DARLINGTON NUCLEAR REFURBISHMENT AND CONTINUED OPERATION ENVIRONMENTAL ASSESSMENT FOLLOW-UP PROGRAM

Submitted by:

Ontario Power Generation Inc.

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Revision Summary

Revision Number	Date	Comments
001	2013-09-26	Revised to address stakeholder review comments.
000	2013-07-17	Initial issue.

1.0 INTRODUCTION

This *Darlington Nuclear Refurbishment and Continued Operation Environmental Assessment Follow-Up Program* (EA Follow-Up Program) provides the framework for the development and implementation of a follow-up program relative to the environmental assessment (EA) of the Darlington Nuclear Refurbishment and Continued Operation Project.

An EA follow-up program was initially proposed in the Proposed Environmental Assessment Screening Report (CNSC, DFO 2012). The requirement for an EA follow-up program was re-affirmed in the Record of Proceedings, Including Reasons for Decision (CNSC 2013a) issued pursuant to the hearing convened by the Canadian Nuclear Safety Commission (CNSC) in December 2012 to consider the EA (and related licensing matters). The CNSC and Fisheries and Oceans Canada (DFO), as Responsible Authorities, have delegated the design of the follow-up program to Ontario Power Generation (CNSC 2013b).

1.1 Description of the Project

Darlington Nuclear Generating Station (DNGS) is a 4-unit nuclear power plant located in the Municipality of Clarington, Regional Municipality of Durham on the north shore of Lake Ontario approximately 70 km east of Toronto. The four CANada Deuterium Uranium (CANDU) pressurized heavy water reactors have a combined generating capacity of 3,524 MW. They were commissioned between 1990 and 1993 and have operated continuously since that time, with routine outages for maintenance and servicing. The Darlington Waste Management Facility (DWMF) is co-located on the 485-ha Darlington Nuclear (DN) site. The DWMF was commissioned in 2007 for interim dry storage of spent nuclear fuel from DNGS.

Refurbishment of CANDU reactors is an aspect of their design and assumed to be required at the mid-point in their operational service life. The Refurbishment and Continued Operation Project (the Project) will involve two phases: i) refurbishment of the four reactors; and ii) continued operation of each reactor for a period of approximately 30 years followed by a safe storage period of approximately 30 additional years.

During the Refurbishment phase, major components in each reactor will be inspected, serviced, and replaced, if necessary, during a planned outage. A key refurbishment activity will be removal and replacement of the fuel channel assemblies and feeder pipes in the reactors.

Each refurbished reactor will be refuelled and returned to full power operation (i.e., the Operation phase). Ongoing operation after refurbishment will include routine scheduled maintenance activities and inspections as defined by the life cycle

management plans and the Integrated Safety Review (ISR) which is being carried out to support Project planning and related license amendments.

As is the current practice, used nuclear fuel produced during the Continued Operation phase will continue to be stored in the DNGS Irradiated Fuel Bays for approximately 10 years before being transferred to dry storage at the DWMF. Refurbishment waste will be stored at expanded facilities at the DWMF or be shipped to the Western Waste Management Facility (WWMF) at the Bruce Power site near Kincardine, Ontario or to another off-site licensed facility.

The Project will require that the DWMF be expanded to accommodate radioactive waste resulting from refurbishment and used nuclear fuel associated with continued operations. Accordingly, the Project will also include the development of additional storage buildings at the DWMF for these purposes.

1.2 Project Schedule

For purposes of the EA, the following basic timeline was adopted for the Project and continues to be valid for purposes of the EA follow-up program:

- Refurbishment Phase: 2013 to 2024;
- Continued Operation Phase, including:
    - Operating period: 2019 to 2055;
    - Safe storage period: 2048 to 2085.

The Continued Operation phase will include an operating period of approximately 30 years for each reactor and a 30-year period of safe storage, also for each reactor, during which the reactors will have been defueled, dewatered and exterior surface contamination removed. The Continued Operation phase will commence with the return to service of the first refurbished unit (anticipated in 2019) and conclude at the end of the safe storage period (anticipated in 2085).

1.3 Environmental Assessment – Overview

DNGS and the DWMF are classified as Class 1A and 1B Nuclear Facilities, respectively, under the *Nuclear Safety and Control Act (NSCA)*. Actions associated with the refurbishment and continued operation of these facilities will require amendments to the operating licenses for both. Additionally, OPG intends to seek authorization from the DFO under section 32 of the *Fisheries Act* for continued operation of the DNGS condenser cooling water system. Under the federal EA legislation applicable at the time (see below), before the federal licenses could be

amended or approvals granted, an EA under the appropriate federal legislation was required.

