Staff Training program is based on the Systematic Approach to Training (SAT) as required by CNSC Regulatory Document RD-204, *Certification of Persons Working at Nuclear Power Plants*.

A new initial certification program selection and development process for operations staff, which includes classroom and simulator training and evaluation, has been developed and implemented. This program is designed to improve candidate throughput in the initial training programs.

The continuing training program for certified staff includes refresher training, update training as a result of design or engineering changes, exercises on "Infrequently Performed Tests and Evolutions," "Just in Time" training, and formal evaluations of knowledge and performance.

Certified staff on average complete greater than 200 hours per year of simulator focused continuing training. Improvements to this program have included significantly increased focus on operator fundamentals and emergency responses, including response to beyond design basis events.

The training department recently started using the full-scope main control room simulators during the conduct of Emergency Preparedness drills and exercises in order to achieve more realism in the exercises.

All required re-qualification testing programs are being executed as planned. This includes written tests and simulator-based Comprehensive Simulator Tests and Diagnostic Simulator Tests for all certified staff. Table 3-3 below shows the high success rate for certified staff when performing their re-qualification testing.

Year	Success Rate	Number of Candidates	Number of Passes
2011	100%	38	38
2012	96%*	66	63
2013	100%	48	48
2014	100%	35	35

*All unsuccessful candidates were successfully remediated

Table 3-3
Re-qualification Testing of Certified Staff

OPG will continue to demonstrate to CNSC staff its capability to self-administer the certified staff training and examinations, and to ensure sufficient qualified staff are available to ensure safe and reliable operation of Darlington NGS. This includes the requirement that sufficient trained and qualified staff will be available to deliver these training programs throughout the continued operation and refurbishment timeframe. Five-year initial training schedules exist for the Authorized Nuclear Operators, Unit 0 Control Room Operators, Shift Managers, and Control Room Shift Supervisors and these plans are updated on an annual basis.

Personnel Training

Nuclear safety is the overriding priority in all nuclear training activities, focussing on the protection of workers, the public, and the environment. Training is used to ensure workers have the necessary knowledge, skills, and behaviours to safely and reliably conduct work on a nuclear site as well as support professional development.

OPG recognizes the substantial role training plays to ensure staff have the required competence to perform assigned work. Providing high quality initial training to qualify newly hired or newly assigned staff and then maintaining and improving their knowledge, skills and behaviours with continuing training is a key element in OPG's strategy to ensure the safe operation and maintenance of its nuclear facilities.

Professional development at OPG includes financial support for attendance at courses or participation in programs which result in a degree or recognized diploma, or a professional certification not required by an approved Initial or Continuing Qualification. OPG uses professional development to enable staff to add knowledge and skills beyond

those required to be qualified for their current position. The intent is to foster an environment of life-long learning to add breadth and depth to a current knowledge and skill set as the basis to improve performance or prepare staff for future roles.
The Refurbishment project will require retention of a significant workforce of temporary supplemental workers to pre-stage and complete the work activities and projects. The variety of workers required to support the Refurbishment Project includes general labourers, engineers, specific component repair and installation specialists, and other highly specialized workers with unique skill sets.

As each of these supplemental workers arrives they must complete initial training to ensure they are familiar with OPG standards and expectations for their own safety and that of their co-workers. This will be followed by training to ensure they possess the required knowledge, skills and behaviours to perform the technical tasks safely and competently before they are permitted to perform any work at our nuclear power plant.

This important, up-front work is required to ensure only fully competent supplemental workers are hired to support the Refurbishment project. To help accomplish this, OPG built a centralized "Onboarding" Centre, which supports integration of supplemental workers into the OPG work stream and organizational culture. Using industry identified best practices OPG refined its support organization structure and size, as well as the strategies and techniques being used to implement onboarding to improve the effectiveness and efficiency of training incoming supplemental workers.

Leadership Training

OPG has very robust leadership training programs to systematically develop and maintain competent leaders to safely operate, maintain, and improve plant performance, and to drive continuous improvements in human performance.

A committee of senior nuclear leaders ensures nuclear leadership initiatives are implemented and managed to develop the core accountabilities of nuclear supervisors. This includes the processes for the selection, training, orientation, induction, and development of supervisors to achieve the desired attributes, behaviors, and performance.

The OPG initial leadership training programs recently underwent modifications to consolidate the curricula to a single fleet approach. Training content is tightly aligned with OPG values and behaviours. Safety Culture remains an essential element in the nuclear supervisor curriculum. The initial leadership training syllabus incorporates a blended approach to learning, pairing classroom training with on-the-job learning periods. Managers are selected to serve as classroom mentors to reinforce standards and expectations using real life experiences. Trainees attend an entire classroom program in cohorts, which contributes to effective team work and cohesion for in-class work and on-the-job application. Subsequent to initial training, the leadership continuing training program is run annually, reinforcing safety and leadership skills refreshment.

All managers participate in a one-day workshop on Nuclear Safety Culture for Managers. Additionally, to support leaders taking on new roles the Nuclear organization utilizes

structured, level-specific Job Familiarization Guides. The purpose of these guides is to provide supervisors with a suggested approach to better understand how their role relates and interacts with relevant stakeholders to execute work, develop strong relationships with stakeholders, broaden understanding of the scope of their role, and achieve excellent performance earlier in role. This process results in a consistent approach to building leaders, enhancing leadership capability, and qualifying new managers.

High-potential managers are identified through succession planning to attend executive development programs with other industry leaders. These programs establish clear and well understood standards for senior plant staff conduct, and provide advanced knowledge of plant systems and Operations practices. They include: Advanced Operations Overview for Managers (AOOM), the Nuclear Professional Development Seminar (NPDS), the International Senior Nuclear Plant Manager program (I-SNPM), and Peer Evaluation opportunities.

Internationally OPG is the only corporation outside of INPO to deliver I-SNPM and has been doing so since 1996. Each 5-week intensive program involves a mix of OPG leaders and other Canadian and international nuclear utility senior leaders, as well as major contract supplier senior leaders.

Recruitment & Resourcing

OPG has a multi-layered approach when it comes to resourcing positions in the Nuclear business unit. In addition to traditional full-time regular staffing services, non-regular hiring strategies have been devised to meet short-term staffing requirements.

OPG continues to have positive relationships with many universities and colleges in Ontario to meet the needs of two main hiring programs: Nuclear Operators in Training and Engineering Graduate Trainees. This includes a strategic partnership with Durham College/University of Ontario Institute of Technology (UOIT). OPG also sits on the curriculum committees of Algonquin College for their Radiation Safety Program and the Cambrian College Sky Tech Program to meet its talent needs for the operations and maintenance functions. These partnerships have led to offer-acceptance rates at close to 95%. In addition, to fill short-term staffing needs, OPG utilizes the following strategies:

Figure 3-2
OPG Engineering Building at UOIT

- *Co-op/Intern Programs*: Close to 300 students per year are provided co-op or one year engineering internships. This is a cost-effective measure to complete work and to strengthen the pipeline of future Nuclear professionals. Many of the students hired become full-time employees in our entry level openings or go on to work for vendors within the Nuclear industry.

- *Diversity Programs*: OPG has partnered with Career Edge, a non-profit organization that connects underemployed new Canadians, persons with disabilities and new graduates with short-term professional work placements.

- *Aboriginal Recruitment & Outreach*: OPG is committed to partnerships with local Aboriginal communities and continues to offer scholarships and employment opportunities to Aboriginal youth who are pursuing education and career opportunities specific to the electricity sector. Furthermore, OPG has undertaken specific awareness campaigns in local Aboriginal communities to encourage youth to continue studies in math and science to open doors for career paths in engineering and trades.

- *Augmented Staff Process*: OPG has established an agreement with three preferred staffing agencies to provide short-term temporary workers for OPG's needs. At any given time over 300 of these temporary workers are employed at OPG on contract. This includes augmented staff hired to provide expert advice and support for the Fukushima Response Project.

Succession Planning

To ensure a continuing supply of leaders, a company-wide succession planning process is in place and engages corporate and operations leaders in ongoing identification and development of leadership talent. Oversight of leadership talent issues occurs at many levels of the organization on a routine basis. Leadership risks, when they exist, are monitored as part of the company risk management process. In concert with strategic reviews of long term organizational priorities and direction, identification of key behaviours and capabilities to support these priorities are developed and linked to succession, development and selection activities to support successful achievement of long term goals.

OPG Nuclear utilizes an integrated fleet succession schedule to guide the organization through function-specific discussions. Development opportunities are linked to the succession planning process to ensure best utilization of these opportunities.

To ensure a longer-term view of the leadership talent pool, the succession planning process at OPG includes a "9 Box Assessment" process to assess the organization's talent pool and systematically identify high potential candidates.

To address concerns about future leadership talent supply OPG Nuclear launched an Emerging Talent program in 2011 to systematically identify high potential staff in key areas of the business. Participants were exposed to key leadership concepts through learning events, normally run by senior leaders to allow for sharing of organizational experience and networking.

Building on the success of this program, a high potential program "Accelerate" is now in place. Accelerate builds on the key constructs of Emerging Talent with an enhanced alignment to OPG's leadership model and a stratified approach that recognizes the

different learning and development needs of Individual Contributors, First Level Managers and Middle Managers.

Knowledge Management

To address risks associated with the loss of unique knowledge through attrition and retirement, OPG employs a knowledge management process which consists of a three step process.

- Conduct knowledge loss risk assessments
- Develop and implement knowledge retention plans
- Monitor and evaluate knowledge retention plans

Tools are provided to support each step of the process. Knowledge management risk reviews are embedded into the succession planning process so that actions may be taken to address knowledge management risks.

3.3 Operating Performance

As shown in Table 3-4 below, CNSC staff have consistently assessed the Operating Performance SCA as exceeding relevant regulatory requirements and expectations.

2010	2011	2012	2013	2014
Fully Satisfactory	Fully Satisfactory	Fully Satisfactory	Fully Satisfactory	Fully Satisfactory

Table 3-4
CNSC Ratings for Darlington's Operating Performance SCA

This section provides an overall review of activities associated with the operation of Darlington NGS. This includes a review of the Operations program, with particular focus on station performance, operator fundamentals, control of hazards during work (work protection), and the interface between station and refurbishment operations organizations. Other key areas relating to station operation are also discussed, including fuel reliability, fuel handling performance, chemistry, and regulatory reporting.

Operations Program

Darlington NGS implements and maintains an Operations Program, comprised of a series of standards and procedures that ensures the safety of the public, environment, plant personnel and plant equipment as well as high levels of equipment reliability during both normal operation and accident conditions.

This program establishes safe operating practices and processes within OPG Nuclear facilities that provide nuclear professionals the ability to ensure facilities are operated in such a manner that the PROL, Operating Policies and Principles (OP&Ps), Safe Operating Envelope (SOE) limits and other applicable regulations and standards are followed and adhered to.

In the case that reactor operation deviates from normal, Darlington NGS has Abnormal Incident Manuals, Emergency Operating Procedures, Emergency Mitigating Equipment (EME) Guidelines and Severe Accident Management Guidelines (SAMG) in place.

Darlington has a proven track record of excellent operating performance...

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

Nuclear Safety is paramount to OPG; therefore, Darlington NGS must ensure that nuclear safety is maintained at all times. To accomplish this, OPG utilizes the "defence-in-depth" concept where multiple overlapping engineered, administrative and people-based barriers are in place to protect the public, environment and plant personnel.

Engineered Barriers begin with having a robust design and highly reliable and well-maintained process and safety systems. Administrative Barriers include having robust programs and processes as well as high quality procedures that define quality operation and support. Darlington ensures that both certified and non-certified staff are extremely well-trained and engaged in operating our facilities in accordance with the traits of a healthy nuclear safety culture. The Operator Fundamentals are consistently applied and understood to ensure a foundation of Operational Excellence and event-free operation.

Figure 3-3
Darlington Unit 2 Turbine-Generator

Station Performance

One of the best indicators of overall reactor performance is Forced Loss Rate (FLR). The purpose of the FLR indicator is to monitor Darlington's progress in terms of minimizing outage time and power reductions that result from unplanned equipment failure, human errors, or other conditions during the operating period. This indicator reflects the overall effectiveness of plant programs and practices in maintaining systems available for safe and reliable operation. Table 3-5 demonstrates Darlington's accomplished history of low FLR across all four Units over the past several years.

Unit	2011	2012	2013	2014	2015 (Q1)
1	0.38 %	4.35 %	1.27 %	2.15 %	0.04 %
2	0.99 %	3.66 %	7.08 %	2.21 %	2.47 %
3	0.74 %	0.05 %	3.35 %	1.16 %	0.01 %
4	0.21 %	0.86 %	9.32 %	0.60 %	4.97 %
Average	0.59 %	2.31 %	4.84 %	1.50 %	1.88 %

Table 3-5
Darlington NGS Forced Loss Rate

During the current licensing period, all Darlington units operated with minimal number of unplanned transients and reactor trips. These occurrences are minimized by ensuring the following:

- Proper application and understanding of Operator Fundamentals
- Correct application of the Human Performance Error Reduction Tools
- Corrective and Preventative Maintenance is performed such that station operation is not challenged by unanticipated or long-standing equipment failures.

Operator Fundamentals

Operator Fundamentals are defined as the essential knowledge, behaviours, and practices that operating crews need to apply to operate the plant safely and effectively. To further improve Operations Performance, Darlington performs external benchmarking, most recently in early 2015 to Palo Verde Nuclear Station for the purposes of improving the DNGS Crew Performance Review Board Process and improving use and understanding of the Operator Fundamentals in general. Palo Verde is recognized by INPO as being an industry leader in these areas.

Figure 3-4
Darlington Main Control Room

In addition to external benchmarking, the following actions have been completed to further engrain the philosophy of Operator Fundamentals into all Operations staff:

- Senior Operations managers continually reinforce high standards of performance within the Main Control Room and throughout plant activities.
- The Operator Fundamentals have been integrated into certified and non-certified training in accordance with INPO White Paper, Training to Improve Operator Fundamentals.
- A new Crew Performance Review Board has been created based on the model benchmarked at Palo Verde. These review meetings are run by the Operators on the

crew to create a greater sense of accountability and engagement, with oversight provided by managers in the Operations department.

- The first wave of Supervisor Dynamic Learning Activities (DLAs) for Shift Managers and Control Room Shift Supervisors are in progress. These DLAs reinforce expectations for operations supervisor observation, coaching, and mentoring in the Main Control Room and in the field with a focus on Operator Fundamentals. The second wave of DLAs will be targeted at Field Shift Operating Supervisors and Supervising Nuclear Operators, beginning Q3 of 2015.

- Operator Fundamentals Working Committee has been formed where metrics are discussed and corrective actions to address deficiencies are defined and tracked. The purpose of this committee is to strengthen the behaviours of individuals who operate the plant in order to minimize events caused by weaknesses in Operator Fundamentals.

Work Protection

Work protection establishes safe conditions for work by creating a Safe Work Area to ensure complete isolation and de-energization of isolated equipment. Work Protection at Darlington is owned by the Operations Manager and oversight is provided through the following:

- *Nuclear Work Protection Review Board*: reviews and provides oversight of work protection performance at OPG. This includes monitoring significant trends or events and their associated Corrective Action Plans.

- *Local Work Protection Review Board*: provides oversight of work protection performance at site. Work Protection ratings are discussed at this meeting. Focus is placed on key lessons and required corrective actions from work protection events.

Refurbishment/Station Operations Interface

Nuclear Refurbishment activities will be conducted in accordance with the requirements of Darlington Operating Policies and Principles and the Nuclear Operations Program.

Nuclear Refurbishment and Darlington staff will establish a plan to transfer responsibility for the PSC of a unit undergoing refurbishment. This will be documented in the Operations Transfer Plan.

Boundary points and physical barriers will be in place to ensure partition between the operating station systems and the refurbishment systems, to the extent possible.

Whenever a system, structure, or component is returned to service after maintenance or modification, a rigorous process will be used prior to the system being declared available for service. This includes alignment checks, post-maintenance testing, and an approval process to ensure all required activities have been completed.

Fuel Reliability

Historically, fuel performance has been very good in Darlington reactors. Post-discharge fuel inspections of fuel discharged in the last five years of operation indicate that the fuel condition remains within the design basis compliance envelope. A minor modification in 37 element fuel design to improve thermal-hydraulic conditions within the bundle was successfully implemented in Darlington units resulting in an overall improvement of safety margin (improved cooling within the bundle).

Physical defects in the fuel bundles can arise through various factors including the manufacturing process, manual handling, or wear during operation. The presence of a fuel defect can be detected based on changes to chemical parameters in the Heat Transport system. The station goal is to operate with zero fuel defects, consistent with best industry practices in Canada and worldwide. A significant amount of effort has been invested in achieving defect-free operation following an increase in fuel defects observed in the previous licence period. Post-irradiation hot cell examinations, tighter control of fuel manufacturing, and acquisition of a new facility for fuel inspections are only a few examples of major steps towards that goal. Following implementation of these improvements, all Darlington units have operated fuel defect-free since September 2014.

Fuel Handling

Safe, reliable and predictable performance of the fuelling machines is necessary to maintain core reactivity and support outage activities. Online refuelling operation is required on a continuous basis to ensure sufficient reactivity to maintain full power operation.

In 2013, Fuel Handling equipment issues resulted in unit derates, contributing 0.61% to the Darlington station Forced Loss Rate (FLR). Focused effort on improving equipment reliability through performing preventive and corrective maintenance on fuelling machine equipment has resulted in significant reduction in unplanned equipment degradation. In 2015 year to date, there has been no impact on FLR from Fuel Handling equipment.

Opportunities to perform maintenance have been identified and utilized, resulting in significant improvement in the aggregate health of Fuel Handling systems. A new fleetwide metric for equipment reliability has been developed specific to Fuel Handling systems, recognizing the unique elements contributing to reliable operation of Fuel Handling equipment. This metric has been presented to the CANDU Owners Group (COG) Fuel Handling Peer Group, and is planned to be adopted by the Canadian COG utilities in 2015.

A Fuel Handling Refurbishment readiness schedule has been developed that integrates the priority equipment reliability initiatives and the critical Refurbishment pre-requisites.

Each unit's Refurbishment outage will begin with removal of all fuel from the reactor core. Planning for defueling the core is well underway with a Commissioning team in place integrated with the Fuel Handling organization to oversee the commissioning

activities. An operations training plan is in place that will have qualified staff to support both the Defueling project and the fuelling capability on the operating units throughout the entire Refurbishment window.

Figure 3-5
Fuel Handling System Montage: Operator loading New Fuel, On-power Fuelling at Reactor Face, Used Fuel Storage in Irradiated Fuel Bay

(Artist: Paul Rankin, Supervising Nuclear Operator, Darlington Fuel Handling Department)

Chemistry

Control of system chemistry, during all plant states, targets optimum conditions necessary to minimize corrosion and performance degradation to achieve safe and reliable operation. Proper chemistry control maximizes equipment life, reliability, and long-term economic performance. Chemistry specifications are established that identify parameters which must be controlled within specified limits. While these limits are in place to prevent adverse impacts, chemistry parameters are maintained well within the limits during normal operating conditions. Limits can relate to safety, minimizing corrosion, maximizing efficiency, Operating Experience and/or industry best practices.

As part of the chemistry program to control plant parameters within optimal control limits, more than 400 separate analytes across more than 100 systems are monitored via approximately 4000 analyses per week. Monitoring occurs by on-line instruments as well as "grab" samples taken by station staff. Analyses are completed by qualified chemistry laboratory staff using a rigorous system of quality checks.

Figure 3-6
Darlington Chemistry Laboratory

Results are stored electronically and compared to specifications. The control limits are graded to provide warning of degrading conditions. Results outside the specifications are verified and corrective actions taken to minimize the duration of abnormal chemistry. Out of specification events are also evaluated and corrective actions are taken to prevent recurrence.

Darlington Chemistry Laboratory operations comply with all elements of the quality system and requirements of ISO/IEC 17025, *General Requirements for the Competence of Testing and Calibration Laboratories*. The Quality Management System is audited regularly by both internal and external processes to ensure compliance and continual improvement consistent with industry standards.

Regulatory Reporting

OPG reports operating information to CNSC staff in accordance with Regulatory Standard REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*. REGDOC-3.1.1 superseded Regulatory Standard S-99, *Reporting Requirements for Operating Nuclear Power Plants*, and there has been a successful transition to unscheduled reporting under REGDOC-3.1.1 as of January 1, 2015. Scheduled reporting under REGDOC-3.1.1, which involves the provision of the quarterly Safety Performance Indicators, commenced with the Q1-2015 submission in June 2015.

To promote public engagement and transparency, events reported under REGDOC-3.1.1 are listed on OPG's external website www.OPG.com.

3.4 Safety Analysis

As shown in Table 3-6 below, CNSC staff have consistently assessed the Safety Analysis SCA as meeting relevant regulatory requirements and expectations.

2010	2011	2012	2013	2014
Satisfactory	Satisfactory	Satisfactory	Satisfactory	Satisfactory

Table 3-6
CNSC Ratings for Darlington's Safety Analysis SCA

OPG maintains and routinely updates the safety analysis that supports the overall safety case for Darlington NGS. This safety analysis consists of a systematic evaluation of the potential hazards associated with the operation of Darlington NGS and considers effectiveness of preventative measures and strategies in reducing the effects of these hazards. This section outlines activities associated with both Deterministic and Probabilistic safety analysis, including a summary of analysis results and discussion on severe accident management. Deterministic safety analysis, as documented in the Darlington Safety Report, demonstrates compliance with CNSC public dose limits for internal and external design basis events, such as piping failures and seismic events. Probabilistic Safety Analysis is a comprehensive set of models of plant systems and operator actions in response to abnormal events. This analysis demonstrates that the public risk from Darlington NGS remains very low.

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

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

<u>Deterministic Safety Analysis</u>

The Reactor Safety Program establishes the requirements and processes to demonstrate the plant satisfies public safety requirements through the following key components:

- Safety Analysis Basis
- Safe Operating Envelope
- Beyond Design Basis Accident Management

The Safety Analysis Basis includes the nuclear safety analysis and assessments performed to ensure safe plant operation, in particular the Design Basis Event (DBE) analyses contained in the Safety Report. The Safe Operating Envelope (SOE) is defined by the safety related limits and system credits that ensure operation within the safety analysis basis. Beyond Design Basis Event (BDBE) Management is related to the approach to managing a very low frequency event sequence that is not included in the plant design basis (due to low frequency of occurrence) and is not bounded by analyses of the station design basis.

OPG uses the Safety Report Update Process to evaluate, prioritize and resolve safety analysis issues, and subsequently to update the Safety Report. The Safety Report is formally updated every five years as per REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*. Interim improvements are documented in an internal update report issued at least once per year in accordance with OPG procedures.

The Reactor Safety program includes a Nuclear Safety Oversight Committee which meets monthly to present and discuss high level nuclear safety issues and ensure support to address nuclear safety concerns is obtained. Attendees of the meeting include all major station work groups, and specialists are brought in as required to ensure the right details are available for discussion. The primary consideration for this oversight committee is to ensure all appropriate actions are being taken to operate the facility in such a way as to minimize risk to the public.

Implementation of REGDOC-2.4.1, Deterministic Safety Analysis

New CNSC REGDOC-2.4.1 includes requirements for Safety Analysis that will improve the quality, reproducibility, and documentation associated with Safety Analyses in alignment with modern international standards. In addition, the new framework for performing Safety Analyses has the potential to demonstrate additional safety margins not previously realized in the existing Safety Report analyses.

OPG has utilized a systematic process to prioritize selected pieces of analysis from the Safety Report Appendices to undergo Safety Analysis Improvements as part of REGDOC-2.4.1 implementation based on their associated safety significance. All existing Safety Report Analyses continue to provide assurance of adequate safety margins and will continue to be updated as part of the existing Safety Report Update process. OPG's detailed plan for REGDOC-2.4.1 implementation has been submitted to CNSC staff.

Management of CANDU Safety Issues

At the request of CNSC staff, Canadian nuclear power plant licensees have been systematically reassessing the status of potential design and analysis safety issues for CANDU reactors. These so-called CANDU Safety Issues (CSIs) have been categorized in order of potential risk importance from Category 3 (highest) to Category 1 (lowest). As actions are taken to reduce the risk associated with each CSI, the CSI is reclassified to a lower risk category.

In 2009, CNSC staff identified sixteen Category 3 CSIs requiring resolution to allow re-categorization to a lower risk category. These were further split into two groups: CSIs related to Large Break Loss of Coolant Accident (LBLOCA) and non-LBLOCA CSIs. On the LBLOCA items, OPG has been working with industry partners on development of a Composite Analytical Approach (CAA) – see below for further details. Once accepted, CAA will form the basis for re-categorizing these issues. For non-LBLOCA issues, OPG has requested CNSC to re-categorize most of the issues into lower risk categories, based on empirical and analytical evidence and actions taken.

Large Break Loss Of Coolant Accident: Composite Analytical Approach

Working with industry partners, OPG has proposed the use of a Composite Analytical Approach (CAA) methodology which is currently under CNSC staff review. The CAA is a new analysis framework to address potential LBLOCA scenarios. Traditional LBLOCA methodology is overly conservative, for example in how it treats plant operating parameters and in assuming an instantaneous opening of a large pipe break (not physically realistic). Pending CNSC acceptance of CAA methodology, Darlington's licensing basis for the LBLOCA scenario will continue to be based on traditional safety analysis results.

Neutron Overpower Protection: Enhanced Methodology

For many years, OPG and other Canadian Nuclear Power Plant licensees have used traditional Neutron Overpower Protection (NOP) analysis methodology to demonstrate acceptable safety margins and NOP trip set-points. Traditional NOP analysis methodology is overly conservative; however over the past several years OPG has developed an Enhanced Neutron Overpower Protection (E-NOP) analysis methodology in cooperation with industry partners which more accurately reflects plant conditions. This new methodology has been extensively assessed and evaluated by independent third parties, which concluded that E-NOP is superior to traditional NOP analysis methodology. E-NOP has been submitted to CNSC staff for acceptance as the approach OPG intends to use in future. In the interim, OPG has applied a Risk-Informed Decision-Making (RIDM) assessment to demonstrate acceptability of the currently installed trip set-points for Darlington through August 2017. These existing trip set-points provide adequate protection of the fuel and fuel channels.

Probabilistic Safety Analysis

The Darlington 'A' Risk Assessment (DARA) is a Probabilistic Safety Assessment (PSA) that is performed in accordance with CNSC Standard S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*. The S-294 compliant DARA was first completed in 2011 and has now been updated as described in the present CMD. The 2015 DARA update addresses Level 1 and Level 2 PSA aspects for various internal and external events, for both at-power and outage operating conditions, including internal events, internal fire, internal flood, seismic, high winds, as well as an external and internal hazard screening assessment.

The 2015 DARA update was performed consistent with the methodologies for which CNSC's acceptance has been obtained. The DARA reports submitted to CNSC staff demonstrate that the Darlington station satisfies OPG's safety goal limits for all internal and external hazards considered, and hence represents very low public risk. OPG continues to meet industry best practices through periodic updates to account for operating experience and changes at the station.

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

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

"Safety Goals" refer to a set of numerical values, expressed in terms of the frequency of severe core damage or large release events, which establish targets and limits for station design and operation. These goals represent the high standards of safety and reliability for nuclear power plant operations and are summarized below in Table 3-7.

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

Table 3-7
OPG Safety Goals Expressed as a Frequency

Implementation of REGDOC-2.4.2, Probabilistic Safety Assessment (PSA) for Nuclear Power Plants

OPG has committed to implement REGDOC-2.4.2 as per the transition plan provided to CNSC in 2014. This involves completion of the PSA work summarized in Tables 3-8 and 3-9 below, followed by a full DARA update within 5 years.

Summary of 2015 DARA Update

The baseline 2015 DARA update incorporates enhancements under the OPG Fukushima Action Plan, in particular Phase 1 Emergency Mitigating Equipment (EME). The impact of Safety Improvement Opportunities (SIOs) has also been considered in various sensitivity cases because these modifications will be implemented in the near future.

The Severe Core Damage Frequency (SCDF) and Large Release Frequency (LRF) values shown below are within OPG's safety goal limits for each of the internal and external hazards considered in the 2015 DARA update. The benefits of EME are incorporated into the baseline 2015 DARA results for SCDF and LRF as shown in Tables 3-8 and 3-9, respectively. Based on sensitivity studies in the 2015 DARA update, the estimated risk benefit of EME ranges up to a factor of 14 depending on the hazard scenario. Thus, the overall conclusion is that EME, as a physical improvement to plant safety, significantly reduces risk.

The 2015 DARA update also includes sensitivity studies on the impact of the SIOs on SCDF and LRF. The SIOs were developed as a result of performing the Environmental Assessment for the refurbishment and continued operation of Darlington NGS.

- *SIOs relevant to both SCDF and LRF reduction*: Emergency Power Generator 3, Emergency Heat Sink (firewater supply to support reactor decay heat removal capabilities), and Powerhouse Steam Venting System (PSVS) enhancements.

- *SIOs relevant to LRF reduction only*: Shield Tank Over-Pressure Protection System (STOP) and Containment Filtered Venting System (CFVS).

The 2015 DARA update results for SCDF and LRF, with credit of EMEs and SIOs, are shown in the right column of Table 3-8 and Table 3-9, respectively. It is important to note that these SIO sensitivity results are based on preliminary SIO design information; the risk estimates will need to be finalized in a future DARA update. In some cases, where shown by a "less than" symbol (<), the analysis simply shows a reduction in risk, details of which have not yet been quantified. Nonetheless, the approximate results indicate that the Darlington plant risk will be significantly reduced with the future implementation of SIOs. This constitutes part of OPG's action plan for continued improvement and risk reduction.

In accordance with OPG governance, the PSA results are compared to the OPG safety goals for individual hazards on a per-unit basis. As shown in Table 3-8, the SCDF for individual hazards is well below the OPG safety goal limit of 10^{-4} per reactor-yr. Moreover, the SCDF results are below the OPG safety goal target of 10^{-5} per reactor-yr, which is 10 times lower than the safety goal limit. Similarly, as shown in Table 3-9, the LRF for individual hazards is well below the OPG safety goal limit of 10^{-5} per reactor-yr. All of the LRF results are below the OPG safety goal target of 10^{-6} per reactor-yr, with the exception of seismic hazards. As such, in accordance with OPG governance, an action plan is required to further reduce the estimated seismic risk for Darlington NGS.

OPG's action plan to further reduce risk is to implement the Phase 2 EME as well as the committed SIOs. Phase 2 EME, as a defence in depth measure, includes provision of larger mobile generators to provide power supplies to re-establish heat sinks and manage water for the protection of containment as the event progresses. Once physical implementation is completed, and the detailed analysis is performed, it is expected that the preliminary estimates of SIO benefits can be improved and that Phase 2 EME will be shown to further reduce the plant risk. The action plan will also consider analytical improvements based on insights derived from the 2015 DARA update, as well as other station changes committed or in progress.

Tables 3-8 and 3-9 also show aggregated SCDF and LRF results for all hazards for a single unit, based on the method of simple addition. It is important to note that there is no widely accepted methodology for risk aggregation and that simple addition leads to overly-conservative results. As shown, this method of aggregation results in SCDF and LRF values that are still lower than the per-unit/ per-hazard based Safety Goal Limits.

Severe Core Damage Frequency (x 10^{-5} per reactor-yr)		
PSA Hazards	2015 DARA baseline (with EME)	2015 DARA (with EME & SIOs)
Internal Events at Power	0.23	0.14
Internal Events during Outage	0.10	0.05
Fire at Power	0.09	<0.09
Flood at Power	0.02	<0.02
Seismic Event at Power	0.37	0.14
High Winds at Power	0.22	0.08
Unit SCDF Aggregated across all hazards	0.93*	0.47*
Safety Goal Limit	10	10

* The aggregated SCDF excludes the SCDF for Internal Events during Outage since the Internal Events at Power results are bounding and assume that the unit is at full power 100% of the time.

Table 3-8
Severe Core Damage Frequency

Large Release Frequency (x 10^{-5} per reactor-yr)		
PSA Hazards	2015 DARA baseline (with EME)	2015 DARA (with EME & SIOs)
Internal Events at Power	0.10	0.04
Internal Events during Outage	<0.10	<0.05
Fire at Power	0.08	<0.08
Flood at Power	0.02	<0.02
Seismic Event at Power	0.28	<0.14
High Winds at Power	0.10	0.05
Unit LRF Aggregated across all hazards	0.58*	0.33*
Safety Goal Limit	1	1

* The aggregated LRF excludes the LRF for Internal Events during Outage since the Internal Events at Power results are bounding and assume that the unit is at full power 100% of the time.

Table 3-9
Large Release Frequency

OPG has committed that a summary of the 2015 DARA update will be posted publicly on www.OPG.com in August 2015 to enable public review and filing of interventions for the Darlington Part 2 licence renewal hearing.

Whole-site PSA Strategy

OPG is collaborating with other members of the Canadian nuclear industry in the development of a whole-site PSA methodology. A concept-level whole-site PSA methodology has been issued as a CANDU Owners Group (COG) document representing the common preliminary perspective of the industry. OPG has previously submitted the COG report, entitled *Development of a Whole-Site PSA Methodology*, to CNSC staff and posted the document on www.OPG.com.

A pilot application of the whole-site PSA methodology is planned to be completed for Pickering NGS by the end of 2017. The undertaking of this work is subject to further discussion and planning among COG members as well as feedback from the CNSC and international organizations. Lessons learned from this pilot will be reviewed for applicability to Darlington, and OPG will provide CNSC staff an update on whole-site PSA plans for Darlington by June 29, 2018.

In the meantime, a measure of the aggregated whole-site risk associated with Darlington NGS has been estimated using a simplified methodology accounting for all units and hazards. The results of this aggregated whole-site risk for LRF are as follows:

- 0.98×10^{-5} per year, which is better than OPG's per-unit/per-hazard safety goal limit
- 0.74×10^{-5} per year with SIOs, which is significantly better than OPG's per-unit/per-hazard safety goal limit

Whole-site risk aggregation was only considered for LRF as it is a more direct indicator of risk to the public. In contrast, SCDF is related to consequences of an event on the reactor, which is bounded by LRF from a whole-site risk perspective. A large release requires severe core damage to take place; however, in many cases, severe core damage would not result in a large release.

Severe Accident Management Guidelines (SAMG)

The implementation and continued refinement of the SAMG program is an important part of OPG's post-Fukushima follow-up project. Requirements for an effective SAMG program are outlined in CNSC Regulatory Document G-306, *Severe Accident Management Programs for Nuclear Reactors*.

OPG has completed extensive SAMG updates to specifically address multi-unit severe accidents, irradiated fuel bay severe accidents, lessons learned from Fukushima, and severe accidents from shutdown/low power states. The remaining work includes training for the SAMG updates and execution of a multi-unit severe accident drill for both Darlington and Pickering. Upon completion of these activities in December 2015, OPG will be in compliance with REGDOC-2.3.2, *Severe Accident Management Programs for Nuclear Reactors (2013)*, on schedule.

It is noted that a major emergency preparedness exercise, Exercise Unified Response, was conducted from May 26-28, 2014, involving successful integration of provincial, national and municipal entities in response to a postulated severe accident scenario. The results from this 3-day exercise demonstrated that OPG has a robust emergency preparedness program, well integrated with external emergency response organizations.

Hypothetical Severe Nuclear Accident and Effectiveness of Mitigation Measures

At the request of CNSC staff, OPG provided technical assistance in their study of the consequences of a hypothetical severe nuclear accident. This benchmark study examined the potential health effects of larger radiological releases. The DNGS case study demonstrated that Canadian nuclear power plants are protective of human health, even in the event of a more severe "Fukushima-like" radiological emission. The potential human health effects measured in the study, from doses similar in magnitude to those actually measured in the Fukushima event, were found to be very small, essentially not measureable, against natural background occurrence of cancer in Canada today. The Provincial Nuclear Emergency Response Plan (PNERP) was also found to be protective of public health, taking into considering the size of the protective zones, the conservative Protective Action Levels, and the focus on more sensitive receptors (e.g. children).

3.5 Physical Design

As shown in Table 3-10 below, CNSC staff have consistently assessed the Physical Design SCA as meeting relevant regulatory requirements and expectations.

2010	2011	2012	2013	2014
Satisfactory	Satisfactory	Satisfactory	Satisfactory	Satisfactory

Table 3-10
CNSC Ratings for Darlington's Physical Design SCA

Defence-in-Depth

The physical design of Darlington NGS incorporates a defence-in-depth approach with multiple redundant safety systems in place to ensure the safety of workers, the public, and the environment. With respect to fuel, five layers of defence-in-depth are in place to prevent radioactive exposure to the public. These are the fuel pellet, fuel sheath, heat transport system, containment system, and the 1km site exclusion zone.

Darlington NGS also has four special safety systems. Two independent and diverse shutdown systems which can shut down the reactor in less than two seconds by the addition of neutron-absorbing material; an Emergency Coolant Injection System, which ensures fuel cooling is maintained; and a Containment System, which includes a concrete vacuum building designed to prevent the release of radioactive material to the environment.

Darlington's design proven to be solid...

- ✓ Defence in depth approach with multiple safety systems
- ✓ Rigorous process for plant modifications
- ✓ Seismically robust and located in a low seismic risk area

Design Program

Darlington NGS has a design program that ensures the ability of systems, structures and components to meet and maintain their design basis function. The design program at OPG implements a series of processes, standards, and procedures for performing engineering work in a consistent manner across OPG Nuclear. The program establishes the following practices for engineering:

- Ensures each plant's configuration is maintained in accordance with the design and licensing basis, and operated within its Safe Operating Envelope (SOE)
- Ensures essential plant equipment performs safely and reliably
- Complies with relevant legal, statutory, and regulatory requirements

- Encourages continuous improvement in the conduct of engineering targeted at achieving safe, reliable and competitive operation of OPG Nuclear power generating stations

All design changes are prepared and executed in accordance with the OPG Engineering Change Control (ECC) process. The OPG programs and procedures have been written to ensure the ECC process complies with CSA N286.0, *Overall Quality Assurance Program Requirements for Nuclear Power Plants*, and all relevant legal and regulatory requirements. The ECC Program ensures all modifications to OPG Nuclear plant systems, structures, and components are planned, designed, installed, and commissioned within the parameters of the SOE, design basis, and plant licensing conditions.

The transition plan for CSA N290.0-11, *General Requirements for Safety Systems of Nuclear Power Plants*, was submitted to CNSC staff. Darlington will be in compliance with N290.0-11 by December 2015, on schedule.

Over the licence period, OPG has continued to make improvements to the Engineering Change Control (ECC) process and the supporting Design Management processes to incorporate enhancements identified through the Corrective Action Program, OPEX and benchmarking. Included in those improvements are changes to enhance control and oversight of engineering related work conducted under Engineer, Procure and Construct (EPC) processes.

Self assessments and audits completed through 2013 and 2014 noted an improving trend in design quality and overall compliance with ECC requirements as reflected in ECC site index improvement from 94.3% in 2013 to 98.5% in 2014. The improvement is due to many initiatives such as continued use of the Design Review Board, fleet-wide communication of lessons learned through the Design Managers Working Group and the Design Summit led by the Chief Nuclear Engineer and Chief Nuclear Officer. Additional initiatives include the formation of a Design Training Committee, the use of the Design Authority Grading Sheet and the Design Verification Checklist and Observation and Coaching database.

OPG and the University of Ontario Institute of Technology (UOIT) have combined to offer a graduate diploma in Nuclear Design Engineering, which provides staff with continuing technical training as well as interaction and networking within academic and power generation communities. As recognized by experts in the nuclear industry, this diploma program increases the capability of design staff by broadening their knowledge of nuclear systems and industry standards while encouraging a questioning attitude.

OPG's Engineering Department Managers teach at UOIT for Undergraduate programs. OPG industry partnership with UOIT provides Capstone / Thesis projects for students graduating with Undergraduate Engineering degrees. OPG engineers are also active members of many CSA and ASME committees including CSA N285.0, *General Requirements for Pressure-Retaining Systems And Components In CANDU Nuclear Power Plants*, and ASME B31.1, *Power Piping*. These committees provide forums for continuing improvements in industrial standards.

Through self assessments conducted in 2014, OPG has identified vendor documentation as an area for improvement in design quality. Through the Conduct of Engineering program, Vendor Oversight training was provided to all Engineering staff with a focus on a collaborative approach. This training included review of oversight procedures which assisted in clearly identifying roles, responsibilities and accountabilities of both the vendor and OPG employees.

OPG Supply Chain works with vendors and closely monitors vendor quality to ensure that the equipment procured meets design and quality requirements and that Darlington's expectation for quality are understood and met by suppliers.

Pressure Boundary Program

Pressure Boundary activities at Darlington are carried out in accordance with Codes and Standards as required by the PROL. Pressure Boundary work at Darlington is controlled in accordance with Pressure Boundary Quality Assurance Manual that complies with the applicable rules and quality requirements contained in CSA N285.0 and CSA B51 series standards.

Darlington maintains a Pressure Boundary Certificate of Authorization from TSSA to carry out Pressure Boundary activities as required by CSA N285.0. The Certificate of Authorization is renewed every three years after an extensive TSSA audit. Darlington routinely conducts Nuclear Oversight Audits, Independent External audits, and Internal Self Assessments to ensure compliance with relevant requirements. Darlington obtained a renewal of its Pressure Boundary Certificate of Authorization in February 2014, which remains valid through to April 2017. There were no significant findings in the last TSSA Certificate of Authorization Audit.

A Pressure Boundary Oversight Meeting is scheduled every month with stakeholders to review the Darlington Pressure Boundary Health Report. This report is prepared with defined health indicators. Any areas of concerns are addressed through the Corrective Action Program. The Pressure Boundary Nuclear Sites meeting is held every month where program issues concerning both Darlington and Pickering are addressed with corporate oversight. OPG leads the COG Pressure Boundary Group meetings to share experience and continuously improve the Pressure Boundary Program. OPG also actively participates in CSA N285.0/ B51 Technical Committees and the ASME Committees to support development of the Codes and Standards.

Environmental Qualification

The OPG equipment Environmental Qualification program defines activities to ensure that essential safety-related equipment, required to mitigate the consequences of a design basis accident, will perform its intended function when exposed to harsh environmental conditions resulting from that accident, and to maintain this capability over the life of the stations. This program also includes programmatic controls necessary to maintain the qualified status of equipment over the life of the plants.

Seismic Qualification

Although studies by the Geological Survey of Canada conclude that the Darlington station is located in a region of low seismic activity, the reactors and safety systems at Darlington NGS are designed and constructed to withstand a severe seismic event. As such, a seismic event is a Design Basis Event for which the Darlington station has dedicated equipment, systems and procedures for ensuring safe reactor shutdown and continuous fuel cooling.

3.6 Fitness for Service

As shown in Table 3-11 below, CNSC staff have consistently assessed the Fitness for Service SCA as meeting relevant regulatory requirements and expectations.

2010	2011	2012	2013	2014
Fully Satisfactory	Fully Satisfactory	Fully Satisfactory	Satisfactory	Satisfactory

Table 3-11
CNSC Ratings for Darlington's Fitness for Service SCA

OPG has several programs in place to ensure systems, structures, and components credited in licensing documents are fit for service and continue to satisfy their design intent over time in accordance with applicable CNSC regulatory documents and CSA standards. These programs ensure all equipment is available to perform its intended design function when called upon to do so. Routine on-power maintenance activities are performed on a daily basis, while other more complex tasks or inaccessible equipment require a unit shutdown, or 'outage' to perform required repairs or inspections. Various programs address long-term equipment reliability, including component surveillance, work management, and aging management programs. Major components such as fuel channels, feeders, and steam generators have specific life cycle management plans to address aging issues, which are communicated to CNSC staff on a routine basis. Inspections are also completed on reactor components and concrete structures to assure ongoing fitness for service. The various elements of the overall OPG fitness for service program are discussed in further detail below.

Maintenance

Darlington has a Conduct of Maintenance Program to ensure plant equipment is maintained to maximize reliability and avoid adverse operational impacts resulting from equipment failure. This objective is achieved through balancing emergent or immediate corrective maintenance needs with proactive preventive and predictive maintenance strategies intended to avoid failures before they occur. Scheduled work load consists largely of preventive maintenance, such as proactive component replacements or testing of poised equipment. Predictive maintenance involves diagnostic testing, such as infrared thermography or lubricating oil analysis, to detect signs of degradation well before equipment failure. A feedback loop has been established for all types of maintenance to learn from experience and continuously refine and improve the maintenance program.

Fitness for service of major components is confirmed...

- ✓ Equipment is well maintained to ensure performance requirements are met throughout life of plant
- ✓ Fuel channel life extended to at least 235,000 EFPH
- ✓ Periodic inspections confirm major components remain fit for service

Maintenance backlogs arise when available resources cannot complete all of the desired maintenance activities. Work activities are categorized and prioritized based on the nature of degradation/ deficiency as well as the importance of affected equipment to system operation. This categorization is based on the industry standard INPO AP-928, *Work Management Process Description*. This standard is also the basis for determining maintenance backlog targets for the station.