OPG began planning for the refurbishment of DNGS in 2010 and submitted a Project Description to the CNSC in April 2011 (OPG 2011a). Based on that submission, an EA process under the *Canadian Environmental Assessment Act (CEA Act)* was initiated. In July 2012, the CEA Act was repealed and new federal EA legislation was promulgated as the *Canadian Environmental Assessment Act, 2012 (CEA Act 2012)*. Despite the new legislation, the Minister of the Environment designated that it be completed under the former CEA Act.

The CNSC and DFO declared themselves as the Responsible Authorities (RAs) for the conduct of the EA. Other federal agencies including Health Canada, Natural Resources Canada and Environment Canada, were identified as Federal Authorities (FAs) with expertise relative to the EA. The RAs determined that a screening EA was appropriate for the proposed Project, and the conduct of technical studies to support the EA was delegated to OPG.

OPG submitted its Environmental Impact Statement (EIS) (OPG 2011b) and a series of technical support documents (TSDs) to the CNSC (as the lead RA) in December 2011. These documents and other related information submitted in response to the RA and FA review of the EIS and TSDs served as the basis for preparation of a draft Screening Report by CNSC and DFO staff. Stakeholders, including the public and the FAs, were given an opportunity to review the draft Screening Report prior to its finalization and submission to the CNSC Tribunal for its decision.

In December 2012, the proposed Screening Report (CNSC, DFO 2012) was considered at a CNSC hearing. The Record of Proceedings, Including Reasons for Decision (CNSC 2013a) was published on March 14, 2013. The Tribunal's conclusions are summarized as follows:

- The Screening Report meets all applicable requirements of the *CEA Act*;
- The Project, taking into account the appropriate mitigation measures identified in the Screening Report, is not likely to cause significant adverse environmental effects;
- The Commission does not request the Minister of the Environment to refer the Project to a review panel or a mediator (in accordance with the *CEA Act*); and
- The Commission can proceed with the consideration of a license amendment under the *NSCA* that would allow the project to proceed, if approved.

1.4 Follow-Up Program Requirements

Under the provisions of the *CEA Act*, a follow-up program may be required to verify the accuracy of an EA and/or to determine the effectiveness of measures taken to mitigate adverse environmental effects of the Project. In the case of the subject Project, the Screening Report identified a series of follow-up actions specifically developed for the Project with a focus on the following:

- Surface water (liquid effluents and stormwater quality);
- Aquatic environment (impingement, entrainment and thermal effects);
- Malfunctions and accidents (safety improvement opportunities (SIOs)); and
- Effects of the environment on the Project (liquefaction potential of fill materials).

The CNSC Tribunal's decision (CNSC 2013a) reiterated the requirement for an EA follow-up program and required that the basis for that program be as described in the Screening Report. Accordingly, with specific reference to the requirements of the Screening Report and the Tribunal's decision, the follow-up program will comprise the elements described in Table 1.4-1.

Table 1.4-1: Follow-Up Program Elements

Program Element Reference Number	Applicable Environmental Component	Description of Follow-Up Program Element	Expected Timing and Duration
1	Surface Water	Review the DNGS effluent monitoring program relative to that of applicable CSA standards and subsequent confirmation through applicable ERA results to verify EA predictions related to liquid effluents. At a minimum, this shall include: • broad spectrum characterization of effluents (parameters beyond those currently contained in license/permits). • screening of the parameters for	Coordinate with OPG's review of new standards against current programs.

Program Element Reference Number	Applicable Environmental Component	Description of Follow-Up Program Element	Expected Timing and Duration
		inclusion in the site's operational ecological risk assessment (ERA). • review of the adequacy of existing effluent and environmental monitoring programs based on the site's ERA.	
2	Surface Water	Conduct a Stormwater Control Study for areas subject to refurbishment activities within the Protected Area during the Refurbishment of the first unit for two representative storm events (spring and summer storm) to confirm that the Project has not adversely affected storm water quality. Analyze the stormwater based on historical findings, including, but not limited to, Municipal/Industrial Strategy for Abatement (MISA) parameters such as total suspended solids, total phosphorus, aluminum, iron, oil and grease, ammonia and ammonium and biological oxygen demand[1].	One season of monitoring during the Refurbishment phase. Determine need for additional monitoring based on results.

[1] Proposed CNSC Screening Report listed “chemical oxygen demand.” However, the MISA parameter is “biological oxygen demand.”

Program Element Reference Number	Applicable Environmental Component	Description of Follow-Up Program Element	Expected Timing and Duration
3	Aquatic Habitat / Biota	Monitor data on cooling water discharge temperature and plume characteristics and interpret in relation to fish habitat and susceptibility of VEC species. Compare temperature criteria and other assessment metrics based on Griffiths (1980) with the results of the CANDU Owners Group study examining thermal effects to round whitefish eggs (underway by others).	Two monitoring periods (not withstanding any additional monitoring to be developed as part of an adaptive management plan): • one winter season (November to April) during the Refurbishment Phase. • one winter season (November to April) following restart of all reactors. (The comparison with the CANDU Owners Group study will occur once the study is published).
4	Aquatic Habitat / Habitat	Monitor entrainment and impingement mortality associated with DNGS intake.	Program will comprise three components (not withstanding any additional monitoring to be developed as part of an adaptive management plan): • entrainment monitoring with larger sample size and invertebrate component - prior to refurbishment outage. • benthic invertebrate community study - prior to refurbishment outage. • impingement and entrainment - two years of monitoring following restart of all reactors.