In an effort to reduce station backlog (fixing non-functioning or degraded equipment) that is typically executed while the unit is running, Darlington is undertaking a new initiative to add some of this on-line work into planned outage scope. This will increase overall maintenance and operations efficiency (i.e. when equipment is isolated under an outage permit, it makes sense to complete online work that can use the same permit). Also, this initiative will result in the unit being more reliable after it is placed back in service.

The Darlington maintenance organization has completed a transition to a days-based model where the majority of maintenance activities are scheduled on day shifts. This approach is aligned with industry best practice. Advantages of this approach include the ability to form specialty maintenance teams, reduced fatigue resulting from a rotating shift schedule, fewer turnovers and handoffs during a work activity, and reduction of re-work. This model also promotes accountability amongst the maintenance crews, who "own" the condition and performance of equipment for which they are responsible. This entails becoming familiar and efficient with the maintenance of equipment to the point where the crews begin to identify ways to minimize breakdowns, reduce repair times, and optimize preventive and predictive maintenance schedules. A cross-functional peer group has been established to investigate how work processes can be enhanced to further realize the full potential of a days-based maintenance model.

A new Darlington Maintenance facility has been constructed on site to provide improved shop facilities and state-of-the-art equipment to maintenance staff. The new facility includes shop space for various groups including the following:

- *Reactor maintenance*: reactor face and control rod mechanism mock-ups allow staff to train in realistic conditions that mimic actual field environment
- *Welding*: industry-best cut-off saw, metal shear, and metal brake machines allow more efficient fabrication of materials
- *Breaker overhaul & insulation*: new shop facilities have created more working space for crews to execute daily tasks
- *Relief valve*: new equipment allows testing at higher pressure set points, reducing off-site testing requirements

Darlington continues to utilize Dynamic Learning Activities (DLAs) as a training tool to continually improve human performance within the Maintenance organization. A DLA in Procedure Use and Adherence was conducted to increase awareness and reduce rework, and currently a DLA on supervisory observation skills and situational awareness is in progress with Maintenance staff.

Darlington plans to continue its capital investment in the station to improve equipment reliability through projects to replace and upgrade key equipment. Some examples include replacement of the travelling screens, which remove debris from cooling water from the lake, and pump motors, which drive the pumps that maintain flow in the Heat Transport System.

Outage Management

The scope of a typical Darlington planned unit outage begins with the identification of major scope based on Business Plan assumptions. Operating experience is used to proactively define which inspections and maintenance programs are required while a unit is shut down to ensure the unit runs safely and efficiently until the next planned outage. Key representatives from Operations and Engineering provide input into defining the major scope for planned outages.

Safety and quality are the top priorities in outage planning, and are paramount to successful outage execution. From a production perspective for planned outages, the three main considerations are scope, cost and duration. The right work needs to be in scope with resources being able to execute the outage within the allotted budget and timeframe. This is accomplished through a series of formal milestones established in a nuclear procedure. There are forty-five milestones in total beginning two years prior to the start of a planned outage. External utilities have benchmarked Darlington and adopted these milestones as part of their planning process.

The latest scheduled outage at Darlington (Unit 1, D1411) was completed six days prior to the original committed date to the energy grid with greater than 97% completion of scope – excellent performance.

Darlington has established a process to manage and execute forced outages in the event that a unit is unexpectedly taken offline, or if it is determined an outage is required prior to the end of the planned operating cycle. The Darlington outage department is always in a prepared state in that the projects are ready to go whenever a unit is unexpectedly shut down. There is a dedicated forced outage team to support the forced outages from start to finish.

Figure 3-7
Darlington Vacuum Building

The third Vacuum Building Outage (VBO) performed since Darlington was commissioned in 1991 is planned for the fall of 2015. The primary purpose of the VBO is to perform a pressure test of the containment structure and vacuum building and perform concrete inspections to ensure the integrity of the structure can last until the planned end of life of the station.

Equipment Reliability Program

Equipment Reliability is a key focus area for Darlington as the plant matures. A station equipment reliability plan is developed annually taking into account equipment performance and reliability data from the previous year. Reliability is affected primarily by equipment aging, particularly in the area of electrical and electronic equipment. Long term modification projects are in progress to address these issues, and "bridging" strategies have been developed to mitigate risk in the interim.

Improvement plans to address Equipment Reliability are included in the 2015 "Journey of Excellence" program. Specific initiatives will focus on maintenance backlog reduction, preventive maintenance indicators, and system health improvements. Oversight of equipment reliability is performed weekly by the Plant Health Committee, consisting of senior managers from Operations, Engineering, Maintenance, and several other organizations.

Component and Equipment Surveillance Program

The Component and Equipment Surveillance Program ensures that component and equipment performance support the safe, reliable and economic operation of OPG Nuclear facilities. Component and equipment health is evaluated and trended by means of technical evaluations, inspection, maintenance, and testing in accordance with licensing codes and standards.

Work Management Program

The Work Management Program ensures maintenance, modification, and testing activities are identified, prioritized, planned, scheduled, and executed to protect plant operational integrity. Corrective maintenance and modification activities are performed, where possible, during windows when affected equipment has been removed from service.

All work in the plant (both online and during an outage) is regularly reviewed weeks in advance, and just prior to execution to evaluate and mitigate impacts to Nuclear Safety. Potential challenges are identified early and discussed with stakeholders regularly to allow rescheduling of work and ensure mitigating actions are put in place to minimize any increase in risk.

Integrated Aging Management Program

OPG's Integrated Aging Management Program is comprised of a set of programs and activities to ensure performance requirements of critical equipment are met on an ongoing basis. This program, which is aligned with International Atomic Energy Agency (IAEA) Safety Guide NS-G-2.12, *Ageing Management for Nuclear Power Plants*, and REGDOC-2.6.3, *Aging Management*, confirms the effectiveness of the constituent programs by periodically completing aging management plans for critical components.

These aging management plans supplement the ongoing engineering surveillance activities in place to monitor and optimize system performance. From these plans, actions are established to ensure equipment performance requirements are met throughout the life of the station.

The transition plan for REGDOC-2.6.3 has been submitted to CNSC staff, and Darlington will be in full compliance by July 15, 2017. This will enhance and integrate the management of physical aging and obsolescence of structures, systems and components important to safety over the full life cycle of the plant.

Major Components Program

The Major Components Program establishes a formal and systematic process for the life cycle management of major components including Fuel Channels, Feeders, Steam Generators, and Reactor Components and Structures. This program provides a framework for integrating and reporting of the component performance, condition, and compliance with design basis documents. The objective is to ensure that these major components perform safely and reliably over the life of the station, maintaining the design and licensing basis.

Fuel Channels

Darlington has a fuel channel life cycle management plan whose implementation allows OPG to continue to meet the licensing basis for Darlington NGS as specified in CSA N285.4, *Periodic Inspection of CANDU Nuclear Power Plant Components,* and CSA N285.8, *Technical requirements for in-service evaluation of zirconium alloy pressure tubes in CANDU reactors,* during the requested licence period.

This plan provides the basis and specification for ongoing inspection and maintenance requirements for fuel channels, and the strategy to ensure that fuel channels remain fit for service. The plan provides OPG continued assurance that the fuel channels will remain within licence requirements until the time when each unit will be removed from service for refurbishment.

Routine inspections and material surveillance activities include inspecting the fuel channels during outages, modeling future degradation based on inspection results, and laboratory testing of materials removed from the reactor core. The extent of the inspections and testing exceeds the requirements of CSA N285.4. All results are submitted to CNSC along with the associated analysis that supports ongoing fitness-for-service. The plan is updated annually to incorporate inspection results, operating experience from industry and results from R&D and is provided to CNSC staff. Ongoing inspections, maintenance and testing will continue to confirm fitness for service of pressure tubes and spacers throughout the life of the plant.

Fuel Channel Life Management Project

OPG is actively leading the industry and has assigned considerable resources to the Fuel Channel Life Management Project (FCLMP) and other fuel channel research and development (R&D) activities. The focus of the FCLMP is to prioritize and perform the work needed to support the long-term operation of the Darlington fuel channels. The work completed as part of the FCLMP includes:

- Assessment of fuel channel aging, with improved assessment methodologies and predictive models,
- The development of a plan for the management of Inconel X-750 spacers, and
- The development of Inconel X-750 annulus spacer structural and engineering models, enabling the projection of spacer properties and fitness for service over the remaining service life.

The improved assessment methodologies and predictive models developed from extensive R&D testing and analysis have been integrated into the routine process of life cycle management, consistent with aging management principles.

Through the implementation of fuel channel aging management processes and strategies, OPG has obtained the information required to assess fuel channel pressure tube fitness for service and predict component properties later in life. Based on this work, and confirmatory actions in the life cycle management plans for assuring ongoing fitness for service, OPG is confident in the continued safe operation of the fuel channel components and spacers to at least the end of Darlington's pre-refurbishment service life.

Table 3-12 provides the Equivalent Full Power Hour (EFPH) projections for Darlington units at the start of their planned Refurbishment outages per the latest revision of the Fuel Channels Life Cycle Management Plan.

Darlington Unit	Approximate EFPH at Planned Refurbishment Outage*
Unit 1	222,000
Unit 2	188,000
Unit 3	208,000
Unit 4	227,000

* Assuming the current inspection and maintenance outage schedule and business plan Forced Loss Rate (FLR)

Table 3-12
Approximate EFPH at Planned Refurbishment Outage

CNSC staff have concurred with OPG's position that the Darlington fuel channel components are safe to continue operating to at least 235,000 EFPH, which has been established as the business plan target for the pre-refurbishment life of the Darlington

units. OPG has mitigation strategies in place for the active degradation mechanisms that affect fuel channel components, and we have not identified a degradation mechanism that would prevent us from operating beyond 235,000 EFPH, if there were a business decision to do so. OPG will continue to confirm fitness for service of pressure tubes and spacers through ongoing inspection and maintenance activities that are mandated by a rigorous aging management process. Inspection and assessment reports will continue to be provided to CNSC, consistent with reporting requirements and OPG regulatory commitments.

Based on results from inspections and the strategy in the life cycle management plan, the Darlington pressure tubes will remain within licence requirements until the time when each unit will be removed from service for refurbishment.

Feeders

The life cycle management plan for feeders specifies requirements for inspections of feeder piping and extensive visual inspections of feeder support components. This inspection and maintenance plan is forward-looking and defines the activities required to demonstrate feeder fitness-for-service to unit refurbishment. The plan is revised on an annual basis to incorporate changes to these requirements that may be warranted from inspection or assessment results.

Feeder wall thickness measurements acquired during inspections are used to predict wall thickness at the time of the next planned outage. At all times, wall thickness is confirmed to be above the minimum required thickness for fitness-for-service. Feeder inspections results and fitness-for-service assessments are submitted to CNSC in accordance with licence requirements. When engineering assessment of inspection results predicts that feeder fitness-for-service cannot be assured, a feeder replacement is performed.

Based on results from inspections of feeders and feeder support components and the strategy in the life cycle management plan, OPG is confident that the feeders will remain within licence requirements until the time when each unit will be removed from service for refurbishment.

Steam Generators

The life cycle management plan for steam generators provides a forward looking plan for all required activities during planned outages and refurbishment outages, implementing industry best practices and industry OPEX in the steam generator inspection program.

OPG inspects steam generator tubes and internals every planned outage to confirm the steam generators remain fit for service until the next planned inspection. OPG works with EPRI, COG and CSA to maintain industry best practices and industry OPEX for steam generator inspections and assessments.

OPG has performed a detailed analysis and concluded that the steam generators do not need to be replaced during unit refurbishment as it is expected that fitness for service will

continue to be demonstrated for the life of the station. To facilitate enhanced inspection capability moving forward, inspection ports will be installed on the steam generators during the refurbishment outage.

Reactor Components & Structures

The life cycle management plan for reactor components and structures is a forward looking plan for all required activities to address any fitness for service considerations in other key component areas including the calandria assembly, end shield assemblies, reactivity mechanisms, calandria supports, calandria relief ducts, and calandria tubes.

This plan provides the basis and specification for ongoing inspection and maintenance requirements for reactor components and structures, and the strategy to ensure that reactor components remain fit for service. The plan provides continued assurance that the reactor components and structures will remain within licence requirements until the time when each unit will be removed from service for refurbishment. It is updated annually to incorporate inspection results, OPEX from industry and results from R&D.

Based on results from inspections of reactor components and structures and considering the strategy in the life cycle management plan, OPG is confident that they will remain within licence requirements until unit refurbishment. Furthermore, OPG has concluded that the reactor components and structures do not need to be replaced during unit refurbishment as it is expected that fitness for service will continue to be demonstrated for the life of the station.

Containment Structures

An aging management plan for containment structures was developed based on CNSC Regulatory Document RD-334, *Aging Management for Nuclear Power Plants*, OPEX from CANDU plants and outside the industry, COG, and other industry leaders such as the IAEA. This plan evaluates the programs and practices currently in place at OPG that create a systematic and integrated approach to manage aging of containment structures. Documentation of lessons learned is based on inspection and testing programs and is used to determine the overall effectiveness and complete the cycle of a systematic and integrated approach to manage aging.

The concrete containment structures at Darlington are periodically inspected to confirm the integrity of the entire concrete containment boundary in accordance with CSA N287.7, *In-Service Examination and Testing Requirements for Concrete Containment Structures for CANDU Nuclear Power Plant Components*. Leak rate test results from the 2009 Vacuum Building outage confirmed that the vacuum structure was leak tight and the leakage rate was within specification.

The inspection results from each unit's concrete containment structure inspection campaigns conducted during the planned unit maintenance outages were compared to previous inspection results. No significant changes were observed in the trending and the concrete containment structures were confirmed to be performing satisfactorily.

3.7 Radiation Protection

As shown in Table 3-13 below, CNSC staff have consistently assessed the Radiation Protection SCA as exceeding regulatory requirements and expectations.

2010	2011	2012	2013	2014
Fully Satisfactory	Fully Satisfactory	Fully Satisfactory	Fully Satisfactory	Fully Satisfactory

Table 3-13
CNSC Ratings for Darlington's Radiation Protection SCA

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

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

In terms of protecting the public, the Radiation Protection program prevents the uncontrolled release of contamination or radioactive materials from the site by controls and monitoring of people and materials.

OPG's Radiation Protection program ensures...

- ✓ Darlington's radiation safety performance among industry best
- ✓ Employee radiation dose always kept well below regulatory limits
- ✓ State-of-the-art equipment used to minimize exposure to radiation

Worker Dose Control

Worker exposures are planned and managed to ensure doses are kept well below regulatory limits and to ensure unplanned exposures are avoided. This ensures individual risk from lifetime radiation exposure is kept to an acceptable level.

The worker dose control program at Darlington is managed through the following processes:

- limiting individual worker dose
- assessing hazards and maintaining knowledge of conditions
- planning radioactive work to keep exposures ALARA and preventing unplanned exposures
- using best practices and RP procedures during radioactive work performance
- controlling the use of licensed radioactive devices and equipment

There were no radiation exposures at Darlington that exceeded regulatory or the much more stringent administrative dose limits during the licensing period.

Since 2009, there have been improvements in the lowest level "precursor" indicators related to worker dose control such as the number of electronic personal dosimeter dose and dose rate alarms and precursor tritium uptakes, which have generally trended downwards and are consistent with industry benchmarks. This is attributed to improved line accountability and focus on preventing alarms. See Figure 3-8 below.

For example, significant improvements in precursor-level tritium uptake events have been obtained due to focus on reinforcing the right protective measures to be taken and actions to reduce tritium hazards in confinement and containment rooms. Challenging targets are established each year to drive continual improvement.

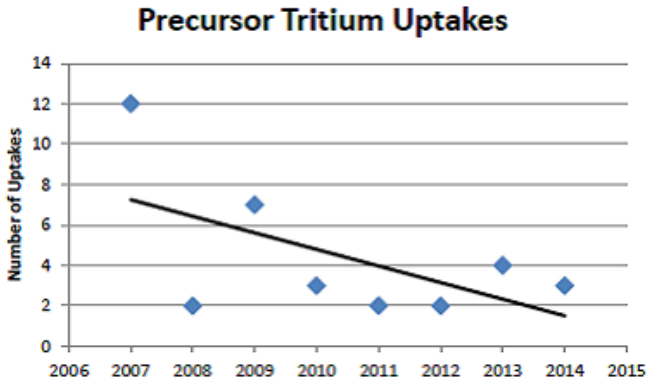


Figure 3-8
Precursor Tritium Uptakes

Successful achievements in reducing dose during the licensing period include:

- Tritium dose reduction by innovative plant equipment alignments and use of portable driers

Figure 3-9
Example of a portable drier

- An industry best practice program was implemented for alpha hazard classification and control. This program includes the provision of alpha monitoring instruments,

increased surveys to measure surface and air-borne alpha contamination, and the use of personal air samplers to measure alpha uptakes as per radiological exposure permit requirements.

- A four-fold reduction in reactor face dose rate was achieved by installing a combination of overhead shielding canopy and end fitting shielding tiles (see below).

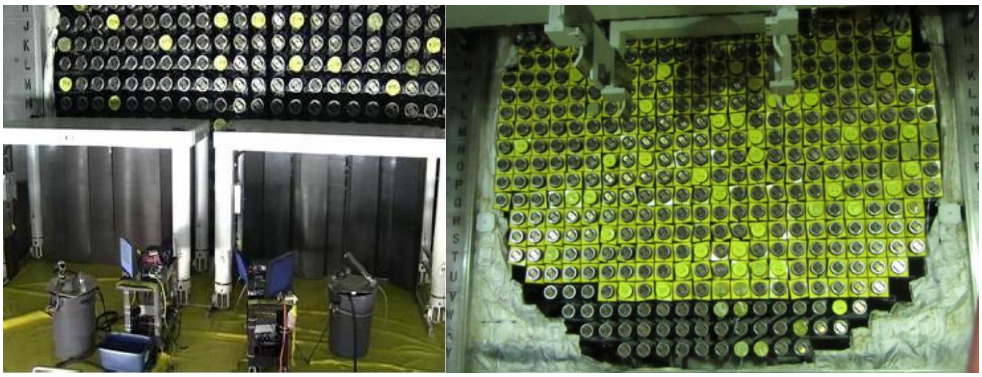


Figure 3-10
Examples of shielding used at Darlington during outages

- The use of remote real time gamma and tritium monitors during outages has reduced dose by minimizing the need for a person to enter containment and manually perform routine gamma and tritium surveys.

Collective Radiation Exposure (CRE) is the industry standard measure of the effectiveness of the ALARA program. As shown in Figure 3-11, Darlington's CRE performance of 699 mSv/unit in 2014, averaged over three years from 2012 to 2014, is significantly better than the CANDU industry standard of 800 mSv/unit.

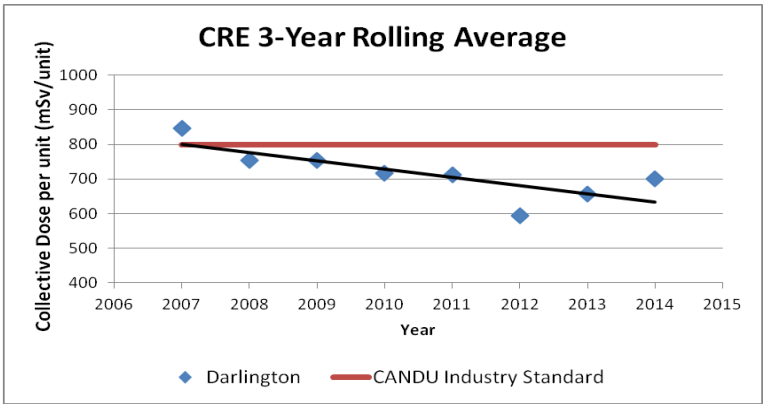


Figure 3-11
Collective Radiation Exposure 3 Year Rolling Average

The use of remote monitoring and teledosimetry is a key component of the ALARA program. The installation of remote monitoring equipment has improved radioactive work planning and reduced dose to workers. Remotely operated cameras have been used

to perform visual inspections and monitoring of inaccessible areas. Remotely operated robotic equipment will continue to be used to mitigate high dose rate projects.

The use of new technologies such as pulsed x-ray equipment is being implemented. The use of this equipment will reduce the risk of exposures to those performing radiography and potential risks to workers in the rest of the plant.

Figure 3-12
New Pulsed X-Ray device and X-ray survey meter

Contamination Control

The RP Program prevents the uncontrolled release of contamination or radioactive materials from the site by on-site controls and monitoring of people and materials. These measures control occupational exposure to contamination and prevent public exposures. The contamination control program ensures that contamination is prevented from leaving the radiologically controlled area, and that the spread of contamination within this area is minimized.

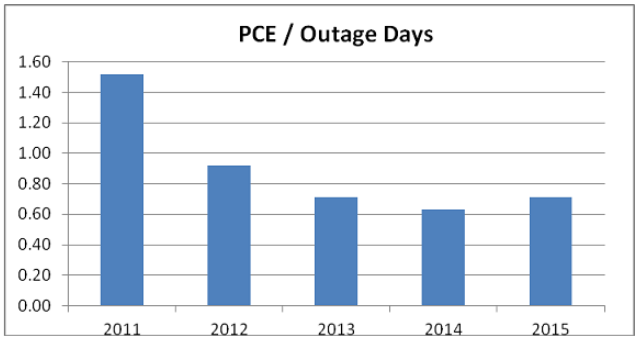
Since 2010, Darlington's contamination control program has been enhanced as part of continuous improvement through the following measures among others:

- Increased clarity of contamination control boundary delineation and positioning of contamination control monitoring equipment. This included the use of hard barriers and painted instructions on floor surfaces to reinforce the worker understanding of monitoring requirements. Computer aided training was included as part of the communication strategy.

Figure 3-13
Zone Boundary Monitors, Floor Markings and Barriers

- Benchmarking industry best practices in regards to exit monitor programs and lowering the alarm set points on exit whole body monitors from the plant. The best plants were benchmarked for alarm set points and monitor testing practices. The exit monitor alarm set points at Darlington have been reduced by 36% to be in line with the industry best.

The primary industry indicator for contamination control performance is the number of Personal Contamination Events (PCEs). Contamination control improvements, coupled with increased field oversight, have resulted in reduction in the number of PCEs. The PCE count at Darlington has shown an overall downward trend over the last several years as shown in Figure 3-14 below, and is consistent with industry benchmarks.



*2015 value projected for year including Vacuum Building Outage

Figure 3-14
PCE Trend per Outage Days

Darlington Nuclear will continue to drive improvements in the area of contamination control. Future plans include the following:

- Implementation of new hand and foot and whole body monitors with improved technologies to monitor for alpha contamination, and improved reliability.

- Dedicating additional resources to focus on refurbishment plans, preparation and execution. A full parallel Radiation Protection department that mirrors the station structure at Darlington is in place and being expanded upon to support the refurbishment evolution in a focussed and dedicated manner.

- Use of additional enhanced automated air samplers for airborne radioactivity.

3.8 Conventional Health and Safety

As shown in Table 3-14 below, CNSC staff have consistently assessed the Conventional Health and Safety SCA as meeting relevant regulatory requirements and expectations.

2010	2011	2012	2013	2014
Fully Satisfactory	Fully Satisfactory	Fully Satisfactory	Fully Satisfactory	Satisfactory

Table 3-14
CNSC Ratings for Darlington's Conventional Health and Safety SCA

The goal of OPG's Health and Safety Program is to ensure that safety is the number one priority and conventional risks in the workplace are managed accordingly.

Health and Safety Program Improvements

In 2014, OPG moved to a centre-led single OPG Health and Safety Management System (HSMS), adopting best practices from each of the business unit programs to develop a single, more robust HSMS. Examples of best practices adopted in the new HSMS include formalization of the full Safe Work Planning Process to encompass worker understanding of assigned work activities, identified hazards, safe work expectations, and mitigating efforts established to minimize the risk including use of the Job Safety Analysis.

The first independent 3rd Party Audit of the new OPG-wide HSMS will take place in 2015. Any findings from this audit will be reviewed and incorporated as appropriate into the continuous improvement of OPG's HSMS.

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

- ✓ Over 4 million hours worked without a lost time injury
- ✓ Total Health program promotes health and well-being for all employees
- ✓ Numerous awards and recognition from external associations

OPG has received national recognition from the Canadian Electricity Association (CEA) for its outstanding safety performance. At the CEA's annual award reception held in Ottawa on Nov. 5, 2014, OPG was presented with a CEA President's Bronze Award for Safety Excellence in 2013. This is the third consecutive year OPG has received an award for its safety performance from the CEA, having been recognized for performance in 2011 and 2012, and the second time that OPG has received the CEA President's Bronze Award. Initiated in 1995, these awards are presented to CEA member organizations ranked at the very top of the electricity industry in terms of employee safety.

Figure 3-15
OPG receives national award from Canadian Electricity Association
for outstanding safety performance

Accident/Injury Performance

Darlington's All Injury Rate has been better than target since 2010 and the site has reached 4 million hours without a lost time injury. With an injury-free 2015, Darlington would attain approximately 6.9 million hours by December 31, 2015.

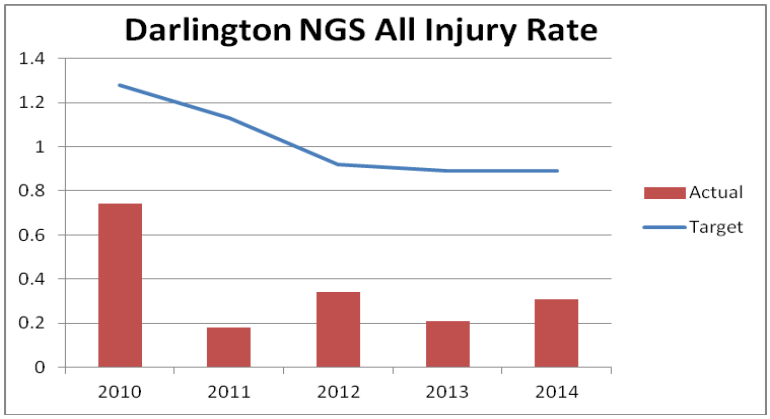


Figure 3-16
Darlington NGS All Injury Rate

In 2014, conventional health and safety focus areas at Darlington were situational awareness and prevention of slips, trips and falls.

The situational awareness initiative was a multi faceted plan that included training, awareness communications, and face-to-face roll outs at the supervisor and crew levels. The expectation is for all staff to perform a quality "2-Minute Job-Site Drill," which requires employees to confirm all hazards surrounding their work locations are eliminated or have adequate controls in place before commencing work.

The “slips, trips and falls” initiative concentrated on preventing slips during the winter season in parking lots and entrance ways, as well as preventing slips and trips in the station. It included snow and salting plans for the winter months, observation and coaching for appropriate footwear, and walking behaviours as well as a housekeeping focus during outage periods. A Self Assessment conducted in early 2015 confirmed that this initiative was successful at decreasing the number of slip and fall events.

In September 2014, OPG Health and Safety launched the Total Health Initiative. This initiative provides a host of resources and information to support OPG employees and their families in their efforts to achieve an optimal level of physical and mental health and well-being, primarily through health education, health promotion, disease and injury prevention, and crisis intervention.

3.9 Environmental Protection

As shown in Table 3-15 below, CNSC staff have consistently assessed the Environmental Protection SCA as meeting all relevant regulatory requirements and expectations.

2010	2011	2012	2013	2014
Satisfactory	Satisfactory	Satisfactory	Satisfactory	Satisfactory

Table 3-15
CNSC Ratings for Darlington's Environmental Protection SCA

Environmental Management System (EMS)

OPG has established an EMS to sustain high level performance in all areas of environmental protection. Darlington was the first Nuclear Generating Station in North America to achieve EMS compliance with ISO 14001, *Environmental Management*. Darlington continues to work to prevent or mitigate adverse effects on the environment with a long term objective of continual improvement in its EMS and environmental performance. Verification of DNGS ongoing compliance will be completed in the fall of 2015.

OPG understands the importance of environmental stewardship...

- ✓ Internal performance targets set significantly more stringent than regulatory requirements
- ✓ Public dose remains a fraction of 1% of the regulatory limit
- ✓ Environmental releases are monitored, and results made available to the public
- ✓ Programs to support wildlife diversity and habitat

Continual improvement in environmental performance at Darlington is achieved by committing to leading edge performance targets on emissions and protection of the significant natural areas and associated species of interest / concern on site. DNGS routinely updates stakeholders on its environmental performance in face to face discussions and on our website. OPG's Performance Report for Darlington Nuclear, and the Environmental Emissions Data Reports for OPG Nuclear facilities, including Darington NGS, are published quarterly on www.OPG.com to promote public awareness and engagement. OPG's Environmental Policy and Sustainable Development Report are also posted online each year.

OPG Environmental Policy confirms OPG shall meet all legal requirements and any environmental commitments that it makes, with the objective of exceeding these legal requirements where it makes business sense. The Policy requires OPG to:

- Establish an EMS and maintain registration for this system to the ISO 14001 standard

- Work to prevent or mitigate adverse effects on the environment with a long-term objective of continual improvement in environmental performance
- Manage its sites in a manner that strives to maintain, or enhance where it makes business sense, significant natural areas and associated species of concern. OPG will work with community partners to support regional ecosystems and biodiversity through science-based habitat stewardship
- Set environmental performance targets on an annual basis and monitor performance against these targets
- Communicate its environmental performance to employees, governments, local communities, and other stakeholders

Figure 3-17
OPG President and CEO Tom Mitchell accepts certificate of registration for OPG's EMS

Radioactive Emission Control

Darlington's emission control programs are based on the guiding principle of As Low As Reasonably Achievable (ALARA) to minimize radiation impacts to the environment and the public. All radioactive emissions to air and to water during the licensing period were less than 0.5% of station Derived Release Limits (DRLs), established in accordance with CSA N288.1-08, *Guidelines for Calculating Derived Release Limits for Radioactive Material in Airborne and Liquid Effluents for Normal Operation of Nuclear Facilities*.

Darlington has consistently maintained the annual public dose resulting from station operations at a level that is equivalent to 0.1% of the regulatory dose limit of 1,000 uSv/year, and less than 0.1% of the estimated annual average background radiation around DNGS of 1,400 uSv/year.

Environmental Monitoring Program (EMP)

Darlington's EMP is maintained in accordance with the requirements of CSA N288.4, *Environmental Monitoring program class I nuclear facilities and uranium mines and mills*. Darlington is in the process of updating its Environmental Emissions Monitoring Program to be consistent with the requirements of CSA N288.5, *Effluent Monitoring programs at Class I nuclear facilities and uranium mines*. These programs are based on information obtained from the most recent Environmental Risk Assessments (ERAs) conducted as part of the Darlington Environmental Assessment for refurbishment and continued operation.

In addition to summarizing the routine EMP, the "2014 Results of Environmental Monitoring Programs" report highlights the results of supplementary studies performed to confirm and/or clarify ERA predictions. In 2014, these studies focused on total residual chlorine concentrations in the lake as a result of chlorination at the station to limit zebra mussel infestations, and morpholine concentrations in the lake as a result of boiler

maintenance. The results of both studies indicated that none of the lake water samples approached the conservative benchmarks established for all receptors, and therefore no ecological effects are expected from the low emission rates associated with ongoing plant operations.

Groundwater Monitoring

Darlington has an established groundwater monitoring program designed to ensure that there are no adverse off-site impacts from contaminants in groundwater and this program has shown minimal groundwater contamination around the Darlington site. In 2014, the environmental site assessment was completed regarding the 2009 Injection Water Storage Tank (IWST) spill. The assessment concluded that the environmental effects from tritium contamination did not present any risk to human health or the environment around DNGS, the contamination has decreased, and that it will fully dissipate by 2020. No measurable change in drinking water quality has been measured in the lake or at the nearest drinking water supply plant as a result of the initial spill or in subsequent years.

The 2014 annual average tritum concentrations in drinking water remained very low, well below OPG's commitment of 100Bq/L. 2015 has seen a continued focus on tritium emission reduction through improved equipment performance, leak search and emphasis on leak management.

Darlington's water supply has been upgraded to be fully connected and in service from both the east (Bowmanville) and the west (Oshawa). The new sewer system is also now in service, connected to the Courtice Water Pollution Control Plant. As a result, the old Darlington Sewage Treatment Plant is disconnected and is being dismantled.

Spill Management and Response

Darlington has extensive programs to ensure the risk of spills to the environment is effectively managed, with a primary focus on prevention. As a result, Darlington has seen improved performance in spill management with no significant spills for the past five years. Two minor spills were reported to regulatory authorities in 2014 and were discussed with the Commission. Neither of the spills resulted in a measurable effect on the environment. No reportable spills have occurred in 2015 to date.

Darlington has a liquid emergency response protocol in case of an abnormal waterborne tritium release. Response capabilities are assessed through drill exercises. Some of the key aspects of the protocol are:

- Multiple redundant monitoring points for prompt identification of an abnormal waterborne tritium emission
- Clearly identified actions and predetermined decision criteria
- Communication with key stakeholders

Fish Impingement and Entrainment

Darlington's cooling water intake and discharge systems are located near the lake bottom in order to minimize impingement and entrainment of fish. Darlington's discharge duct design includes a diffuser type discharge duct to dissipate water from the station, thus reducing the impact on thermal emissions to Lake Ontario.

OPG continues to participate in the Round Whitefish Action Plan with the CNSC, Ministry of Natural Resources, Fisheries and Oceans Canada (DFO), and Environment Canada. As part of this effort, OPG has confirmed to Federal and Provincial Agencies that thermal emissions from Darlington are a low risk to Round Whitefish eggs and larvae and that no further mitigation or offsetting is warranted going forward.

OPG has continued to participate in the ongoing study of Round Whitefish under the leadership of the Ontario Ministry of Natural Resources and Forests. OPG has agreed to work collaboratively with the Ministry to collect samples of Round Whitefish in the vicinity of Darlington NGS, as part of a meta-population study, to better understand the population dynamics of this species in Lake Ontario.

OPG has also submitted its application to the DFO for a Fisheries Act authorization, and has implemented offsets to compensate for any potential aquatic impacts arising from the operation of Darlington NGS through the licence term. In June 2015, DFO issued a Fisheries Act authorization for continued operation of the Darlington NGS lake water cooling system.

To address the potential ongoing effects of DNGS continued operations, OPG has implemented a habitat restoration project to address requirements established by the DFO. As a result OPG has undertaken the restoration of aquatic habitat in the Big Island Wetland, managed by the Quinte Conservation Authority. OPGs restoration of this deteriorated coastal wetland is now complete, creating 5 hectares of open channels and 12 hectares of linked ponds connected to the Bay of Quinte. Monitoring in 2014 demonstrated that the improvements to the aquatic habitat produce many more fish annually than are potentially affected by the ongoing operation of DNGS.

As outlined above, the elements of the OPG EA Follow-up Monitoring Program are being implemented consistent within the appropriate timeframes accepted by the CNSC and committed to in the IIP.

Land and Habitat Management

The Darlington site covers more than 1,000 acres and is host to over 900 species of plants and animals. A natural habitat monitoring program has been implemented for birds, amphibians, and bats. The bird monitoring program in particular has data for more than 15 years and has been conducted using the same protocol for all of those years, providing an extensive baseline database for the lakeshore environment in Durham.

OPG maintains an ecological constraints map for the Darlington site to assist project teams, contractors, and Darlington operations staff in ensuring awareness of regulatory compliance issues, and to assist staff in maintaining updated information regarding the locations of significant flora and fauna across the site.

Under OPG's biodiversity program, Darlington site maintains a 3-year biodiversity management plan for beyond compliance biodiversity management for priority natural areas on the Darlington site.

Darlington is certified by the Wildlife Habitat Council (WHC) under its Wildlife at Work program and is a repeat recipient of the "Corporate Habitat of the Year" award for successful implementation and maintenance of a comprehensive wildlife habitat management program and a commitment to long-term wildlife habitat enhancement. Darlington is also certified under the WHC Corporate Lands for Learning Program, which focuses on community partnerships, enriching environmental educational opportunities, and increased community use of the Waterfront Trail.

In cooperation with the Minstry of Transportation's highway 407 project activities parallel to the South Service Road and OPG property, and with the cooperation of the Municipality of Clarington, the Waterfront Trail Association and Darlington's Community Advisory Committee, the waterfront trail is being realigned, widened, paved, and relandscaped.

Figure 3-18
Darlington's biodiversity efforts were recognized at the 26th Annual Wildlife habitat council Symposium

Community and Stakeholder Relations

OPG maintains a community relations program that proactively provides information to the general public, elected officials, media, labour unions and employees. Information posted relates to various topics including station operation, participation and involvement in the community and the general nature and anticipated effects on the environment and the health and safety of persons that may result from station operations.

In 2013, Darlington staff partnered with the Get to Know program, which encourages young people to Connect with nature, celebrate their Commitment to the environment

and Create art (the three Cs). Through this innovative program, young people learn about the importance of sustainability and biodiversity in their communities, and they are empowered through knowledge and creativity to become environmental guardians.

Darlington staff participate in community events such as: Clean up of the Courtice Millennium trail; Darlington Scout Tree Planting; Migratory bird surveys; Amphibian monitoring; and Durham Children's Groundwater Festival.

Additional details on community and stakeholder relations are provided in Section 4.5.

Figure 3-19
Darlington's "Getting to Know Nature Program"
provides a learning opportunity for young children

3.10 Emergency Management and Fire Protection

As shown in Table 3-16 below, CNSC staff have consistently assessed the Emergency Management and Fire Protection SCA as meeting all relevant regulatory requirements and expectations.

2010	2011	2012	2013	2014
Satisfactory	Satisfactory	Satisfactory	Satisfactory	Satisfactory

Table 3-16
CNSC Ratings for Darlington's Emergency Management and Fire Protection SCA

Emergency Preparedness Program and Drills

The Nuclear Emergency Preparedness program is documented in OPG's Consolidated Nuclear Emergency Plan (CNEP). This plan serves as the basis for site-specific nuclear emergency preparedness and response arrangement at OPG's Nuclear generating stations. It describes concepts, structures, roles and processes to implement and maintain an effective OPG response in the unlikely event of a nuclear emergency that could endanger onsite staff, the public, or the environment. It provides a framework for interaction with external authorities and defines OPG commitments under the Provincial Nuclear Emergency Response Plan (PNERP).

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

- ✓ OPG has robust emergency preparedness plans integrated with the Province/ Municipality
- ✓ "Exercise Unified Response" demonstrated readiness on a large scale
- ✓ Predistribution of KI pills complete by end of 2015
- ✓ State of the art fire training facility

As an overview, in the unlikely event of an emergency at a nuclear power station, OPG would perform the appropriate notifications to the Province, CNSC, local municipalities, etc per procedures. OPG takes actions to control and mitigate the emergency on-site and minimize off-site effects. The Province under the PNERP takes actions to notify and protect the public, including direction on sheltering, potassium iodide ingestion, or evacuation. The local municipalities, police etc also have key roles such as guiding members of the public should an evacuation be required. The roles of these and a range of other organizations are integrated to ensure effective emergency measures are in place (see Figure 3-20).

In order to demonstrate OPG's emergency response capability, Darlington maintains an extensive Emergency Preparedness drill and exercise program. This program validates emergency plans and procedures, and provides OPG's Emergency Response Organization (ERO) the opportunity to improve and sustain their emergency response capability.

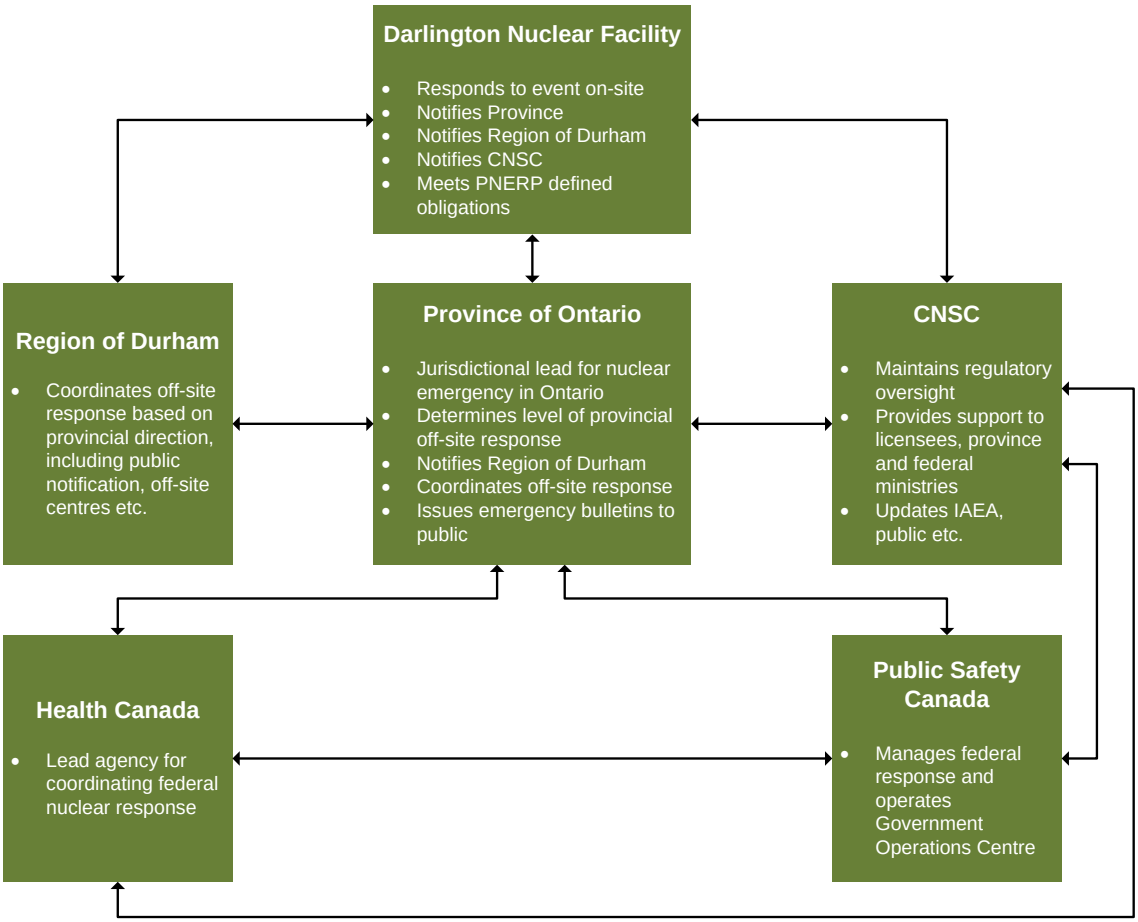


Figure 3-20
Emergency Response Agency Interactions

To test and demonstrate the integration of effective emergency response across the many organizations which would be involved, in May 2014 OPG executed "Exercise Unified Response". This exercise assessed the preparedness of OPG and government agencies at federal, provincial, and municipal levels to respond to a simulated severe nuclear event with off-site releases at the Darlington station. This exercise involved over 2000 participants and 54 agencies over three days. The exercise was very successful and demonstrated the integration of nuclear response plans at all levels of government. Agencies continue to improve their plans as a result of lessons learned in Exercise Unified Response. A summary of lessons learned was also presented to the CNSC Commission in a public meeting in Ottawa on November 5, 2014.

Figure 3-21
"Exercise Unified Response" Montage

Since mid 2014, OPG has increased focus on the scheduling and scenario development of drills and exercises to allow for more integrated participation from Fire and Security response organizations. Three integrated drills were conducted at Darlington in 2014, with an additional seven scheduled in 2015. Learnings from drills and exercises are documented and used to improve processes and training programs. Furthermore, benchmarking industry best practices in the area of drills and exercises as well as drill realism has been a focus over the last few years.

Figure 3-22
Darlington EME Portable Pumps and Fire Trucks

Figure 3-23
Workers connecting hoses during EME Drill

OPG's readiness to respond to a Beyond Design Basis Event (BDBE) has been recognized as industry leading. Emergency Mitigation Equipment (EME) is available at both Darlington and Pickering sites, procedures are issued, staff are trained, and response has been practiced in a number of drills and exercises (see Figures 3-22 and 3-23 above).

In 2012, OPG completed the installation of automated gamma monitors for in-plant and near boundary radiation monitoring which reduces the need for staff performing manual radiation surveys following a station event. There are now 10 monitors installed for relaying in-plant radiation data and 21 monitors installed around the Darlington site boundary.

Figure 3-24
Gamma monitor located at Darlington site boundary

Public Alerting and Protective Actions

In the unlikely event of an emergency where the Province initiates protective actions under the Provincial Nuclear Emergency Response Plan (PNERP), the need to shelter, evacuate or take other actions is communicated to the public as follows:

- *Sirens*: Mounted on poles, sirens emit a single tone alarm that can be heard outdoors. These sirens are located within 3 kilometres of the Darlington site.

- *Radio, Television, Social Media*: Local radio and television stations, and social media, will broadcast information on public health, safety, and welfare. Instructions on what to do in the event of a nuclear emergency will be provided.
- *Telephone Dialing System*: An automated telephone dialing system will deliver a recorded emergency message through landline home phones to a large population in a short time.

In accordance with PNERP requirements, both outdoor public alerting sirens and indoor phone alerting systems are operational in the Municipality of Clarington and are tested regularly by the Region of Durham. In addition, OPG is an industry partner participating in a Wireless Public Alerting Service research and development project. The objective of this project is to introduce emergency cell broadcast technology to Canada. A trial is planned in the Region of Durham in 2016. This technology would provide cell broadcast emergency alerts to people in specific geographic locations including alerting for nuclear emergencies in any zone identified by the authority having jurisdiction. The alerting is intended to be linked to the National Alert Aggregation & Dissemination (NAAD) System.