Program Element Reference Number	Applicable Environmental Component	Description of Follow-Up Program Element	Expected Timing and Duration
5	Malfunctions and Accidents	Design changes related to safety improvement opportunities (SIOs) will reduce accident frequency achievable. The assignment of probabilities to represent the SIO design changes is judged to be sufficient to approximate the reduction in accident frequency achievable. Per the requirements of CNSC S–294, the station PRA will be updated to reflect the detailed design and as-installed configuration prior to bringing refurbished units back on-line.	Prior to bringing refurbished units back on-line with updates provided to CNSC as part of this process.
6	Effects of the Environment on the Project	Undertake a full review of available documentation regarding fill materials and their liquefaction potential in the Protected Area. Should sufficient verification not be realized for the prediction of low liquefaction potential, undertake a liquefaction assessment of fill materials as appropriate.	Prior to bringing refurbished units back on-line.

1.5 Relationship to Site Monitoring Programs

In practice, the monitoring elements of the EA follow-up program will be incorporated into the existing programs at the station that may be underway concurrently. The CNSC licensing and compliance process, as well as the requirements of other applicable approvals and regulatory processes (e.g., *Fisheries Act* authorization; Provincial Environmental Compliance Approval (ECA)) will serve as the means to ensure that the EA follow-up program requirements are appropriately designed and carried out. As examples, it is anticipated that the Power Reactor Operating License (PROL) for the station as amended to facilitate refurbishment and continued operation will include the requirement for implementation of the EA follow-up activities as they are prescribed in the Record of Proceedings, Including Reasons for Decision (CNSC 2013a). Similarly, it is also expected that authorization(s) granted under the *Fisheries*

Act may include requirements for periodic monitoring to confirm compliance with the authorization.

In the case of both examples above, the follow-up monitoring elements are specific in terms of scope, timing and objectives. Nonetheless, it is to be noted that the objectives of the regulatory approvals are related and generally similar to those of the follow-up program elements, and the routine monitoring to demonstrate regulatory compliance will continue in accordance with the approvals granted beyond the specific term and scope of the follow-up program.

All applicable OPG governance relative to the conduct of environmental monitoring will be used in the development of the EA follow-up program. This will include processes for program management, health and safety and quality control/quality assurance (QA/QC). In addition, OPG is in the process of implementing the N288 series of standards developed by the Canadian Standards Association (CSA) relating to environmental monitoring and associated activities for Class 1 nuclear facilities. These standards on environmental management of nuclear facilities were developed to align with internal and external stakeholder expectations while incorporating current international best practices.

A summary of the CSA standards N288.4 (CSA 2010), N288.5 (CSA 2011) and N288.6 (CSA 2012) are provided below:

- N288.4 (CSA 2010) Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills:

  The standard addresses the monitoring of radioactive and non-radioactive contaminants, physical stressors, potential biological effects, and pathways for both human and non-human biota. The monitoring program design is risk informed and based on the results of an environmental risk assessment completed for the facility. This program is called the Environmental Monitoring Program (EMP). Detailed design of the DNGS EMP to comply with N288.4 (CSA 2010) has been completed. OPG will have its first annual EMP report compliant with N288.4 (CSA 2010) in 2014 which will provide the results of the 2013 program.

- N288.5 (CSA 2011) Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills.

  Federal and provincial regulations set the requirements to monitor and report on the characteristics of airborne and waterborne effluents. This standard expands on some of the basic regulatory requirements and addresses design,

implementation and management of an effluent monitoring program that meets legal, business practices and incorporates best management practices.

- N288.6 (CSA 2012) Environmental risk assessment at Class I nuclear facilities and uranium mines and mills.

  The standard addresses the design, implementation and management of the environmental risk assessment (ERA), including human health risk assessment (HHRA) and ecological risk assessment (EcoRA). This standard is intended to be used in conjunction with N288.4 standard on environmental monitoring and CSA 288.5 standard on effluent monitoring to establish a risk based monitoring program.

  The ERA also inputs into the effluent monitoring program by identifying the specific nuclear/hazardous substances of concern and the sources or release points from the nuclear facility or licensed activity. An ERA also contributes to development of effluent limits that are the focus of compliance monitoring. The effluent monitoring program can inform the ERA by providing the effluent loading that was used in estimating environmental exposure concentrations of nuclear and hazardous substances.