Figure 3-25
Sample Wireless Public Alerting Service

OPG provides Monitoring and Decontamination Unit capability and readiness at the Emergency Workers' Centers and Reception Centers. OPG participated in Durham Region

Reception Centre Exercises in 2010 (Legends Centre), 2012 (Durham College) and City of Peterborough in 2013 (Fleming College), as well as an Emergency Worker Centre Exercise in 2014 as part of Exercise Unified Response (Orono). This effort is in addition to the routine work of OPG's Emergency Response and Fire Protection staff to work with key members of Bowmanville hospital staff to review and familiarize each other with procedures and training relevant to radiological emergency situations.

To ensure emergency plans continue to support a timely and safe evacuation in the event of a nuclear emergency, OPG monitors and engages with the Province, Region of Durham, and the Municipality of Clarington regarding land use policies and activities in associated emergency planning zones to ensure no adverse impact on implementation of nuclear emergency plans.

An update to the current Evacuation Time Estimate (ETE) is in progress for Darlington and is expected to be complete by the end of 2015. This update will consider current population and infrastructure, and will predict out to 2026. Industry accepted methodology is being used for these studies. The 2015 update to the Evacuation Time Estimate study will take into consideration the time required to evacuate schools, hospitals and other residential institutions.

A program to manage Equipment Important to Emergency Response (EITER) has been implemented to align with industry best practices. This program identifies equipment that is required in an emergency response, its back-up equipment, and ensures contingency actions if equipment is out of service with no acceptable back-up available. OPG continues to progress improvements based on lessons learned from the Fukushima event response and associated industry reports and actions. Additional equipment and supplies are being procured as part of a project, and processes improved to provide further resilience to a potential BDBE. Refer to Section 4.4 for more information on OPG's response to the Fukushima event

OPG has continued to take an emergency management leadership role in Canada, by chairing the development of the new Canadian Standards Association (CSA) standard N1600-14, *General Requirements for Nuclear Emergency Management Programs*. This document was published in May 2014. A revision to further enhance this standard is currently underway.

OPG maintains an active role in the Provincial Nuclear Emergency Management and Public Education Committees. OPG provided support during the development of the Radiation Health Plan and Potassium Iodide Fact Sheet under the direction of the Provincial Ministry of Health and Long Term Care.

OPG, with the support of the Province, Durham Region, and the City of Toronto, issued a new emergency preparedness public information document, entitled 'Never be in the Dark with Your Safety', to residences and businesses located in the primary zone of Darlington in May 2014. This document was produced with extensive public consultation and was very well received by residents. Packaged as a functional

flashlight, the document provides guidance on what to expect in the unlikely event of a nuclear emergency and how to prepare prior to an emergency.

Figure 3-26
Emergency preparedness public information document sent
to primary zone residences and businesses

Potassium Iodide (KI) Pills

Ingestion of Potassium Iodide (KI) is one of the protective actions that may be directed by authorities in the unlikely event of a nuclear emergency. When swallowed just prior to or shortly after exposure to radioactive iodine, KI fills up the thyroid with stable iodine so it cannot absorb any other iodine for a period of time. This prevents the thyroid from absorbing harmful levels of radioactive iodine so that the radioactive iodine will not accumulate, and the body will naturally excrete it.

Historically, off-site response plan protocol for KI pill pre-distribution to residents in the primary zone (within 10km radius of the site) has been to provide them free of charge to residents who want them through local pharmacies. Each year, the Durham Emergency Management Office has placed advertisements in local media which provide information on KI and how to obtain the tablets to have on hand. In addition KI pills have been available in schools, child care centres, health care facilities, municipal services, and reception centers' designated in nuclear emergency plans.

In response to new requirements in REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response*, and the Darlington Licence Condition Handbook, the pre-distribution of KI pills is being expanded. OPG is working with the Region of Durham, City of Toronto, and the Office of the Fire Marshall and Emergency Management on pre-distribution of KI pills to all residents, businesses, and institutions within the primary zone prior to the end of 2015. In addition, KI pills will be made available to residents within the 10 to 50 km radius (secondary zone), and stockpiles of tablets will be available for distribution by public authorities in an emergency, should it ever be required. A media and communications plan will be implemented to support these initiatives.

OPG will submit a transition plan for compliance with REGDOC-2.10.1 to CNSC staff by September 30, 2015, and will be fully compliant by December 31, 2018.

Fire Protection

Darlington NGS made significant improvements to its Fire Protection Program during the current licensing period. These improvements have been driven by the Fire Hazard Assessment (FHA) and Fire Safe Shutdown Analysis (FSSA), Space Allocation for Transient Material (SATM) audits and drill evaluations.

The Darlington FHA, FSSA and fire protection Code Compliance Review (CCR) reports have been submitted to the CNSC. As part of the defence-in-depth principle for fire protection, fire detection coverage will be extended to plant areas identified as higher fire hazards in the FHA currently without detection systems.
Overall, the fire protection system has been operating well with no significant degradation or challenges. Looking ahead, some parts obsolescence issues have been identified with detectors and fire panels which are currently being addressed.

Darlington is in compliance with the 2012 edition of CSA N293, *Fire Protection for CANDU Nuclear Power Plants*. OPG continues its participation in the Technical Committees of CSA N293 as well as CSA N393, *Fire Protection for Facilities that Process, Handle, or Store Nuclear Substances*.

Darlington's Emergency Response Team (ERT) participated in numerous HAZMAT and live fire drills in 2014. The complexity of the drill scenarios exercised in 2014 was greater than in past years as many of the scenarios involved multiple disciplines and integrated response. ERT and Security commenced joint exercises in 2014 to practice and implement a unified response to emergencies.

Figure 3-27
Fire Fighting Drill at OPG's Fire Fighting Training Facility in Wesleyville

OPG operates a Fire and Emergency Services training school located at the Wesleyville facility near the town of Port Hope. This facility has been in operation for 22 years and provides Systematic Approach to Training (SAT) based training in fire fighting, high angle rescue, medical response, incident command, and hazardous materials response to OPG's ERT. In addition, Weselyville provides training in first aid, fire prevention, fire investigation, fire inspection, and fire engineering to other work groups. External to OPG, Wesleyville provides fire and emergency services training to other Canadian nuclear operators, fire colleges, municipal fire departments, and private industrial fire brigades from across Ontario.

The training delivered at the Wesleyville facility meets provincial requirements and the international benchmark of the National Fire Protection Association (NFPA) standards. External audits and benchmarking with other training facilities is routinely performed to ensure we continue to exceed regulatory requirements.

OPG has a bilateral agreement with the Durham municipalities providing support and availability of specialized resources in emergency situations. This was demonstrated in April 2015, when Darlington provided specialized on-scene support for a fire at a century-old building in Whitby.

Darlington will take receipt and deploy two new additional large capacity fire pumpers by end of 2015. The apparatus will further supplement the fire-fighting capability in support of the station's response to an incident.

3.11 Waste Management

As shown in Table 3-17 below, CNSC staff have consistently assessed the Waste Management SCA as meeting all regulatory requirements and expectations.

2010	2011	2012	2013	2014
Satisfactory	Satisfactory	Satisfactory	Satisfactory	Fully Satisfactory

Table 3-17
CNSC Ratings for Darlington's Waste Management SCA

In-Plant Waste Management

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

OPG has a well established Nuclear Waste program...

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

- Minimizing the amount of waste generated by making a plan on how to minimize and manage the waste for each job during Pre-job briefs.

- Proper segregation of waste at the point of generation into the three waste categories: incinerable, compactable, and non-processible, prior to shipping to the Western Waste Management Facility (WWMF) for processing:

    - Incinerable waste is further reduced by as much as 95 % through the incineration process.
    - Compactable waste is also volume reduced by as much as 75%.
    - Non-processible waste cannot be incinerated or compacted and needs to be stored. Darlington sets business planning targets to drive down the generation of non-processible waste.

- Throughout these activities, emphasis is placed on performing them safely and at the lower possible dose to workers and the public

Used Fuel Management

The condition of the Darlington Irradiated Fuel Bays (IFB) was evaluated and found to be fit for service as part of the preparatory work for refurbishment. As part of OPG's engineering programs and consistent with CSA and licence requirements, IFB conditions will continue to be evaluated on a periodic basis to confirm they remain fit for service.

Used fuel is stored in the IFB for an appropriate cooling period, nominally 10 years, and then moved into Dry Storage Containers (DSCs) for interim storage on-site. The Nuclear Waste Management Organization (NWMO) Adaptive Phased Management (APM) program, established by the federal government, is developing plans for the long term disposal facility for used fuel. When this comes into service, used fuel would be transferred from the interim storage location at Darlington site to the APM facility.

Figure 3-28
Darlington Irradiated Fuel Bay

Details of the waste management activities arising from the Refurbishment project are described in Section 4.1.

Decommissioning Program

Planning for the eventual decommissioning of the Darlington NGS is an ongoing process, taking place throughout each stage of the licensed facility's life cycle. The Preliminary Decommissioning Plan (PDP) is the proposed plan for decommissioning and is prepared in accordance with CNSC Regulatory Guide G-219, *Decommissioning Planning for Licensed Facilities* and CSA N294, *Decommissioning of Facilities Containing Nuclear Substances*. The PDP is updated periodically as required.

OPG has adopted the "Deferred Dismantling" strategy for decommissioning its nuclear plants. OPG will shut down and store its nuclear generating stations in a safe state for nominally 30 years, followed by dismantling, demolition, and site restoration. OPG will retain ownership of the site throughout the course of the decommissioning process and restore the site to an industrial status to be made available for other future uses.

After the safe storage period, when considerable decay of radioactive components will have occurred, physical dismantling and demolition of the remaining structures can begin. At this time, OPG plans to place L&ILW generated during decommissioning in the L&ILW Deep Geological Repository (DGR) expected to be located in the Kincardine area.

The DNGS PDP describes the activities that will be required to decommission and restore the site for other OPG uses. It demonstrates that decommissioning is feasible with existing technology and it provides a basis for estimating the cost of the decommissioning. The PDP includes schedules and cost estimates based on the

assumptions that form the basis for this plan. OPG will update this decommissioning plan as required to incorporate lessons learned, updates to regulatory requirements, and industry best practices. These updates will add clarity and detail to the decommissioning of the OPG fleet of nuclear facilities.

The DNGS PDP was provided to CNSC staff in support of the 2013 to 2017 Financial Guarantee submission. This Financial Guarantee ensures that the full costs of future decommissioning will be covered by investments being made during the operation of the plant. The requirements of CSA N294 as well as any relevant domestic and international experience obtained in the previous five years were incorporated into this revision. The next revision of the PDP will be submitted to the CNSC by January 31, 2017 as part of the 2018 to 2022 Financial Guarantee submission and updated revisions submitted every 5 years thereafter. Additional details are provided in Section 4.7.

OPG continuously monitors and incorporates best practices from the industry and has a high degree of confidence that the current plans are appropriate and sufficient based on the following:

- Benchmarking of OPG's cost estimates against the international community of nuclear plants planning, undergoing, or completed decommissioning projects.
- Independent third party review of OPG's cost estimates and plans that were compared against estimating methodologies from the nuclear decommissioning industry.
- Continuous review of international best practices in decommissioning nuclear power plants to improve and increase confidence of the plans.
- OPG employs leading experts to ensure OPG's approach and practices are of the highest quality.
- Internal audit review to assess OPG's nuclear liability cost estimate processes.

The Darlington PDP will be replaced by a Detailed Decommissioning Plan (DDP) prior to the commencement of dismantling and demolition and will be submitted to the CNSC according to applicable regulatory requirements.

3.12 Security

As shown in Table 3-18 below, CNSC staff have consistently assessed the Security SCA as meeting all regulatory requirements and expectations.

2010	2011	2012	2013	2014
Satisfactory	Satisfactory	Satisfactory	Fully Satisfactory	Fully Satisfactory

Table 3-18
CNSC Ratings for Darlington's Security SCA

Darlington NGS has a security program in accordance with CNSC regulatory documents and regulations. OPG has established a comprehensive nuclear security program that utilizes the security-in-depth model. The nuclear security program supports OPG's fundamental nuclear safety objective to protect the public, site personnel and the environment from harm by establishing and maintaining effective security defences against theft, sabotage or other malicious acts.

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

- ✓ Extensive and integrated security drills & training
- ✓ State-of-the-art security equipment deployed throughout the site
- ✓ Cyber security protects computer systems and software programs

Security Program

The objective of OPG's security program is to ensure safe and secure operation of the station, by maintaining protection through use of equipment, personnel, and procedures. A wide range of state-of-the-art security equipment is deployed around and throughout the Darlington site.

Figure 3-29
Darlington Main Security Building

OPG participates in an Inter-Utility Security Working Group which includes all power reactor operators in Canada. This group is part of the overall program to ensure nuclear security programs in Canada continue to evolve to meet future requirements. OPG continues to use external benchmarking, consultative services and shared OPEX to ensure that the security program meets or exceeds industry standards.

OPG Security regularly participates in public awareness initiatives within the two geographic areas represented by the Darlington and Pickering sites, to maintain and enhance public confidence in the security program.

Training

Training is conducted to enhance and sustain improved performance in the Security Division. Specialized security training is provided to armed/ unarmed security officers, to ensure qualifications are maintained and re-qualifications and new qualifications are delivered, so that all security officers remain current in all aspects of their roles.

The security drill program is a means of validating security practices, ensuring regulatory compliance, and identifying areas for improvement in security operations. These drills are conducted both with armed and unarmed members of the security force ensuring full integration of OPG's security program. Recently, the Security and Emergency/Fire response organizations have been combined to promote better coordination in response to emergency situations. Integrated drills are conducted to provide more comprehensive and realistic drill scenarios.

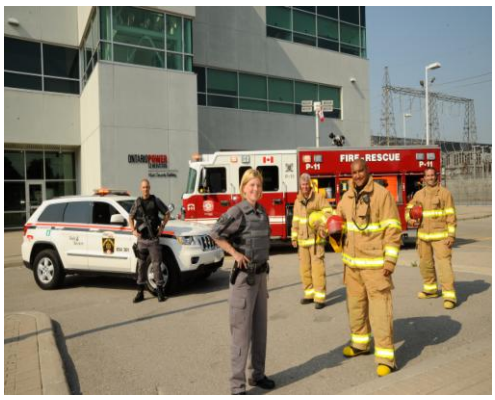


Figure 3-30
Security and Fire Response staff

A training facility is planned for the near future that will include both physical classrooms and use of force training areas as well as an indoor range.

Performance Testing Program exercises were executed in 2011, 2013 and 2015 to assess the integrated response capabilities of the OPG Nuclear Security armed and unarmed elements, against adversaries equipped and performing within the Design Basis Threat. OPG has an off-site response arrangement with Durham Regional Police Service who have been part of the Incident Command structure during these exercises.

The following are examples of the high performance of OPG security teams:

- In 2010 and 2012, OPG security personnel captured the gold medal in the Superstars event of the Toronto Police Games.

- OPG participated in the 2012 Ontario Tactical Advisory Body Competition claiming first place, winning the Nuclear Security category but also posted the best marks for the 18 Police and Nuclear Tactical Teams in the competition.

- In 2013, OPG was the recipient of the Security Educator and Women in Security award from the American Society of Industrial Security. This was the second year that OPG has been honored with the Security Educator award.

Cyber Security Program

OPG has implemented a cyber security program to protect the computers and software used to monitor and control the power plant. The program is risk-based, enabling resources to be applied to minimize threats to those cyber assets which have the highest impact on plant safety and reliability. Real-time process computers are architecturally segregated from other information systems, in order to minimize the threats from external sources.

Figure 3-31
Cyber Security Awareness

The impact of design modifications on cyber security is evaluated as part of the Engineering Change Control (ECC) process. Cyber security requirements are considered and incorporated at the start of the design processes.

Software Maintenance Plans including software recovery exist for critical cyber assets, which are identified in a list maintained by the Engineering department. Recovery exercises are conducted periodically to ensure that critical cyber assets can be restored in a timely manner following a cyber security incident.

Cyber security incident reporting and response processes are documented in procedures. Automated tools and periodic log reviews are used to detect cyber security threats and events. New cyber threats are evaluated and dispositioned periodically and staff undergo appropriate training to perform these tasks. By the end of 2015, all staff and contractors are required to complete a new computer-based training module outlining common cyber security threats and how to avoid them.

3.13 Safeguards and Non-Proliferation

As shown in Table 3-19 below, CNSC staff have consistently assessed the Safeguards and Non-Proliferation SCA as meeting regulatory requirements and expectations.

2010	2011	2012	2013	2014
Satisfactory	Satisfactory	Satisfactory	Satisfactory	Satisfactory

Table 3-19
CNSC Ratings for Darlington Safeguards and Non-Proliferation SCA

OPG has established and implemented a Safeguards Program to ensure compliance with the Governing Agreement made between the Government of Canada and the International Atomic Energy Agency (IAEA) in connection with the Treaty on the Non-Proliferation of Nuclear Weapons. The Safeguards Program is fully compliant with CNSC Regulatory Document RD-336, *Accounting and Reporting of Nuclear Material*, REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*, as well as the Nuclear Safety and Control Act and Regulations.

The Safeguards Program at Darlington is supported by a Safeguards Officer and qualified back up staff to ensure there is adequate coverage at all times. Regular communication is maintained with both IAEA and CNSC Safeguards staff to ensure any issues are promptly addressed. This includes transmission of reports on movement of nuclear material and notification of activities in areas under IAEA video surveillance. IAEA monitoring equipment is in place to ensure all nuclear fuel is accounted for at all times.

Darlington staff completes an annual Physical Inventory Taking (PIT) of fuel as part of licence conditions pursuant to the implementation of safeguards by the IAEA. Canadian facilities are selected at random by the IAEA for a Physical Inventory Verification (PIV) that follows the PIT. The last annual PIT inspection occurred in September 2014. IAEA inspections and monitoring will continue as scheduled throughout the Refurbishment window.

Several initiatives are planned or underway to further support the Safeguards program at Darlington NGS, including close coordination with IAEA technical staff to install upgrades to the Units 1 and 2 Core Discharge Monitor equipment in the reactor vault. Upgrades to Units 3 and 4 will take place in their respective refurbishment outages.

OPG meets its international safeguards obligations...

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

3.14 Packaging and Transport

As shown in Table 3-20 below, CNSC staff have consistently assessed the Packaging and Transport SCA as meeting regulatory requirements and expectations.

2010	2011	2012	2013	2014
Satisfactory	Satisfactory	Satisfactory	Satisfactory	Satisfactory

Table 3-20
CNSC Ratings for Darlington Packaging and Transportation SCA

The objective of the Radioactive Material Transportation Program (RMTP) is to ensure that shipments of radioactive material are performed safely and in accordance with the Transportation of Dangerous Goods and Packaging and Transport of Nuclear Substances Regulations.

Figure 3-32
Tritiated Heavy Water Transportation Package

The RMTP establishes controls and procedures for handling, packaging, shipment, and receipt of radioactive material, and verification that emergency response for transportation incidents is appropriately established. The program is both self and independently assessed on a routine basis to ensure regulatory and program compliance. Federal regulators, such as Transport Canada and the CNSC, also complete periodic inspections of the program and its performance.

OPG provides a high quality training program to ensure personnel are adequately trained in accordance with Transportation of Dangerous Goods Regulations. This training is reviewed annually to ensure it remains accurate and effective. OPG also frequently delivers training to personnel from external licensed facilities.

An adequate compliment of trained and qualified personnel is maintained to ensure compliance with the radioactive material transportation program and procedures. All radioactive shipments are reviewed and verified by qualified staff prior to being shipped.

OPG's radioactive material transportation program ensures...

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

OPG has a Transportation Emergency Response Plan (TERP) which is designed to respond to an incident involving transportation of any radioactive material. OPG's plan is registered with and has been accepted by Transport Canada.

Figure 3-33
Transportation Emergency Response Plan (TERP) Drill

Radioactive material transportation emergency response capability is tested on an annual basis. The drills provide a means of validating the effectiveness of TERP capability to ensure the safety of the public, the environment, and employees in the unlikely event of a transportation emergency.

Radioactive material transportation packages are required by regulations to meet specific design criteria. All packages meet or exceed regulatory requirements for design, testing, manufacturing, and usage. The RMTP implements design and configuration control measures to provide documented assurance that transport packages are in compliance with their certification.

Figure 3-34
Loading Transportation Packages

OPG has been safely transporting radioactive materials from its nuclear stations and other licensed nuclear facilities for over 40 years, and has never had an accident resulting in a radioactive release or a serious personal injury. OPG drivers have travelled 3 million kilometers over the past 5 years with no injuries.

In an average year, OPG transports approximately 800 consignments of radioactive material and travels approximately 500,000 kilometres. There have been no reportable events associated with shipments from Darlington during the licence period.

The RMTP includes a strategic equipment replacement plan to ensure that transportation packages are replaced or supplemented as required. Aging management studies are conducted on the structures and components most vulnerable to aging. OPG is in the process of replacing older transportation packages with new packages designed to incorporate improvements based on operating experience and industry best practices.

4.0 OTHER MATTERS OF REGULATORY INTEREST

The refurbishment and infrastructure improvements of the Darlington station and site is a multi-year, multi-phase program to replace and rehabilitate systems and components to further improve safety, enhance reliability and extend the life of the station. A refurbished Darlington NGS will continue to provide a significant portion of the Provincial energy supply, thereby helping to maintain system stability, moderate the overall cost of electricity and sustain the province's economic competitiveness. The significant investment in refurbishment will also offset the production of greenhouse gases, as electricity production at Darlington NGS will displace carbon dioxide emissions from other energy sources. During refurbishment, up to 2,000 direct jobs and many thousands of indirect and induced jobs will be created across Durham Region and the Province.

4.1 Refurbishment of Darlington NGS

OPG is the first utility to be in complete compliance with Regulatory Document RD-360, *Life Extension of Nuclear Power Plants*, which specifies the regulatory requirements for determining the safety case for refurbishment and plant life extension.

OPG's priorities for the refurbishment project are to safely complete the project with quality, on schedule and within the approved budget committed to the province of Ontario.

Darlington Refurbishment – OPG is Ready

Start with....
- ✓ Strong safety case
- ✓ One of the best performing stations in the world
- ✓ An excellent safety record
- ✓ Generating 20 percent of Ontario's power, virtually free of greenhouse gas emissions

Then add...
- ✓ Six years of planning
- ✓ 40 years of project management experience
- ✓ A world leading nuclear training and test facility
- ✓ Extensive use of benchmarking external experience

<u>Refurbishment Planning</u>

OPG has built a strong foundation for a successful refurbishment based on:

- Extensive benchmarking and continuous learning;
- Management capability;
- Extensive and detailed planning;
- Development of supplier and contractor relationships; and
- Robust management system

Benchmarking and Continuous Learning

Consistent with best industry practices, OPG has amassed a significant amount of industry knowledge and experience on the planning and execution of major nuclear rebuild projects. This has been done through benchmarking visits to other stations, project reviews, industry working groups (e.g. CANDU Owners Group, Construction Industry Institute, etc.) and involvement in World Association of Nuclear Operators activities at

Bruce Power, Point Lepreau, Pickering A, Pickering B and Wolsong Nuclear Power Plants. For example, based on the Wolsong experience, it was decided to construct a full scale reactor mock-up to assist in the training of personnel and development and testing of tools and work plans. This will ensure worker familiarity with tasks and tooling compatibility before the execution phase begins.

Operating Experience (OPEX) was also incorporated from benchmarking of non-CANDU Nuclear Power Plants and non-nuclear complex projects.

Based on the Project Management Institute's Project Management Body of Knowledge, and other industry standards, refurbishment of Darlington is being managed as a program. As a result, Nuclear Refurbishment is a distinct business unit within OPG with dedicated resources in a number of areas, including operations and maintenance, engineering, project management and execution, project planning and controls, and management system oversight. This allows the personnel working on refurbishment to focus their attention on successful planning and implementation. It also enables a strong customer service orientation between the Nuclear Refurbishment organization as the service provider and Darlington NGS as the customer.

To ensure alignment between Nuclear Refurbishment and Darlington NGS, both organizations established common goals and objectives for the refurbishment effort. They created plans that specifically provide for the transition of each unit to the Nuclear Refurbishment organization and the transition of each unit back to the Darlington NGS organization. The Senior Vice President of the Darlington site will delegate operational control and responsibility for the administration of work protection for unit(s) in a refurbishment outage to the Nuclear Refurbishment Director of Operations and Maintenance. The managed processes ensure control and accountability is clearly defined at all times.

Management Capability

OPG has resourced the Nuclear Refurbishment organization with personnel who have extensive experience in major nuclear projects. The management team experience includes:

- Work on the OPG project team that completed the Pickering Large Scale Fuel Channel Replacement and the return to service of Units 1 and 4.

- Working as seconded staff to the Bruce Power Units 1 and 2 refurbishment project to gain experience and capture lessons learned.

- Working as seconded staff to an AECL/CANDU Energy project team to recover the Point Lepreau refurbishment project. Once in place, this team of OPG managers delivered the balance of the project on time and on budget.

As OPG transitions from refurbishment planning to execution, the management team is evolving to ensure the right skills and experiences are available. OPG continues to acquire talent to enhance the management team and develop future leaders.

Extensive and Detailed Planning

OPG well understands that detailed front-end planning is critical to successful completion of any large and complex project like Darlington refurbishment. Based on lessons learned from previous nuclear and non-nuclear project work, the scope of refurbishment will be well defined in advance of execution. Engineering and detailed planning will be completed prior to start of field execution and long lead materials are being ordered so that they will be available in advance of the need date.

Another key lesson learned from other refurbishments that have taken place is that rehearsal of the critical activities prior to execution in the plant provides a significant benefit to the project. As a result, a state-of-the-art training facility (Figure 4-1) has been constructed in the Darlington Energy Complex which includes a full scale replica of a Darlington reactor with its surrounding systems and structures. This training mock-up facility will be used for personnel training and development of specialized tooling. At the mock-up facility, personnel will face the same physical execution challenges as they would when working on the reactor, including such details as location of power outlets, breathing air outlets, column location, lighting, etc. Specialized tooling required for field work will be tested and commissioned on this replica reactor. Personnel will have the opportunity to use these tools as part of their training before field use to familiarize themselves and minimize the potential for problems arising during refurbishment.

Scope of Work

In determining the scope of work for refurbishment and plant life extension, OPG completed the following reviews, assessments and products in accordance with RD-360.

- *Environmental Assessment (EA)*: The EA is a comprehensive assessment of the potential impacts of refurbishment and continued operation on the natural environment including public safety and socio-economic considerations and impacts beyond the plant boundary. The EA determined that refurbishment and continued operation of Darlington, given the mitigations described, will not have significant adverse environmental impacts.

- *Integrated Safety Review (ISR)*: The ISR was a systematic and comprehensive assessment of the plant design and actual condition, and of the management system used to operate and maintain the nuclear plant. The ISR enabled determination of the reasonable and practical modifications that should be made to the plant design or the management system to further enhance future safe operation. The ISR concluded that Darlington NGS conforms closely to modern standards and international practices and that there were no safety significant gaps identified. This review also confirmed that the licensing basis will remain valid over the extended operating life and that

there are adequate measures in place to maintain plant safety for long-term operation to approximately 2055.

- *Component Condition Assessments (CCA)*: CCAs were performed on critical components to determine condition, reliability of material and to ensure that required activities are in place to monitor the condition of the components going forward, or that components are repaired or replaced as necessary to ensure good system performance as the plant ages. A safety factor report presented a preliminary list of recommended actions required to allow each unit within the station to reach the end of its current life, as well as actions to be undertaken during and following the refurbishment.

- *Global Assessment Report (GAR)*: The GAR used the results of the EA and ISR and examined them in an integrated manner. It assessed the strengths, opportunities for improvement, and actions to address the opportunities for improvement, in order to provide an overall judgment on the acceptability of the risk arising from continued operation. The GAR further assessed the adequacy and implementation timing of the actions arising from the EA and ISR that are identified to extend the life of the plant. The GAR concluded that Darlington NGS is a safe and reliable generating station with opportunities for further improvements that will result in an even safer and more reliable supplier of clean electrical power to the Province of Ontario.

- *Integrated Implementation Plan (IIP)*: The IIP defines the regulatory scope and schedule of work which was derived from the ISR, EA and the CCA reviews. The scope of the IIP resulting from the EA includes the mitigation measures, committed Safety Improvement Opportunities (SIOs) and the follow-up program elements. The mitigation measures and SIOs address potential environmental effects. The follow-up program elements are actions to confirm that the predictions of environmental effects are accurate post-refurbishment, and that the mitigation measures are effective. IIP work that is unit-specific will be performed during the unit refurbishment outage and the period up to and including the first scheduled maintenance outage post-refurbishment. The IIP timeline is presented in section 1.3 and shows completion of the IIP during the requested 13 year licence term including conduct of a periodic safety review. CNSC staff accepted IIP Revision 2 in June 2015; approval of the IIP by the Commission is requested as part of renewal of Darlington's operating licence.

Supplier and Contractor Relationships

Another key lesson learned is that the best model for a large and complex project is direct management of the work using a single integrated schedule. This ensures that the interfaces between work activities are discussed and accepted in order to prevent overlap. OPG, as the owner and General Contractor, holds the single integrated schedule and oversees all of the refurbishment work whether performed internally or through the use of external resources.

Due to the size and complexity of the work that is planned for refurbishment, the overall program has been divided into several projects. These projects each have an OPG lead

that is responsible to ensure that their project is planned in detail and integrated with the other work activities. Clearly defined requirements are established for each project.

The projects are being implemented through contracts for the detailed design, procurement and/or execution of the scope of work to be done. The contractors that OPG has chosen to work with are experienced multi-national firms who have been performing similar work for OPG over the past several years and are familiar with OPG processes. Dedicated, experienced OPG project resources provide oversight of the contractors on engineering, scheduling, construction, procurement and contract management.

A focus area for the OPG project managers is ensuring that the unique need of ongoing nuclear safety is recognized in the definition, planning, and execution of the work. OPG is working with the contractors to ensure a common understanding of the importance of nuclear safety and of the behaviors we expect to see in the contractor staff during planning and execution of the work. OPG expects contractor personnel to hold the same core value for conventional, radiological, environmental and nuclear safety.

Robust Management System

OPG, as the licensee, retains overall responsibility for ensuring protection of workers, the public and the environment. This responsibility, whether the work is performed internally or externally, is ensured through a robust management system, including oversight of contractors.

The Nuclear Refurbishment Program is designed to provide assurance that all aspects of the work (e.g. engineering, procurement, construction, turnover) is conducted in accordance with:

- CSA Standard N286, *Management System Requirements for Nuclear Facilities*, and other applicable standards, and

- Regulatory requirements specified in the station Power Reactor Operating Licence and Licence Conditions Handbook.

<u>Refurbishment Execution</u>

Refurbishment activities requiring a defuelled reactor or drained systems will be performed in the so-called “Re-tube Outage”. Other work activities that can be performed with a fuelled reactor will be scheduled either during the re-tube outage or when the reactors are on-line, or when they are in a planned maintenance outage as appropriate.

The regulatory scope for refurbishment and life extension is defined in Revision 2 of the Integrated Implementation Plan (IIP) which provides a brief description of the activity along with the schedule for completion. Work that is unit-specific will be performed during the unit re-tube outage or the period up to and including the first planned maintenance outage following the re-tube outage. IIP work that is generic in nature (i.e.

applies to all four units) will be completed prior to or during the first unit re-tube outage. Exceptions will be documented and the justification provided to CNSC staff for their acceptance.

Work activities executed when the units are operating or while they are in a planned maintenance outage will be managed by station staff. Execution of work in the re-tube outages will be managed by the Refurbishment Program staff. Major steps of the re-tube outages are:

Shutdown of the Reactor

The first major activity during the re-tube outage will be to shut down the reactor. At this time, systems that will not be required for an extended period of time are placed into a safe state referred to as "lay-up". OPG is establishing specific maintenance activities for these systems to sustain the equipment until the systems are ready to be returned to service.

Removal of Fuel and Heavy Water

The fuel will be removed from the reactors using the fuelling machines. The majority of channels will be flow defueled (bundles conveyed into the fuelling machines by the flow of heavy water). Flow restricting outlet bundles will be installed in the empty channels to ensure sufficient flow of heavy water is maintained to other channels. Channels that cannot be flow defueled will be push defueled using dummy bundles. The removed fuel will be placed in the irradiated fuel bays consistent with current practices.

Once the reactor is defueled, heavy water will be drained from the moderator system and the heat transport system and transferred to an appropriate storage facility. The heavy water will be processed and available for reactor use when the re-tube outage is completed.

Islanding the Refurbishment Unit from the Operating Units

Once the reactor undergoing refurbishment has been defueled, it will be separated ("islanded") from common Containment. At this point, the nuclear safety risks associated with the reactor will have been essentially eliminated.

Separating the refurbishment unit from the balance of the station maximizes the ability of OPG staff and contractors to perform work efficiently on the reactor while minimizing the impact of refurbishment on the operating units and common systems. This is accomplished by establishing physical barriers to delineate the refurbishment, "island" from the operating reactors. Connections between refurbishment unit systems and operating unit equipment will have boundary points identified. These boundary points will be operated using an established protocol that will ensure no adverse impacts on either the operating or refurbishment units.

Replacement of Reactor Components

The reactor components will be restored or replaced before they reach their designed end of life. This includes the removal and replacement of 480 fuel channel assemblies and 960 inlet and outlet feeders per reactor. The removed components will be subject to volume reduction processing and placed into appropriate containers for either storage at the Darlington Waste Management Facility or transferred to a licensed waste management facility. In addition, inspections will be conducted on the calandria internals to ensure the components that are not being removed are acceptable for continued operation.

Removal and replacement of the reactor components is the critical path for the re-tube outage. As previously noted, OPG has applied lessons learned from past refurbishment efforts and has taken steps to avoid the performance issues that have been encountered by developing intensive personnel training and tooling testing programs in the full scale mock-up of the reactor.

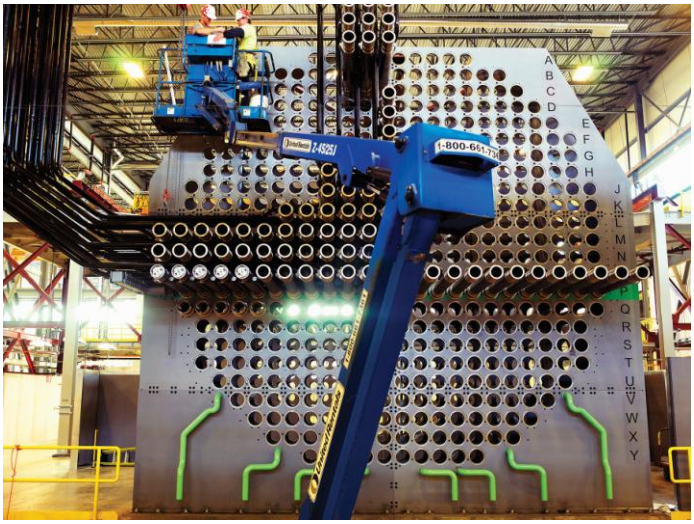


Figure 4-1
Full scale reactor mock-up located at DEC

Turbine and Steam Generators

A majority of the turbine generator systems and auxiliary systems will be disassembled and rebuilt or replaced. The planned refurbishment work includes a replacement of the turbine generator electronic control systems, excitation control and power systems, and several of the generator auxiliaries.

OPG has concluded that, due to good chemistry management, the Steam Generators will remain fit for service over the life extension period and, therefore will not require replacement. The steam generator tubes and internals will be inspected, inspection nozzles will be installed and the steam generators will be cleaned to improve heat transfer.

Balance of Plant Repair and Maintenance

The remaining scope of work is being carried out to maintain or improve the safety and reliability of Darlington NGS to the post-refurbishment end of life. The scope of work includes:

- Work on nuclear systems, such as the primary heat transport system and the reactor regulating systems; and

- Work on conventional systems, such as the low pressure service water system and the fire protection system.

Return to Service of Reactors

The return to service portion of the re-tube outage covers the range of activities from completion of installation work to reactor power at 100% including modification commissioning and restart activities.

The Refurbishment Restart Program specifies a series of Restart Control Hold Points (RCHP). The RCHP allows for quality checks to ensure proper assessment of available restart pre-requisites and commissioning results against pre-defined acceptance criteria. A subset of the specified RCHPs will align with prescribed CNSC Hold Points.

The return to service of each unit is broken down into four commissioning phases as per RD-360 for which OPG has established nine RCHPs. These nine RCHPs will ensure that all of the necessary equipment, systems, operating procedures and plant staff are ready to proceed with the next step in the start-up process. The nine RCHPs include, moderator fill, fuel load, containment bulkhead removal, heat transport system fill, GSS surrender, reactor power greater than 1%, steam to turbine, reactor power greater than 30%, and unit available for service.

Of the nine RCHPs, the CNSC have established four regulatory hold-points for each phase as per RD-360 that will require approval of the Commission or person authorized by the Commission prior to transitioning to the next phase of the start-up as follows:

- *Phase A – Prior to fuel load*: Ensures that those systems required to ensure safety with fuel loaded into the reactor have been adequately commissioned.

- *Phase B – Prior to Guaranteed Shutdown State removal*: Ensures that the fuel is loaded into the reactor safely, the reactor is in a suitable condition to be started up and all prerequisites for permitting the reactor to go critical have been met.

- Phase C – Prior to exceeding 1% Full Power: Confirms reactor behaviour at the stage of initial criticality and subsequent low power tests, and includes activities that cannot be done during the guaranteed shutdown state.

- *Phase D: – Prior to exceeding 35% Full Power*: Demonstrates reactor and systems behavior at higher power levels, including activities that could not be carried out at the power levels in Phase C.

As per RD-360, Completion Assurance Documents (CADs) will be prepared by OPG for CNSC approval and will contain information that provides confirmation that all pre-requisites, modification commissioning, testing, system restart activities and commitments have been completed to allow release of the CNSC hold point.

Refurbishment Programs and Processes

OPG's nuclear management system will be applied to Darlington refurbishment, although in some instances, the management system will be augmented to address the unique nature of the work. This is described in the following sub-sections.

Management System

Program Management Plans have been prepared describing how Refurbishment meets the Nuclear Management System and identifies any supplemental guidance or direction specific to undertaking refurbishment of the units.

Contractors are qualified by OPG Supply Chain Quality Services under a process that ensures that the contractors meet the requirements outlined in the CSA Standard N286. The principal contractors will be allowed to use their own quality program and manage quality to all applicable standards. This allows the contractors to use the systems to which they are accustomed as they supervise the work to achieve cost, schedule and quality deliverables. They will prepare, monitor, and report to OPG on agreed project metrics and implement improvements as required.

Human Performance Management

Expectations for the behaviors of personnel involved in the refurbishment will be confirmed through extensive field supervision, cultural and task specific training, job planning, rehearsal (mock-up), sound work procedures (comprehensive work packages), oversight, and the implementation of a continuous improvement program. Contractors will be required to have human performance programs that are equivalent to those established by OPG.

In addition to the established OPG training requirements, refurbishment specific training is being undertaken, including:

- Contractor on-boarding training and contractor project/job specific training;

- Islanding and Interface Training that will be completed prior to first unit breaker open. This training will ensure that expectations are clearly understood for accessing the refurbishment island and other satellite areas; and

- Modifications and Return to Service Training, that will be completed prior to first unit breaker close.

Operating Performance

Qualified station Operations and Maintenance staff will be transferred to Nuclear Refurbishment for execution of refurbishment.

Nuclear Refurbishment and Darlington NGS Operations staff have established a plan to transfer responsibility for the plant status control of a unit prior to entering a re-tube outage and prior to returning the unit to station staff. Continuous oversight of plant status control will be performed during the re-tube outage.

The Safe Operating Envelope of the unit will be maintained at all times. The Operating Policies and Principles (OP&Ps) will be revised, as required, to reflect the unit and station unique configurations. In all cases, the changes will be supported by the appropriate safety assessments and analysis and subject to CNSC notification or acceptance in accordance with the Darlington Licence Conditions Handbook.

All contractors will have to demonstrate to OPG that either they have their own continuous improvement programs in place that satisfy the requirements of CSA N286, or commit to using the OPG Nuclear continuous improvement processes. In either case, the continuous improvement processes will be open to the OPG management team to confirm that situations or discoveries that occur during refurbishment are documented and appropriate steps are taken in response. Through training and ongoing oversight, OPG will take steps to ensure the contractors understand the need to document such occurrences and make improvements to ensure the future safe, reliable performance of the units.

Safety Analysis

To ensure that an unintentional reduction in safety does not occur, all modifications are carried out in accordance with the OPG engineering change control process. This process includes steps requiring assessment against reactor safety criteria, including explicit consideration of impact on safety analysis.

New or modified systems or components, which have been incorporated into the Safety Analysis, will result in updates of the Operational Safety Requirements documentation and, possibly, the Operating Policies and Procedures.

Once all of the refurbished units are back on-line, the Darlington A Risk Assessment (DARA) will be updated to reflect the changes that have been implemented. In the meantime, the 2015 DARA update includes a sensitivity assessment for the risk improvements obtained from the Safety Improvement Opportunities.

Physical Design

In general, OPG specifies the requirements for modifications and contractors (Design Agencies) to prepare the detailed design in accordance with OPG's Engineering Change Control program and design management procedures. OPG is monitoring and assessing design activities to ensure that appropriate interfaces and oversight are maintained throughout the modification process.

The responsibilities of OPG and the Design Agencies are clearly defined for each phase of the modification process. OPG has established mandatory interface hold points. All design modifications will be accepted by OPG prior to being released for construction. OPG authorizes the design completion assurance verification review and engineering change release.

During refurbishment, contractors will perform pressure boundary activities under their own Certificate of Authorization. OPG will issue a Letter of Authorization to the Engineer, Procure and Construct (EPC) contractor to prepare registration and reconciliation packages and to submit them to the Authorized Inspection Agency for registration on OPG's behalf.

Fitness for Service

OPG will perform surveillance and testing on equipment and systems that are put into a shutdown or lay-up state, in accordance with applicable equipment and system lay-up specifications.

Some components, the condition of which cannot directly be determined based on observed results, may be removed from the system they belong to and subjected to special testing or inspections. Requirements for testing of removed components to confirm ageing mechanisms are driven through OPG's Ageing Management Program.

Radiation Protection

Refurbishment will be executed in a manner consistent with OPG's safety values and objectives, as well as best industry practices. OPG will provide radiation protection field staff to provide oversight to contractors and will ensure that OPG Radiation Protection Program requirements are met. Contractors will follow OPG radiation protection procedures for refurbishment activities including compliance with OPG's radiation protection action levels and administrative dose limits for Darlington NGS.

In addition to the normal OPG radiation protection practice, Nuclear Refurbishment will develop and implement strategies during the execution of refurbishment, such as:

- Routinely analyzing and reviewing radiological source terms associated with major system and components likely to interface with the refurbishment operations, in order to minimize the possibility of unforeseen radiation hazards;

- Ensuring lessons learned from the first outage experience are documented and applied to subsequent outages to further reduce collective doses; and

- Monitoring refurbishment work scope that may provide dose reduction benefits for continued operations, such as closure plug redesign, reactor component crud removal, radiation hot spot removal/remediation, and breathing air upgrades.

Conventional Health and Safety

Nuclear Refurbishment has engaged contractors that have proven health and safety programs. This was verified in a prequalification process that reviews industry experience, historical safety performance, implemented management system elements, and prior OPG experience.

During refurbishment, OPG will be the "constructor" and the contractors will be the "employer" as defined in the Ontario Occupational Health and Safety Act (OHSA). The conventional health and safety interfaces are governed by the requirements set therein.

External construction and support staff will be working under the "employer" programs and procedures. This allows the contractor front line supervisors and workers to work within the programs and procedures they are trained and experienced in. This is expected to improve performance of the teams while reducing human performance errors related to working with multiple programs and systems. This process aligns with the internal responsibility methodology as fostered in the OHSA.

Environmental Protection

Contractor staff will adhere to and monitor their own compliance with all relevant environmental protection governance and procedures. Oversight of contractor environmental protection performance will be performed by OPG.

Environmental requirements for refurbishment, including oversight criteria, have been defined and a Darlington Environmental Review Team has been established as a key oversight mechanism.

Spill prevention and contingency plans will be established for refurbishment to address effluent, releases of chemicals, products planned for use, or products that are present at the facility. The purpose of the plan is to demonstrate the contractor's "project specific" commitment to spill prevention, preparedness, response, reporting and clean-up. Should there be a spill, the contractor will use the OPG template for spill reporting. Hazardous materials spill response will be provided by the station's Emergency Response Team in accordance with current procedures.

The Nuclear Refurbishment organization will require a hazardous materials management plan from the contractors that is in accordance with documented expectations and that complies with the OPG Health and Safety Framework for control and assessment of non-radioactive hazardous materials.

Emergency Management and Fire Protection

OPG will ensure that personnel, programs and processes for emergency preparedness are integrated into refurbishment activities. This will include the following elements:

- Contractors will follow the same procedures as OPG staff;
- Additional assembly and accounting areas will be set up to accommodate refurbishment staff and contractors.