For follow-up program elements 1 to 4, these standards will provide the overall guidance for planning, design and implementation of the monitoring programs. The relationship to these standards is discussed further in subsequent sections.

1.6 Relationship to Integrated Implementation Plan (IIP)

The refurbishment of a nuclear generating station is managed in accordance with the CNSC Regulatory Document; RD-360, *Life Extension of Nuclear Power Plants* (CNSC 2008). RD-360 requires the licensee to demonstrate that continued station operation poses no unreasonable risk to health, safety, security or the environment and will conform to international obligations.

OPG has conducted an Integrated Safety Review (ISR) of the DNGS and has completed the EA. The results of the ISR and EA including the follow-up program in this document will be incorporated into a Global Assessment Report (GAR). The GAR presents significant ISR results, including plant strengths, the Integrated Implementation Plan (IIP) for corrective actions and safety improvements, and an overall risk judgment on the acceptability of continued plant operation. In addition, implementation of the EA mitigation measures (e.g., Traffic Management and Socio-Economics) and follow-up program elements, as identified in the CNSC EA Screening Report, will be captured in the IIP.

2.0 FOLLOW-UP PROGRAM PLANNING AND IMPLEMENTATION FRAMEWORK

This EA Follow-Up Program provides the framework for the development and implementation of the follow-up program objectives as required by the Screening Report and summarized above. The process for developing the details of each follow-up program element will generally follow a step-wise approach. The proposed steps are:

1) Review the preliminary program;

2) Develop the sampling plan (for program elements 1 to 4). The design of the sampling plan or EMP will follow the systematic planning process identified in CSA N288.4 (CSA 2010) as described below:

    a) Define the objectives of the EMP;

    b) Identify the information required to meet the defined objectives;

    c) Define the boundaries of the EMP;

    d) Determine how the data collected will be used to achieve the defined objectives;

    e) Specify performance or acceptance criteria; and,

    f) Develop the detailed design of the EMP that will be implemented to obtain the required data.

    It should be noted that the performance or acceptance criteria includes decision points for use in determining revisions to monitoring and mitigation measures based on thresholds, occurrences, unforeseen effects and other established criteria.

3) Identify how each element might be incorporated or coordinated with DN site monitoring programs;

4) Review the details of program elements with the RAs and other appropriate regulatory agencies;

5) Review and discuss the program with other stakeholders as appropriate;

6) Determine the method of reporting results to the RAs, public, Aboriginal groups and other stakeholders;

7) Incorporate appropriate elements of the program into existing or ongoing DN site monitoring programs;

8) Identify appropriate measures that might be taken to rectify unacceptable results.

The follow-up program will have a specific focus on issues of relevance to the EA. However, because DNGS is an operating station, it already involves a range of existing and ongoing monitoring activities, each with its own scope and purpose. These existing programs comprise environmental monitoring carried out for related purposes, including specific license and other approval requirements as well as to confirm overall regulatory compliance. The follow-up program elements will augment and enhance existing monitoring programs underway during the various Project phases. The phased-based timing for the follow-up program elements is illustrated in Table 2-1.