Waste Management

As part of refurbishment, radioactive waste will be generated that will require ongoing management and storage.

The removed fuel channel components (end fittings, pressure tubes and calandria tubes) will be transferred from the reactors to the Re-tube Waste Processing Building (RWPB) in shielded transfer flasks where they will be volume reduced and packaged into the Re-tube Waste Containers as intermediate-level nuclear waste.

The Re-tube Waste Containers will then be transferred to the Re-tube Waste Storage Building where they will be stored for approximately 25 years. At the end of this time, this waste will be transported to the Western Waste Management Facility and eventually to OPG's proposed Low- & Intermediate-Level Waste (L&ILW) Deep Geological Repository (DGR).

Other L&ILW generated during the outages will be collected and transported to a licensed waste management facility (e.g. the Western Waste Management Facility), consistent with OPG's existing program for managing L&ILW. OPG programs targeted at the reduction of the amount of L&ILW produced at our facilities will continue to be applied throughout the refurbishment period.

Refurbishment will also generate non-radioactive waste typical of any construction project and the coincidental waste resulting from the workforce as a result of their use of consumables (e.g., paper, packaging, food waste). Where feasible, this waste will be re-used or recycled. All residual waste will be collected regularly by licensed contractors and transferred to appropriately licensed off-site disposal facilities. Any hazardous waste will be handled in accordance with applicable provincial regulations.

Radiation monitoring of all waste generated from within the station's radiological zones of the plant will be performed in accordance with existing plant and regulatory requirements.

Security

OPG's Nuclear Security Program will continue to be in effect for all activities during the refurbishment window. This will ensure consistent application of security measures to all areas of the Darlington site.

Nuclear Security is engaged with all projects being executed at the Darlington site, including planned Refurbishment. This involvement includes review of project design to ensure existing security systems remain unimpeded and operational. Secondly, the review ensures required changes to security systems or new security requirements are applied to ensure full compliance is maintained.

Personnel screening equipment is being replaced as it reaches end of life. The new screening equipment ensures a higher level of search rigour is applied enabling OPG to remain compliant with the Nuclear Security Regulations.

To support the large numbers of contractors on site during refurbishment activities, a Refurbishment Project Office is scheduled to be available for service in late 2015. This facility will host an additional security search area for refurbishment staff including a new personnel entry point to the protected area. The existing Physical Barrier System will be extended to the north side of the building, thus extending the facility's overall protected area.

Security has begun conducting multi-vehicle inbound searches at the Darlington sally port in support of increased project work within the station. The construction of a sally port extension is complete and currently in use. A secondary ingress/egress portal has been implemented and is in operation. The extension and secondary portal increases the capacity of vehicles that can be searched at one time without compromising the requirements of the Nuclear Security Regulations and ensuring detailed searches are conducted and continuity of searches maintained.

Security staffing requirements will increase over the next few years to meet the needs of the station and refurbishment work that will be conducted at Darlington NGS. The Design Basis Threat will be reviewed and updated to include changes being made in support of the refurbishment specific to the Refurbishment Project Office building and sally port enhancements. An access authorization process is followed to ensure personnel and contractors requiring physical access to Darlington NGS or access to OPG Confidential or Security Protected documentation, do not pose a risk to the facility, its employees or company assets.

Safeguards

Darlington NGS will provide required routine and advance notifications and declarations to the IAEA of re-tube outage dates and details related to defueling, initial core loading, and maintenance work which may interfere with the functionality of safeguarded equipment.

Monitoring of Nuclear Refurbishment

Timely and effective internal reporting supports the successful execution of the Nuclear Refurbishment Program. Specifically, reporting supports management decision processes, measures progress against established business objectives, and flags any performance gaps that require management attention, including taking corrective actions.

A comprehensive, tiered metrics infrastructure is being established and is maintained at program, project, and functional levels to measure progress in the areas of:

- Environment, Health, and Safety
- Scope
- Schedule
- Cost
- Quality

A set of standard reports is produced for communicating program and project level performance to suit various stakeholder needs. Generally, these reports are differentiated by the intended audience, level of detail required, and the metrics reported.
OPG is working with CNSC staff to determine the information to be reported to the CNSC on a routine basis.

OPG has committed to providing updates to the Commission at public meetings following the re-tube outage on each unit.

4.2 Darlington Safety and Site Improvements

A number of systems, facility and infrastructure projects are being undertaken to improve plant safety and to support plant life extension and refurbishment. These site improvements fall into three categories, Safety Improvement Opportunities, Site Infrastructure Improvements and Refurbishment Related Projects. The location of these improvements are shown in Figure 4-2 and described in the following section.

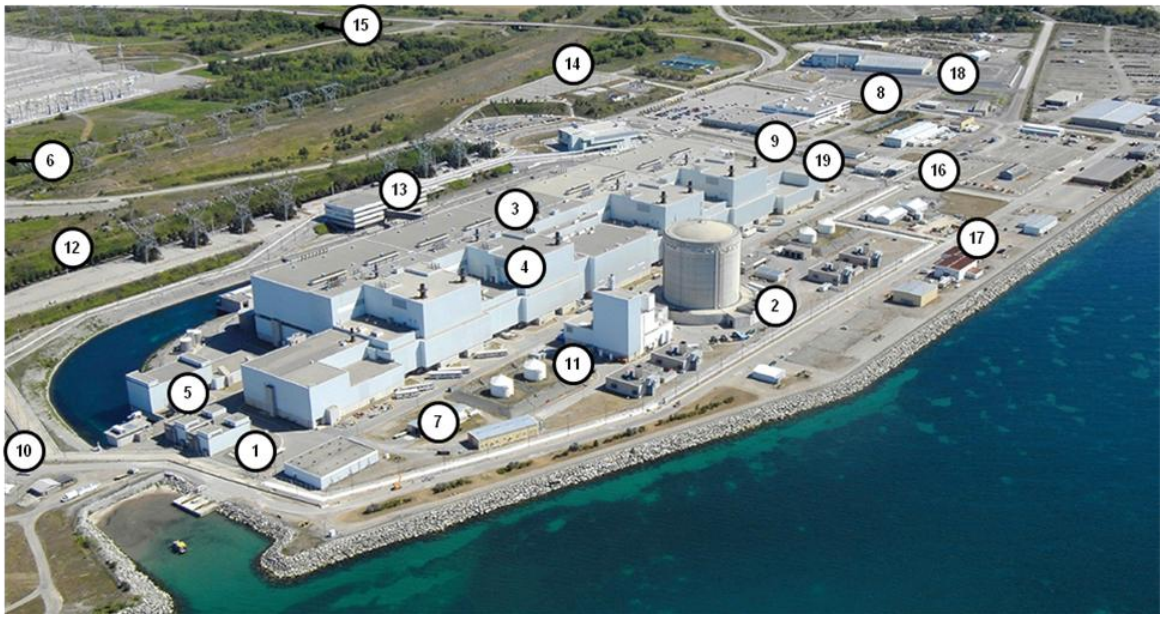


Figure 4-2
Darlington Safety, Refurbishment, and Site Infrastructure Improvements

#	Safety Improvements
1.	Third Emergency Power Generator
2.	Containment Filtered Venting System
3.	Powerhouse Steam Venting System
4.	Shield Tank Overpressure Protection
5.	Emergency Make-up to the Heat Transport System

#	Refurbishment Related Improvements
6.	Darlington Energy Complex
7.	Re-tube and Feeder Replacement Island Support Annex
8.	Re-tube Waste Storage Building
9.	Re-tube Waste Processing Building
10.	Refurbishment Project Office
11.	Heavy Water Management Building

#	Site & Facility Infrastructure Improvements
12.	Electrical Power Distribution
13.	Operations Support Building Refurbishment
14.	Upgrade to Water and Sewer
15.	Holt Road Interchange Improvements
16.	Vehicle Screening Facility
17.	Auxiliary Heating System Facility
18.	Darlington Waste Management Facility Expansion
19	Water Treatment Plant

Table 4-1
Darlington Safety, Refurbishment, and Site Infrastructure Improvements Identified in Figure 4-2

Safety Improvements

From the Darlington Refurbishment and Continued Operation Environmental Assessment, the following modifications are being installed at the Darlington NGS to further improve public safety. The numbering below corresponds to the location of each Safety Improvement Opportunity in Figure 4-2.

1. Third Emergency Power Generator (EPG3)

A third EPG is being installed to complement the two existing EPGs to improve the availability and reliability of the Emergency Power System for delivery of power following a Design Basis Event.

Once installed prior to the start of the first unit refurbishment outage, there will be three EPGs each fully capable of providing power to key equipment on all four Darlington units for fuel cooling and monitoring.

Figure 4-3
Factory Acceptance Testing of EPG3

2. Containment Filtered Venting System (CFVS)

The purpose of the CFVS is to prevent containment system failure from over-pressurization following an unlikely event of a multi-unit severe accident.

The CFVS will limit the radioactive releases of fission products to the environment through the use of high efficiency dry metal fiber filter modules using the Westinghouse technology. CFVS is expected to be available for service in 2016.

3. Powerhouse Steam Venting System (PSVS)

The PSVS is being modified to increase overall system availability and reliability through the installation of additional control units on each unit.

The PSVS 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. The enhanced PSVS is expected to be operational in 2016.

4. Shield Tank Overpressure Protection (STOP)

Additional overpressure protection is being installed to prevent potential shield tank failure in the extremely unlikely event of total and sustained loss of heat sink to any unit.

The installation of STOP in all four units will allow an optimal design and effective operation of CFVS by protecting the shield tank from potential failure thus precluding a challenge to the containment system. This safety improvement will be completed on Units 1, 3 and 4 prior to Unit 2 restart. Unit 2 will be completed during the re-tube outage.

5. Emergency Make-up to the Heat Transport System

As documented in Section 4.4, as part of OPG's Post-Fukushima response, Emergency Mitigation Equipment (EME) which includes portable diesel pumps are currently available for emergency make-up to the heat transport system following a Beyond Design Basis event.

In addition to the EME provisions already in place, permanent fire water pumps will be installed to augment the existing Emergency Service Water System (ESW) for supply to the Firewater system. Permanent piping from the ESW will also be installed to allow the new Firewater pumps to supply emergency make-up water the Heat Transport System.

Refurbishment Related Improvements

The following key projects are being implemented in support of refurbishment. The numbering below is reflected in Figure 4-2.

6. Darlington Energy Complex (DEC)

The Darlington Energy Complex, which was declared operational in 2014, houses a full reactor face training mock-up facility and office facilities for refurbishment staff. As documented earlier in this section, the training mock-up facility is an essential part of ensuring reactor related work activities progress smoothly with worker radiation exposures as low as reasonably achievable. In addition to training of workers under expected realistic conditions, the training mock-up facility is being used for development of procedures, testing of equipment and tooling and for refinement of logistics.

Figure 4-4
Darlington Energy Complex

7. Re-tube and Feeder Replacement Island Support Annex

This building, located to the south of the station, will provide final staging of the reactor components (pressure tubes, calandria tubes, end fittings and feeders) prior to installation.

Figure 4-5
Re-tube and Feeder Replacement Island Support Annex

8. Re-tube Waste Storage Building (RWSB)

The RWSB, which is covered under a separate operating licence, is being constructed south west of the Darlington Used Fuel Dry Storage Facility for the interim storage of Re-tube Waste Containers (RWCs) containing removed reactor components.

9. Re-tube Waste Processing Building (RWPB)

A new RWPB is currently being constructed adjacent to Unit 4 on the east side of the station. This building will house equipment for volume reducing of the removed reactor components. Removed reactor components will be transferred via an enclosed corridor between the unit and this building where machines will cut and crush the material for interim storage in RWCs flasks. The RWCs will then be transferred from the RWPB for storage in the RWSB.

10. Refurbishment Project Office (RPO)

This new three story building located outside of the protected area at the west end of the plant will facilitate efficient entry and exit of the large amount of construction staff required for refurbishment. This building will also house change rooms and showers facilities, security search equipment and offices for refurbishment staff.

Figure 4-6
Refurbishment Project Office

11. Heavy Water Management Building

The objective of this project is to build a new Heavy Water Management Building West Annex at Darlington NGS in order to provide sufficient heavy water storage capacity at the Darlington site during the refurbishment period. The facility would also address the operational needs for sufficient heavy water storage and segregation to improve the existing heavy water management process.

Site and Facility Infrastructure Improvements

The Campus Plan is the site utilization master plan that supports the current and future needs of the Darlington site including refurbishment. It was created to institute a framework for future land use changes and growth for buildings inside and outside the protected area of Darlington NGS and for ensuring that spatial planning accommodated OPG's vision for the site over the next 30 to 40 years. The following changes to the Darlington site have been completed or are being implemented.

12. Site Electrical Power Distribution System Upgrades

Various parts of the Darlington Site Electrical Distribution System are being upgraded with new transformers; switch gear and cabling to provide power to new refurbishment projects outlined above.

13. Operations Support Building (OSB)

The OSB, which houses Operations support staff, is being refurbished to comply with current code requirements and to extend the life of this building to meet the business needs of a refurbished Darlington station through the station's continued operation.

Figure 4-7
Operations Support Building

14. Upgrade to Water and Sewage

To support the refurbishment and long term operation of Darlington NGS, the site water and sewer infrastructure has been upgraded. New domestic and sewage water piping and lift stations now connect the Darlington site to the municipal systems.

15. Holt Road Interchange Improvements

Upgrades are currently being implemented by the Ministry of Transportation Ontario to the existing Highway 401/Holt Road interchange that provides the main entrance to the Darlington station. When completed, the interchange with Highway 401 and Holt Road will be a full interchange allowing for improved traffic flows that will also accommodate the projected increased workforce and traffic growth, in part related to refurbishment activities.

16. Vehicle Screening Facility

To facilitate security searches of all incoming and outgoing vehicles, a new vehicle security screening facility, referred to as the "Sally Port", has been installed.

17. Auxiliary Heating Steam Facility

The existing oil/electric-fired Boiler House for providing heating steam to the station will not be capable of supporting long term operation and therefore is being replaced. The new Auxiliary Heating Steam Facility will supply back-up heating steam to the Darlington Station, Tritium Removal Facility/Heavy Water Management Building, and other support buildings in the event of a design-basis four unit shut down during the winter months. The facility is also used to support Station outages associated with Containment and Vacuum Building Outages. Under normal operating conditions, heating steam is supplied to the station by the operating units.

Figure 4-8
Auxiliary Heating Steam Facility

18. Darlington Waste Management Facility Expansion (DWMF)

The existing DWMF, which is covered under a separate operating licence, is being expanded to provide additional Dry Storage Container (DSC) storage capacity needed for long term operation of the Darlington station. The extension will be similar in design to the existing building and will include roadwork within the secured fence of DWMF Processing Building to allow the DSC transporter to get to the new building.

19. Water Treatment Plant Replacement

The objective of this project is to ensure a continuous, high quality, cost effective supply of demineralised water to Darlington NGS until the end of the station life. The Darlington Water Treatment Plant has been in service since 1987. Despite past reliable operation, the Water Treatment Plant will be challenged to maintain satisfactory system health status and reliability as it reaches or exceeds the end of its design life.

4.3 Tritium Removal Facility (TRF)

The purpose of the Tritium Removal Facility (TRF) is to maintain low tritium levels in the heavy water systems at Darlington and other CANDU reactors. This is performed through a process called "detritiation". It is notable that OPG operates the only such facility in Canada. The TRF also maintains the required heavy water isotopic purity requirements at Darlington using the Station Upgrader.

The TRF Manager reports directly to the Darlington Director of Operations and Maintenance to ensure the TRF work program is aligned with the Darlington Station.

Safe operation is the top priority at the TRF and there have been no lost time accidents since 1999.

The TRF was returned to service after the most recent TRF planned outage in 2013. Significant work was completed on the Cryogenic Refrigeration System as well as the implementation of two major upgrades. Based on the life cycle plan, four additional improvements are planned for the 2015 planned outage.

Figure 4-9
TRF Control Room

Emissions minimization has remained a strong operational focus for the TRF. Major investments are planned to further reduce tritium oxide emissions from the TRF with short-term bridging strategies in the interim.

TRF staff continue to perform benchmarking with industry peers in various fields including the chemical industry, cyrogenics, and tritium removal. This promotes sharing of operating experience and implementation of industry best practices at the TRF. To ensure continued detritiation capability and to improve TRF equipment reliability to end of design life, a life cycle plan is in place. During the next 10 years, OPG will make major investments into the plant as part of the life cycle plan.

Comprehensive work has been completed on the option of TRF life extension. A decision to continue with TRF life extension is expected by 2017. Life extension of the TRF is being addressed in a separate but parallel effort to the Nuclear Refurbishment Program.

4.4 Fukushima Update

OPG has taken an industry leadership role in learning from, and responding to, the 2011 earthquake and subsequent tsunami in Japan, which resulted in the severe accident at the Fukushima Daiichi Nuclear Power Plant. Through supporting analysis, modifications and procedural changes, OPG has strengthened reactor defense-in-depth and enhanced its emergency response at Darlington in response to lessons learned from the Fukushima accident. Earlier this year, OPG was the first Canadian utility to complete and obtain closure from the CNSC on all 101 assigned Fukushima Action Items. Specifically, the following key actions have been completed at the Darlington station:

OPG has obtained closure on all 101 Fukushima Action Items....

- ✓ Significant investment in modifications to enhance safety have been completed
- ✓ Emergency Mitigation Equipment installed and available
- ✓ Staff are trained and drills have been conducted

- Obtained mobile diesel-powered emergency water pumping and electrical power equipment, and created a safe nearby storage facility, located on high ground
- Initiated installation of modifications to plant equipment to allow more rapid connection of hoses and cables from these mobile pumps and generators
- Conducted training, as well as multiple drills, for the staff responsible for deploying, connecting and operating this emergency equipment
- Executed a major 3-day Emergency Preparedness event, “Exercise Unified Response”, in May 2014 in collaboration with over 50 federal, provincial and municipal agencies
- Completed the installation of all Passive Autocatalytic Recombiners for dealing with the hydrogen gas that may be created during a severe accident
- Installed and placed in operation, an automated near boundary radiation monitoring system at the station, providing real-time radiation information
- Enhanced the safety of irradiated fuel bays by adding additional emergency cooling provisions and conducted additional studies confirming their ability to survive extreme earthquakes, and to maintain their integrity under high temperature conditions
- Implemented new guidelines for Severe Accident Management for use by operating and maintenance staff, and conducted training and drills

- Established a Mutual Aid Agreement with all of the Canadian nuclear plant operators, to more readily provide support to each other in the event of an emergency at any location.

Additional planned actions include:

- Additional plant equipment modifications are planned to be installed, to further enhance our already robust safety margin. These changes include Shield Tank emergency water addition and over-pressure relief (providing an additional source of core cooling) and a Containment Filtered Venting System.

- Emergency communications under beyond design basis conditions are being strengthened, by providing additional redundant communications facilities (for use both inside the station, and beyond the station to outside support organizations).

OPG is continuing to work with CNSC staff, industry partners, and international organizations with the aim of further improving nuclear safety through learning from the events at Fukushima Daiichi. OPG chairs the CANDU Industry Integration Team – an international forum under the CANDU Owners' Group (COG) umbrella – that provides a means for all COG members to share common principles and approaches to implementing the needed improvements to station equipment, our processes and our staff training. OPG will continue to aggressively implement the remaining goals of its Fukushima Response project.

4.5 Community Relations and Public Information Program

OPG's open, transparent, and timely communications ensure information regarding its operations and plans, as well as anticipated effects on the environment and the health and safety and persons that may result from licensed activities, are shared widely, and particularly to those living in the vicinity of the site. OPG is compliant with Regulatory Document RD-99.3, *Public Information and Disclosure*, and the Nuclear Public Information Disclosure and Transparency Protocol is posted on www.opg.com.

Support from the Community

OPG's ongoing public information and community relations program generates and maintains positive community support for the continued operations and refurbishment of Darlington Nuclear. OPG Darlington protects the health and safety of workers, the community, and the environment, and provides clean energy that is an important part of the current and future energy mix in Ontario.

OPG's community relations and public information program has been recognized as a strength by national and industry peers. OPG proactively provides timely information to the public. We encourage two-way dialogue with interested parties, on the breadth of Darlington's operations, from safety, operational and environmental performance to the safe storage and transportation of waste, and the refurbishment project. There is a managed process in place to respond and track actions and resolution of issues discussed in public forums.

Stakeholder Sessions

To facilitate public engagement, a variety of public information sessions have been held with stakeholders including local officials, Non-Governmental Organizations, and Aboriginal communities. These information sessions covered the licence renewal process and issues related to Darlington station operation and refurbishment. In addition, over 3,500 members of the public took advantage of two open doors sessions which included a tour of the Darlington refurbishment training mock-up facility. OPG has also made publically available on its website www.OPG.com key documents and information related to Darlington refurbishment and this licence renewal application.

"This was a sincere and constructive attempt to address public concern, a good step forward."

– Feedback from an OPG Stakeholder Session

Welcoming Visitors

Darlington maintains a state-of-the-art Nuclear Information Centre. The site is a showcase for CANDU technology and refurbishment. OPG uses the Information Centre as the base for tours of the station, mock-up and site. In 2015, OPG built a viewing area in the mock-up to allow visitors greater access to the mock-up reactor. Visitors come

away from the Information Centre with a greater appreciation of the role of nuclear in Ontario and the safety and reliability of nuclear technology.

OPG also hosts an annual Open House. This event is widely advertised in the community and in Toronto. It gives another opportunity for the public to view the mock-up facility, observe Darlington's multiple safety systems, and learn about our continuous safety and performance improvements from highly qualified station employees.

Figure 4-10
Darlington Energy Complex Open House Montage

OPG's informative and detailed website and social media program provides information to the public, with more than 27,000 nuclear page visitors annually and more than 5000 Twitter followers. OPG's Darlington community page includes a virtual station tour, programming activities and updates, current newsletters and contact information for the Information Centre. The Darlington Refurbishment home page provides a project overview and related links.

In the Community

A community newsletter, Darlington Neighbours, is distributed three times per year to over 100,000 residents and businesses in the Municipality of Clarington and parts of the City of Oshawa.

Darlington's Corporate Citizenship Program partners with more than 300 community initiatives across Durham Region focused on community, education, environment and aboriginal community-building events.

Figure 4-11
Courtice Secondary School students building bird boxes in partnership with OPG

Darlington senior management participates in many community activities, providing regular updates and presentations and supporting partnerships that benefit the social fabric of the community.