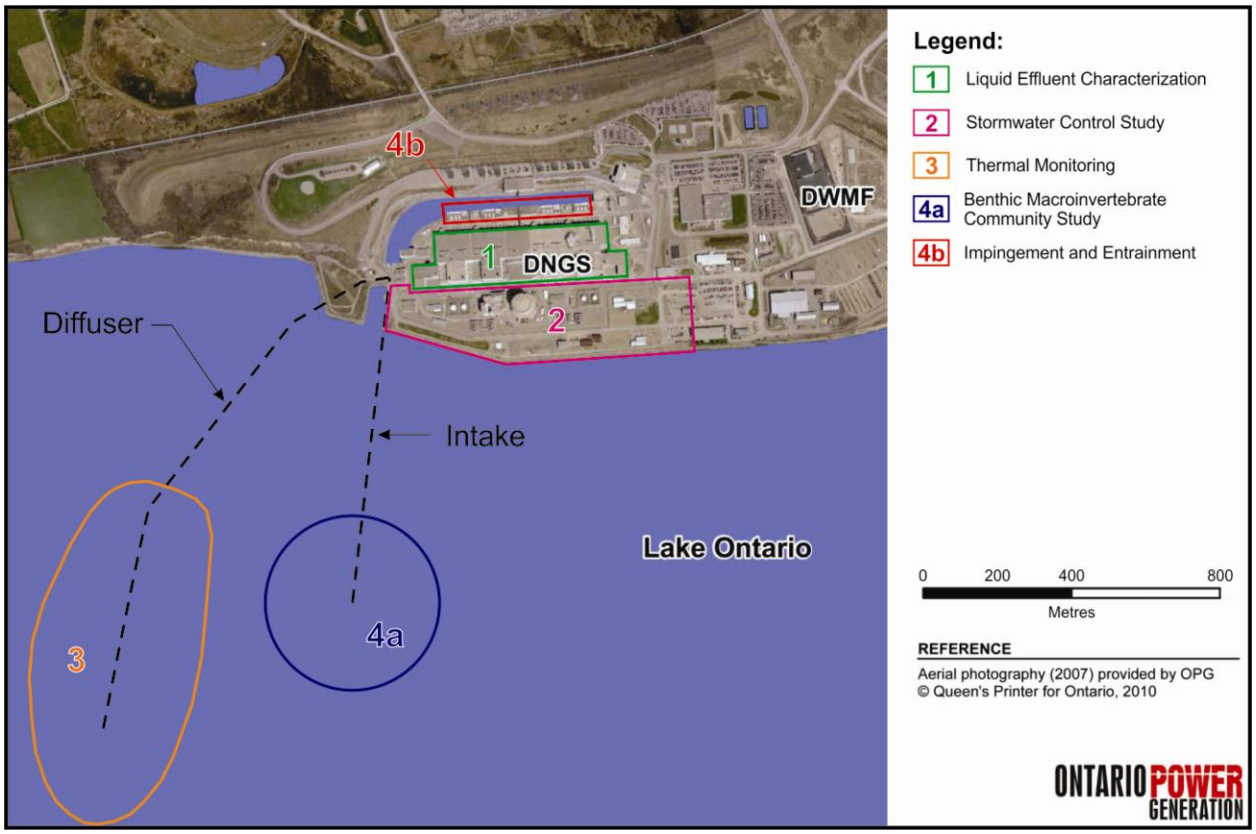
Table 2-1: Follow-up Program Elements by Project Phase

Program Element #	Follow-Up Program Element	Pre-Refurbishment	Refurbishment Phase	Continued Operation Phase
1	Effluent Characterization Program	✓		
2	Stormwater Control Study		✓	
3	Thermal Monitoring Program		✓	✓
4.1	Benthic Invertebrate Community Study	✓		
4.2	Entrainment Monitoring	✓		
4.3	Impingement and Entrainment Monitoring			✓
5	Probabilities Associated with SIOs		✓	✓
6	Review of Liquefaction Potential		✓	

The following sections describe how each of the follow-up program elements (see Table 1.4-1) will be advanced in terms of planning, design and implementation. This material is intended to serve as the basis for initial consultation with regulators and stakeholders concerning the nature of the follow-up elements currently being

contemplated. Based on feedback received, the implementation details of each will be developed. For program elements requiring physical sampling, Figure 2-1 illustrates the approximate locations or areas where the sampling will take place. The number and specific locations for sampling will be determined as part of the sampling plan design.

Figure 2-1 Proposed Area for Sampling Locations for Program Elements 1 to 4



2.1 Program Element 1: Effluent Characterization Program

This follow-up program element corresponds with program element reference number 1 in Table 1.4-1

2.1.1 Background

The EA studies included an assessment of the effects of DNGS effluents on the lake water quality and the potential risk to human and non-human biota (Appendix F of the Surface Water Environment Technical Support Document) (OPG 2011c) and was summarized in the Screening Report (CNSC, DFO 2012). That assessment focused on chemical parameters measured for MISA and Environmental Compliance Approval (ECA) and showed that the station water systems resulting in liquid effluent discharges to Lake Ontario do not have an adverse effect on lake water quality.

Table 2.1-1: Effluent Characterization Program

Activity Description	Detailed effluent characterization to measure non-radiological parameters beyond those currently contained in license/permits. Site ERA (HHRA and EcoRA) will be updated should results warrant revision.
Environmental Component	Surface Water
Related Potential Environmental Effect	Effects on lake water quality resulting from discharge of conventional contaminants in liquid effluents.
EA Conclusion	No residual adverse effect on surface water quality and non-human biota
Phase	Pre-Refurbishment Outage
Objective	Confirm that liquid effluents (non-radiological) from DNGS operations will not result in any adverse effects on human and non-human biota.
Parameters	Based on the sampling plan.
Proposed Locations	Active Liquid Waste, Water Treatment Plant, Inactive Drainage (Lagoons), Boiler Blowdown, and Condenser Cooling Water Duct.
Frequency	Based on the sampling plan.
Threshold	Screening of parameters for inclusion in site ERA. Exposure concentration below Toxicity Reference Value (TRV).
Follow-up Program Endpoint	If the prediction of the EA is confirmed, no further follow-up is required. If the ERA identifies a new environmental issue or the need to study an environmental issue further, the recommendations will be addressed as part of compliance with CSA N288.4, N288.5 and N288.6. The follow-up monitoring will be considered complete and reporting will be part of the annual requirements under CSA N288.4.
Relationship to Other Programs, Standards, etc.	CSA N288 standards (CSA 2010, CSA 2011, CSA 2012), MISA, ECA, and *Fisheries Act*.

However, considering that a full characterization of liquid effluents last occurred in the 1990s and has not been repeated, a follow-up program to confirm that there are no residual adverse effects to water quality from liquid effluents will be carried out.

2.1.2 Monitoring Program

The goal of the monitoring program will be to perform a detailed characterization of the conventional chemical (i.e., non-radiological) parameters present in DNGS effluent streams. The following general activities will be carried out:

1) Develop a sampling plan. Measured parameters will be based on sources of chemicals, metals of construction (e.g. corrosion product transport), and review of Constituents of Potential Concern (COPCs) considered in the EA studies (see Non-Human Health – Ecological Risk Assessment TSD (OPG 2011d) and Human Health TSD (OPG 2011e)). The monitoring frequency will be determined considering the range of conditions encountered under normal operations. In other words, effluents with more variable quality will require more frequent sampling to adequately characterize the effluent.

   Proposed sample locations are at the point of discharge (i.e., MISA or ECA control point). Condenser cooling water (CCW) sampling is also proposed as confirmation of the parameters measured in the systems and to compare with ECA limits.

2) Conduct effluent characterization according to sampling plan.

3) Document and report findings. Update the Liquid Effluent Assessment performed during the EA studies considering the results of the effluent characterization. The measured concentrations will be used to identify Constituents of Potential Concern (COPC), assess the exposure to the COPCs and provide an assessment of environmental risk to receptors. The ERA will be revised according to these new insights.

   If the ERA identifies new environmental issues or the need to study an environmental issue further, additional site data may be needed to refine exposure calculations, reduce uncertainty and identify risk management or remediation measures if required. These recommendations identified as part of this follow-up program element will be addressed as part of compliance with CSA N288 series standards and incorporated in the site EMP accordingly, and this follow-up monitoring will be considered complete.

2.2 Program Element 2: Stormwater Control Study

This follow-up program element corresponds with program element reference number 2 in Table 1.4-1.

2.2.1 Background

During the EA studies, a stormwater control study was carried out (during fall of 2010 and spring of 2011) to confirm existing stormwater quality information. The study was reported in the Surface Water Environment Technical Support Document (OPG 2011c) and summarized in the Screening Report (CNSC, DFO 2012). The water quality data collected during storm events were reviewed and, where possible, compared to observed/typical urban runoff water quality (e.g., United States Environmental Protection Agency (USEPA), Ontario Ministry of the Environment Storm Water Management Planning and Design Manual) and other criteria used as guidelines (e.g., Provincial Water Quality Objectives (PWQOs) and the Durham Region Sewer Use By-law). Since there are no directly applicable criteria regulating allowable concentrations for the water quality parameters measured in stormwater discharges from the DN site[2], the purpose of these comparisons was to put the monitoring results into perspective, where possible.

The DNGS currently does, and will continue to, comply with applicable regulatory requirements associated with stormwater management. Neither the DNGS-specific ECA nor MISA, specify an on-going requirement to monitor and report stormwater quality. Nonetheless, the EA does predict a likely measurable change to stormwater quality during some construction-related activities of the Project. Considering in-design mitigation measures, however, (e.g., good industry management practices during all phases of the Project with respect to stormwater management), no residual adverse effects are predicted on stormwater quality.

To confirm the effectiveness of mitigation measures to protect stormwater quality, the EA follow-up program includes a stormwater control study for areas that are subject to refurbishment activities, for two representative storm events (spring and summer storm).

[2] Note that the DNGS ECA does limit the allowable oil and grease concentrations in storm/ground water collected in the Emergency Power Generator Buildings, the Emergency Power Generator Fuel Management Building, the Standby Generator Buildings, the Standby Generator Fuel Management Buildings and the Standby Generator Fuel Oil Storage Tank Dykes and discharged to the Yard Drainage System.