Environmental Partnerships and Programs

Darlington is certified by the Wildlife Habitat Council as a Corporate Lands for Learning site, recognizing the environmental learning opportunities that are provided in

cooperation with local environmental groups. One of OPG's many environmental partnerships is with Courtice Secondary School students and involves:

- building nest boxes, turtle rafts and benches
- monitoring nesting activity
- tree identification
- development of a butterfly garden

The success of this partnership led to a recent nomination for Wildlife Habitat Council – Partnership of the Year award. Darlington is also a recipient of the Council's prestigious Corporate Habitat of the Year Award as well as the coveted Ducks Unlimited - Wings over Wetlands Award. Additional details are provided in Section 3.9.

"OPG is a corporation that has been so instrumental in drawing all facets of the community together in environmental work."

Figure 4-12
Quotation from Wendy Lee,
Executive Director of
Environmental Earth Angels

Station Reporting

OPG ensures timely, open and transparent public communications as per OPG's Public Disclosure Protocol and in accordance with applicable legal and safety-focused regulatory documents. OPG provides regular updates and seeks feedback from the community, business leaders and elected officials through regular updates and meetings with municipal council, community advisory committees and health councils. Examples include:

- Community notifications and website updates issued for non-routine station activities
- Quarterly reports posted on safety, operations, environmental and regulatory events
- Darlington's extensive Environmental Monitoring Program (EMP) posted annually
- Reports shared widely and discussion and feedback sought from the community

Refurbishment Project

OPG enhances its well-established community relations and public information program when undertaking major projects or significant changes to the site.

For Darlington refurbishment, OPG began official community notifications and information sharing early in 2010. Over the past 5 years, OPG has held workshops, roundtables, briefing sessions, community updates, and open houses. OPG seeks to ensure meaningful community and stakeholder engagement in the development of plans for Darlington's refurbishment.

First Nations and Métis Community Relations

OPG is committed to building and growing long-term, mutually beneficial working relationships with First Nations and Métis communities near our current and future nuclear operations in Ontario. The Darlington station is located on past and present territories of a number of First Nations and Métis communities and citizens. These territories also extend beyond Darlington to include areas supported by the interim storage of waste and transportation to the Bruce County area.

OPG's efforts are guided by an OPG Board level First Nations and Métis Relations policy and supported by annual engagement plans and a number of participation agreements and MOU's with communities.

The program involves ongoing information sharing, engagement and consultation on interests and concerns. We seek input and discussion on station performance, waste management and refurbishment and the environment through informal and formal meetings and round table discussions so that together, we can work towards common goals and interests. Underscoring this work is OPG's acknowledgement of the inherent Aboriginal and Treaty rights of First Nations and Métis communities.

Figure 4-13
First Nations and Métis community representatives attending
Aboriginal Information Session held at Darlington Energy Complex

4.6 Cost Recovery

Regulatory costs are a component of cost included in OPG's Refurbishment Business Case for the Refurbishment of Darlington. OPG has provided timely payments during the licensing period to the CNSC on a quarterly basis based on receipt of invoices. OPG will continue to make timely payments as required.

4.7 Financial Guarantees

OPG is required to provide and maintain financial guarantees for the liabilities associated with operating and decommissioning Darlington NGS which include operational and long-term waste management and decommissioning costs. The financial guarantee is normally updated on a five-year cycle in accordance with CSA standard N294, *Decommissioning of Facilities Containing Nuclear Substances*, and CNSC regulatory documents G-219, *Decommissioning Planning for Licensed Facilities*, and G-206, *Financial Guarantees for the Decommissioning of Licensed Activities*.

In addition to the 5 year update cycle, OPG provides an annual financial guarantee report to CNSC detailing the status of the guarantee including the amounts accumulated in segregated funds and the value of the Provincial Guarantee required.

The sources to satisfy the financial guarantee are the Ontario Nuclear Funds Agreement segregated funds augmented by a Provincial Guarantee. CNSC access to these funds is provided by the "CNSC Financial Security and Ontario Nuclear Funds Agreement Access Agreement" between the CNSC, OPG and the Province of Ontario, and the Provincial Guarantee Agreement between the CNSC and the Province of Ontario.

In June 2012, OPG submitted the required documentation in support of the 2013 to 2017 CNSC Financial Guarantee to CNSC staff for review with a final submission to the Commission in September 2012. Additional details are provided in Section 3.11.

4.8 Nuclear Liability Insurance

OPG continues to maintain Nuclear Liability Insurance for the Darlington Nuclear Generating Station consistent with the Nuclear Liability Act, and will continue to be compliant with the Act, if and when it is amended.

A copy of the certificate of insurance was provided with the licence application submitted on December 13, 2013, and the most current copy has been provided to CNSC staff, confirming that the appropriate insurance is in place. Insurance inspections are conducted every 18 months by the nuclear property insurers. These inspections are also attended by conventional insurers who inspect the non-nuclear side of both stations.

5.0 CONCLUSIONS

OPG is submitting this CMD in support of the renewal of the Power Reactor Operating Licence for Darlington NGS for a period ending on December 1, 2028.

Safety continues to be OPG's overriding priority in its nuclear facility operations. OPG is recognized in the industry as a leader in promoting safety in the workplace. Recently, Darlington surpassed 4 million hours worked without a lost time accident.

Darlington NGS is already a very safe plant and OPG is investing to further enhance its safety. This has been demonstrated through detailed safety assessments which conclude that risk to the public is very low.

Darlington NGS continues to be one of the best performing nuclear plants in the world. OPG remains committed to ensuring high performance levels continue throughout the life of the station. Environmental emissions to the public and all doses to workers were well below regulatory limits.

OPG responded with diligence and urgency to the lessons learned from the events at Fukushima, resulting in several plant improvements being installed to further enhance safety. Robust emergency preparedness plans are in place at all levels of government for a unified response in the unlikely event of a nuclear emergency.

OPG has established and is implementing systematic, thorough and effective station workforce training, testing and qualification programs, to ensure that all full-time and supplemental personnel conduct their daily duties at the station safely and competently, each and every shift.

OPG has a strong commitment to our community. OPG regularly and proactively provides information to the public on our on-going activities, public and environmental impacts, and we consult with key stakeholders and the public on future planned activities.

The power produced from Darlington's four reactor units plays a major role in the Province's long term energy plans. OPG is making a significant investment to extend the operating life of the Darlington station for an additional 30 years. Lessons learned from previous refurbishment projects are being implemented to ensure that the Darlington Refurbishment project will be completed safely, on schedule, and within budget.

Based on high performance in all areas of plant operation and the unique requirements for refurbishment and continued operations activities, OPG believes that the requested licence term is not only appropriate and applicable, but also necessary.

In summary, OPG is qualified to continue operation of the Darlington station to December 1, 2028 and has made provisions for the protection of the environment, the health and safety of workers and the public, and Canada's international obligations.

6.0 ACRONYMS

The following is a list of acronyms used throughout this CMD, to be interpreted in context.

Acronym	Definition
ALARA	As Low As Reasonably Achievable
AOOM	Advanced Operations Overview for Managers
APM	Adaptive Phased Management
ASME	American Society of Mechanical Engineers
BDBE	Beyond Design Basis Event
CAA	Composite Analytical Approach
CAD	Completion Assurance Documents
CBOP	Continuous Behaviour Observation Program
CCA	Component Condition Assessment
CCR	Code Compliance Review
CEA	Canadian Electricity Association
CFAM	Centralized Functional Area Management
CFVS	Containment Filtered Venting System
CNO	Chief Nuclear Officer
CNSC	Canadian Nuclear Safety Commission
COG	CANDU Owners' Group
CSA	Canadian Standards Association
CSI	CANDU Safety Issue
CRE	Collective Radiation Exposure
CMD	Commission Member Document
CNEP	Consolidated Nuclear Emergency Plan
DARA	Darlington 'A' Risk Assessment
DBE	Design Basis Event
DEC	Darlington Energy Complex
DFO	Fisheries and Oceans Canada
DGR	Deep Geological Repository
DLA	Dynamic Learning Activity
DNGS	Darlington Nuclear Generating Station
DSC	Dry Storage Container
DWMF	Darlington Waste Management Facility
EA	Environmental Assessment
ECC	Engineering Change Control
EFPH	Equivalent Full Power Hours
EITER	Equipment Important to Emergency Response
EME	Emergency Mitigation Equipment
EMS	Environmental Management System
EMP	Environmental Monitoring Program

Acronym	Definition
EPC	Engineer, Procure and Construct
EPG3	Emergency Power Generator 3
ERA	Environmental Risk Assessment
ERO	Emergency Response Organization
ERT	Emergency Response Team
ESW	Emergency Service Water System
ETE	Evacuation Time Estimate
FCLMP	Fuel Channel Life Management Project
FHA	Fire Hazard Assessment
FLR	Forced Loss Rate
FSSA	Fire Safe Shutdown Analysis
GAR	Global Assessment Report
HAZMAT	Hazardous Materials
HSMS	Health and Safety Management System
IAEA	International Atomic Energy Agency
IEC	International Electrotechnical Commission
IFB	Irradiated Fuel Bay
IIP	Integrated Implementation Plan
INPO	Institute of Nuclear Power Operators
I-SNPM	International Senior Nuclear Plant Manager Program
ISO	International Organization for Standardization
ISR	Integrated Safety Review
IWST	Injection Water Storage Tank
KI	Potassium Iodide
LBLOCA	Large Break Loss of Coolant Accident
L&ILW	Low- and Intermediate-Level Waste
LRF	Large Release Frequency
NAAD	National Alert Aggregation and Dissemination
NEI	Nuclear Energy Institute
NGS	Nuclear Generating Station
NOP	Neutron Overpower Protection
NFPA	National Fire Protection Association
NPDS	Nuclear Professional Development Seminar
NSRB	Nuclear Safety Review Board
NWMO	Nuclear Waste Management Organization
OHSA	Ontario Occupational Health and Safety Act
OPEX	Operating Experience
OPG	Ontario Power Generation
OP&P	Operating Policies and Principles
OSB	Operations Support Building
PCE	Personal Contamination Event
PDP	Preliminary Decommissioning Plan
PNERP	Provincial Nuclear Emergency Response Plan
PIT	Physical Inventory Taking

Acronym	Definition
PIV	Physical Inventory Verification
PROL	Power Reactor Operating Licence
PSA	Probabilistic Safety Assessment
PSVS	Powerhouse Steam Venting System
RCHP	Restart Control Hold Points
R&D	Research and Development
RIDM	Risk-Informed Decision Making
RMTP	Radioactive Material Transportation Program
RPO	Refurbishment Project Office
RWC	Re-tube Waste Container
RWPB	Re-tube Waste Processing Building
RWSB	Re-tube Waste Storage Building
SCA	Safety and Control Area
SCDF	Severe Core Damage Frequency
SAMG	Severe Accident Management Guidelines
SAT	Systematic Approach to Training
SATM	Space Allocation for Transient Material
SCR	Station Condition Record
SIO	Safety Improvement Opportunity
SOE	Safe Operating Envelope
STOP	Shield Tank Overpressure Protection
TERP	Transportation Emergency Response Plan
TRF	Tritium Removal Facility
UOIT	University of Ontario Institute of Technology
VBO	Vacuum Building Outage
WANO	World Association of Nuclear Operators
WHC	Wildlife Habitat Council
WWMF	Western Waste Management Facility

7.0 GLOSSARY OF TERMS

Beyond Design Basis Event (BDBE) – An extemely unlikely event for which the station has not been specifically designed.

Design Basis Events (DBE) – The set of nonstandard internal and external events for which the station has been designed for and for which the safety analysis must demonstrate acceptable public safety impact.

Emergency Mitigating Equipment (EME) – The set of portable generators and water pumps that operating staff could use to ensure continuous fuel cooling is maintained in the absence of all on-site and off-site sources of power.

Engineering Change Control (ECC) – A rigorous process that ensures all plant modifications are designed and installed in a thorough and complete manner.

Exercise Unified Response (ExUR) – In 2014, OPG conducted a large scale nuclear emergency prepardness exercice involving multilpe agencies that responded to a hypothetical severe accident at the Darlington station.

Forced Loss Rate (FLR) – A measure of unplanned loss of generation, expressed as a percentage.

Fukushima Action Item (FAI) – Tracking tool used by CNSC staff to monitor status of post-Fukushima action plan items. The CNSC have closed all 101 FAIs for Darlington.

Global Assessment Report (GAR) – A requirement of RD-360, the GAR provides an overall risk judgement on the acceptability of continued plant operation based on any significant ISR results and EA mitigation measures and follow-up program elements.

Hold Point – During the process of returning a unit to service at the end of the re-tube outage, hold points have been established by OPG (Restart Quality Hold Points) and the CNSC (Regulatory Hold Points) for ensuring readiness to proceed to the next phase of the start up process.

Integrated Safety Review (ISR) – A requirement of RD-360, this was a systematic and comprehensive assessment of plant design and actual condition that determined reasonable and practical changes to further enhance plant safety and compliance with modern codes and standards.

Integrated Implementation Plan (IIP) – A requirement of RD-360, this plan documents the regulatory scope and schedule of activities to be completed during refurbishment and plant life extension.

Large Release Frequency (LRF) – The sum of the mean frequencies of events that can lead to the release of greater than 1% of the core inventory of Cs-137 to the environment due to the operation of a nuclear reactor when averaged over a one year period. Large Release requires Severe Core Damage with coincident failure of containment.

Licensing Basis – Defined in Darlington's Licence Condition Handbook, the set of requirements for which the station has been licensed (i.e., the basis upon which the station has received an operating licence).

Probabilistic Safety Assessment (PSA) – PSA is a comprehensive set of models of plant systems, components and Operator actions in response to abnormal internal and external plant events. The PSA for Darlington (DARA) updated in 2015 in accordance with S-294, demonstrates that the public risk from Darlington operation remains very low.

Periodic Safety Reviews (PSR) – Defined in REGDOC-2.3.3 and IAEA SSG-25, periodic reviews are conducted to assess the nuclear plant's safety basis.

Primary Zone – The area within 10 km around the nuclear station that is used for emergency preparedness planning.

Plant Life Extension – The life of Darlington NGS is being extended to approximately the year 2055 through refurbishment and life extension activities defined in the IIP.

Safe Operating Envelope (SOE) – Defines the safety analysis bounds (limits, component and system requirements) for safe plant operation.

Safety Goals – In Probabilistic Safety Analysis, safety goal refers to a set of numerical values, expressed in terms of the frequency of severe core damage or large release events, which establish targets and limits for station design and operation. These goals represent the high standards of safety and reliability for nuclear power plant operations.

Safety Improvement Opportunities (SIOs) – The set of five modifications being implemented at Darlington to further enhance public safety. Specifically; installation of another Emegency Power Generator, Containment Filtered Venting System, improvement to the Powerhouse Steam Venting system, Shield Tank OverPressure Protection and Emergency Heatsink enhancements.

Secondary zone – The area that extends between 10km and 50km around the nuclear station that is used for emergency preparedness planning.

Severe Accident Management Guidelines (SAMG) – The set of guidelines used by operating staff to mitigate the effects of a severe accident and for responding to Beyond Design Basis Events.

Severe Core Damage Frequency (SCDF) – The sum of the mean frequencies of events due to operation of a nuclear reactor that can lead to failure of both fuel and fuel channels when averaged over one year.

8.0 LIST OF ORGANIZATIONS

The following is a list of organizations referenced in this CMD.

American Society of Mechanical Engineers (ASME) – ASME is a not-for-profit membership organization that enables collaboration, knowledge sharing, and skills development across all engineering disciplines, toward a goal of helping the global engineering community develop solutions to benefit lives. Founded in 1880, ASME has grown through the decades to include more than 140,000 members in 151 countries.

Canadian Electricity Association (CEA) – OPG is a member of the CEA which is a national association that establishes electrical safety requirements.

Canadian Nuclear Safety Commission (CNSC) – Established under the Nuclear Safety & Control Act, the CNSC regulates the use of nuclear power and material in Canada. The CNSC issues operating licences and confirms compliance with regulatory requirements through ongoing inspections.

Canadian Standards Association (CSA) – The CSA Group is a membership association, serving industry, government and consumers. OPG is a CSA member and participates in the development of industry codes and standards. Many of CSA's energy standards are cited in both federal and provincial regulations. CSA also helps to promote a safe and reliable nuclear power industry in Canada through the creation of specific nuclear industry standards.

CANDU Owners' Group (COG) – The CANDU Owners Group Inc. (COG) is an affiliation of CANDU Nuclear Power Plant Operators and the original CANDU designer Atomic Energy of Canada Limited (AECL), that provides a framework for co-operation, mutual assistance and exchange of information for the successful support, development, operation, maintenance and economics of CANDU technology. OPG is an ongoing partner in COG initiatives.

Electric Power Research Institute (EPRI) - EPRI's mission is to conduct research on key issues facing the electric power industry on behalf of its members, energy stakeholders, and society for the benefit of the public. An independent, non-profit organization, EPRI brings together experts from the industry to help address challenges in electricity, including reliability, efficiency, health, safety, and the environment. OPG has representation on some EPRI Nuclear Advisory Committees.

Fisheries and Oceans Canada (DFO) – This federal department is responsible for regulating activities related to lakes and waterways in Canada. Recently, the DFO issued an authorization to OPG related to fish mortality at the Darlington station.

International Electrotechnical Commission (IEC) – Founded in 1906, the IEC is a leading organization for the preparation and publication of International Standards for all

electrical, electronic and related technologies. These are known collectively as "electrotechnology". IEC provides a platform to companies, industries and governments for meeting, discussing and developing the international standards they require.

Institute of Nuclear Power Operators (INPO) – Established after the Three Mile Island nuclear accident, INPO is responsible for establishing nuclear excellence for Nuclear Power operation in the United States. INPO conducts plant evaluations on a routine basis that assess plant performance against high industry standards.

International Organization for Standardization (ISO) – ISO is an independent, non-governmental membership organization and the world's largest developer of voluntary International Standards. ISO has published more than 19,500 International Standards covering almost every industry including technology, agriculture, and healthcare.

International Atomic Energy Agency (IAEA) – The IAEA is widely known as the world's "Atoms for Peace" organization within the United Nations family. Set up in 1957 as the world's centre for cooperation in the nuclear field, the Agency works with its Member States and multiple partners worldwide to promote the safe, secure and peaceful use of nuclear technologies.

Nuclear Energy Institute (NEI) – NEI's objective is to ensure the formation of policies that promote the beneficial uses of nuclear energy and technologies in the United States and around the world. NEI provides a forum to resolve technical and business issues for the industry. Finally, NEI provides accurate and timely information on the nuclear industry to members, policymakers, the news media and the public.

National Fire Protection Association (NFPA) – Founded in 1896, NFPA is a global, nonprofit organization devoted to eliminating death, injury, property and economic loss due to fire, electrical and related hazards. The association delivers information and knowledge through more than 300 consensus codes and standards, research, training, education, outreach and advocacy.

Nuclear Waste Management Organization (NWMO) – OPG is responsible for safely managing low and intermediate and interim storage of high level nuclear waste. The NWMO is responsible for long term managing of high level nuclear waste and is currently assessing options for a high level nuclear waste storage facility.

University of Ontario Institute of Technology (UOIT) – UOIT is a credited university located in Oshawa Ontario offering post secondary programs in Science and Engineering. OPG has established a Nuclear Engineering program at UOIT and works closely with other post secondary intuitions to assist with meeting future hiring needs.

World Association of Nuclear Operators (WANO) – Established following the Chernobyl nuclear accident, WANO, which is similar to INPO but on a worldwide basis, assists nuclear operators with nuclear excellence. Every two years WANO coordinates a peer evaluation at Darlington NGS where performance in key areas is evaluated against high standards for plant operation.

9.0 LIST OF REGULATORY DOCUMENTS AND STANDARDS

The following is a list of regulatory documents and industry standards found in this CMD.

CNSC Regulatory Documents

G-206 – *Financial Guarantees for the Decommissioning of Licensed Activities*

G-219 – *Decommissioning Planning for Licensed Facilities*

G-278 – *Human Factors Verification and Validation Plans* and

G-306 – *Severe Accident Management Programs for Nuclear Reactors*

G-323 – *Ensuring the Presence of Sufficient Qualified Staff at Class 1 Nuclear Facilities*

RD-99.3 – *Public Information and Disclosure*

RD-204 – *Certification of Persons Working at Nuclear Power Plants*

RD-334 – *Aging Management for Nuclear Power Plants*

RD-336 – *Accounting and Reporting of Nuclear Material*

RD-337, *Design of New Nuclear Power Plants*

RD-360 – *Life Extension of Nuclear Power Plants*

REGDOC-2.3.2 – *Severe Accident Management Programs for Nuclear Reactors (2013)*

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-2.6.3 – *Aging Management*

REGDOC-2.10.1 – *Nuclear Emergency Preparedness and Response*

REGDOC-3.1.1 – *Reporting Requirements for Nuclear Power Plants*

S-99 – *Reporting Requirements for Operating Nuclear Power Plants*

S-294 – *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*

Industry Standards

ASME B31.1 – *Power Piping*

CSA B51 – *Boiler, pressure vessel and pressure piping code*

CSA N1600 – *General Requirements for Nuclear Emergency Management Programs*

CSA N285.0 – *General Requirements for Pressure-Retaining Systems And Components In CANDU Nuclear Power Plants*

CSA N285.4 – *Periodic Inspection of CANDU Nuclear Power Plant Components*

CSA N285.8 – *Technical requirements for in-service evaluation of zirconium alloy pressure tubes in CANDU reactors*

CSA N286 – *Management System Requirements for Nuclear Facilities*

CSA N286.0 – *Overall Quality Assurance Program Requirements for Nuclear Power Plants*

CSA N287.7 – *In-Service Examination and Testing Requirements for Concrete Containment Structures for CANDU Nuclear Power Plants Components*

CSA N288.1 – *Guidelines for Calculating Derived Release Limits for Radioactive Material in Airborne and Liquid Effluents for Normal Operation of Nuclear Facilities*

CSA N288.4 – *Environmental Monitoring program class I nuclear facilities and uranium mines and mills*

CSA N288.5 – *Effluent Monitoring programs at Class I nuclear facilities and uranium mines*

CSA N290.0 – *General Requirements for Safety Systems of Nuclear Power Plants*

CSA N293 – *Fire Protection for CANDU Nuclear Power Plants*

CSA N294 – *Decommissioning of Facilities Containing Nuclear Substances*

CSA N393 – *Fire Protection for Facilities that Process, Handle, or Store Nuclear Substances*

IAEA Safety Guide NS-G-2.12 – *Ageing Management for Nuclear Power Plants*

INPO 12-012 – *Traits of a Healthy Nuclear Safety Culture*

INPO AP-928 – *Work Management Process Description*

ISO 14001 – *Environmental Management*

ISO/IEC 17025 – *General Requirements for the Competence of Testing and Calibration Laboratories*

NEI-09-07 – *Fostering a Healthy Nuclear Safety Culture*