Table 2.2-1 Stormwater Control Study

Activity Description	Conduct a stormwater control study for areas that are subject to refurbishment activities within the Protected Area during two representative storm events (spring and summer storm) to confirm that the Project has not adversely affected storm water quality.
Environmental Component	Surface Water
Related Potential Environmental Effect	Effects of the Project on stormwater quality
EA Conclusion	No residual adverse effect to stormwater quality
Phase	During Refurbishment Outage (first unit refurbishment)
Objective	To confirm the effectiveness of mitigation measures to protect stormwater quality
Parameters	MISA parameters: Total Suspended Solids, total phosphorus, aluminum, iron, oil and grease, ammonia and ammonium, biological oxygen demand and Acute Toxicity testing. Historical findings[3]: boron, iron, cadmium, cobalt, copper, hexavalent chromium (VI), lead, molybdenum, manganese, vanadium, zinc, nitrate plus nitrite, dissolved chloride, total coliform, and toluene.
Proposed Locations	Established through development of study plan and will focus on areas within the Protected Area (e.g., 2010/2011 stormwater control study catchment areas K1, K2, K3, J, L and M).
Frequency	Two representative storm events (spring and summer storm)
Threshold	Similar chemical composition to baseline findings.
Follow-up Program Endpoint	If sampling results confirm no residual adverse effect on stormwater quality during the first unit refurbishment outage then no further follow-up is required. If not, then remedial actions and the need for additional monitoring beyond one season will be determined based on monitoring results.
Relationship to Other Programs, Standards, etc.	CSA N288 standards (CSA 2010, CSA 2011, CSA 2012), MISA, ECA, and *Fisheries Act*

[3] Parameters selected are based on water quality data collected in 2010-2012 Stormwater Control Study and comparison to observed/typical urban runoff water quality (as cited in the USEPA Results of the Nationwide Urban Runoff Program, the MOE Storm Water Management Planning and Design Manual, Provincial Water Quality Objectives (PWQO) and the Durham Region Sewer Use By-law.

2.2.2 Monitoring Program

The objective of the monitoring program will be to confirm the effectiveness of mitigation measures to protect stormwater quality in the area subject to refurbishment activities (i.e., Protected Area). The following general activities will be carried out:

1) Develop a sampling plan. Measured parameters will include MISA parameters as well as other historic relevant parameters based on water quality monitoring. The sample design should be similar to the methodologies employed in the DNGS EA to allow comparison with historical studies. Sampling locations will be established during development of the study plan and focus on areas within the Protected Area (e.g., 2010/2011 stormwater control study catchment areas K1, K2, K3, J, L and M).

2) Conduct a stormwater control study according to the sampling plan.

3) Document and report findings. Include a comparison to previous stormwater sampling results and recommendation for additional monitoring if required.

2.3 Program Element 3: Thermal Monitoring Program

This follow-up program element corresponds with program element reference number 3 in Table 1.4-1.

2.3.1 Background

Potential effects of changes (i.e., increases) in lakewater temperatures as a result of the operation of the condenser cooling water (CCW) system were evaluated in the EA studies in a context of their associated effects on the survival rates of round whitefish embryos. The round whitefish is known for its thermal sensitivity and is also of particular management and conservation interest to DFO. For these reasons, it was considered the appropriate valued ecosystem component (VEC) for assessing thermal effects. Although, the exact location(s) of round whitefish spawning habitat is not known in the vicinity of the DN site, round whitefish larvae have recently been captured in the general vicinity of the CCW diffuser. As a conservative approach, it was assumed that this species could be spawning within the vicinity of the diffuser thermal plume.

Thermal effects-related studies associated with the EA have continued beyond the submission of OPG's EIS in December 2009 and the relevant data are most recently summarized in the Screening Report (see Section 6.3.3, CNSC, DFO 2012). As described in the Screening Report, based on accepted temperature benchmarks for both short and long-term exposure of round whitefish eggs to temperature increases, it was concluded that the only area influenced by the DNGS diffuser discharge having a

reduction in embryo survival greater than 10% relative to reference conditions was an area of about 1.4 ha in size located at the end of the diffuser at a water depth of about 12 m. For perspective, this area of increased risk amounts to less than 1% of available potential spawning habitat in the Site Study Area (SSA).

This very small potential risk to the survival rate for round whitefish embryos was identified as a residual adverse effect in the Aquatic Environment. The assessment of significance of the effect, however, concluded that the effect was minor in nature and not significant. The EA follow-up program includes an element to verify the predictions regarding thermal effects on round whitefish embryos.

Table 2.3-1: Thermal Monitoring Program

Activity Description	Monitor data on cooling water discharge temperatures and plume characteristics and interpret in relation to fish habitat and susceptibility of round whitefish.
Environmental Component	Surface Water and Aquatic Habitat/Biota
Related Potential Environmental Effect	Effect of thermal emissions on aquatic biota.
EA Conclusion	No significant residual adverse effects to round whitefish as a result of thermal discharges.
Phase	Refurbishment Outage Continued Operations – After restart of all reactors
Objective	Confirm the EA predictions in terms of temperature increases associated with the CCW diffuser and likely related effects on round whitefish embryos.
Parameters	Lakewater temperature
Proposed Locations	CCW discharge plume
Frequency	One winter season (November to April) during Refurbishment; repeated following restart of all reactors
Threshold	To be developed as per Section 2.3.2.
Follow-up Program Endpoint	At conclusion of two monitoring campaigns described above. Further monitoring, if determined necessary, to be developed as part of adaptive management strategy (see Section 3.3)
Relationship to Other Programs, Standards, etc.	CSA N288 standards (CSA 2010, CSA 2011, CSA 2012) and Round Whitefish Action Plan (RWAP) (OPG 2013)

2.3.2 Monitoring Program

The objective of the thermal monitoring program will be to confirm the accuracy of the predictions made in the EA concerning changes in lakewater temperatures in the vicinity of the CCW discharge, and their associated possible effects on survival rates for round whitefish embryos. The following general activities will be carried out:

1) Obtain and review the results of an in-progress CANDU Owners Group (COG) study examining thermal effects to round whitefish eggs over the two winter seasons (2011/2012 and 2012/2013). The COG study is currently underway and it is anticipated that the results will be available for current purposes in or about March 2014.

2) Develop a sampling plan. A Thermal Monitoring Protocol Agreement established through consultations with regulatory agencies and other stakeholders will be included in the sampling plan. The Protocol should consider the results of the COG study in establishing:
    - Thermal benchmark(s) for comparison of measured values.
    - Determination of location(s) for ambient water temperature monitoring; and
    - Temperature thresholds that would trigger adaptive management response (e.g., increased thermal monitoring).

3) Implement annual ambient water temperature monitoring.

4) Conduct thermal monitoring during Refurbishment outage.

5) Report monitoring data collected during Refurbishment outage and assess likely effects on the survival of round white fish embryos. If the performance threshold is exceeded, review available mitigation options to determine if additional technically and economically feasible opportunities are available to further reduce the potential for effects (see Section 3.3).

6) Conduct thermal monitoring after restart of all reactors (i.e. Continued Operation phase).

7) Report monitoring data collected during Continued Operation phase and assess likely effects on the survival of round white fish embryos. If the performance threshold is exceeded, review available mitigation options to determine if additional technically and economically feasible opportunities are available to further reduce the potential for effects (see Section 3.3).

2.4 Program Element 4: Entrainment and Impingement Mortality Monitoring

This follow-up program element corresponds with program element reference number 4 in Table 1.4-1. As indicated in the table, this element comprises of three individual programs as follows, and each is discussed separately below:

- Benthic invertebrate community study prior to refurbishment outage;
- Entrainment monitoring prior to refurbishment outage; and
- Impingement and entrainment monitoring following restart of all reactors.

2.4.1 Benthic Invertebrate Community Study Prior to Refurbishment Outage

2.4.1.1 Background

Benthic invertebrates (i.e. zebra mussels, worms and insect larvae) are small animals that live in or on sediments/rocky substrate at the bottom of lakes and streams. For New Nuclear at Darlington (NND), a study was conducted in 2008 in the vicinity of the potential infill area. Results showed that abundance and diversity of invertebrates were low and variable. The sand/cobble substrate in this general nearshore environment is too densely packed for the invertebrates to burrow into and does not provide the nutrients for the invertebrates. The invertebrates are also very exposed to dynamic conditions of local north shore wind and waves, and can drift with the water currents. The results were typical of benthic communities in the shallow water zone of Lake Ontario, and were generally consistent with earlier benthic studies. Since recent studies have examined the area near NND, the proposed sampling program will focus on the vicinity of the DNGS intake.

Table 2.4-1: Benthic Invertebrate Community Study

Activity Description	Benthic invertebrate community study
Environmental Component	Aquatic Habitat/Biota
Related Potential Environmental Effect	Benthic invertebrates will be entrained.
EA Conclusion	No significant residual adverse effects to aquatic biota as a result of entrainment of benthic invertebrates.
Phase	Pre-Refurbishment Outage
Objective	The objective of the invertebrate study is to determine baseline abundance and species diversity of benthic invertebrates in the vicinity of the DNGS intake. Species presence will be classified to order (or genus if possible) and will be compared to future entrainment study results. Previous entrainment studies had indicated the presence of benthic macroinvertebrates in entrainment samples. These benthic results will also be compared to nearshore benthic studies conducted in 2008 in the vicinity of the proposed New Nuclear at Darlington (NND) infill area.
Parameters	Benthic diversity and abundance estimates.
Proposed Locations	Based on the sampling plan.
Frequency	Based on the sampling plan.
Threshold	None. For comparison to benthic invertebrate entrainment.
Follow-up Program Endpoint	One time study to provide context for observed entrainment. Entrainment levels of benthic organisms can be compared to the abundance in the SSA; that is, low densities of benthic invertebrates and low species richness which is characteristic of such high energy, unstable environments.
Relationship to Other Programs, Standards, etc.	CSA N288 standards (CSA 2010, CSA 2011, CSA 2012)

2.4.1.2 Monitoring Program

The objective of the Benthic Invertebrate Community Study is to determine baseline abundance and species diversity of benthic invertebrates in the vicinity of the DNGS intake. Species presence will be classified to order (or genus if possible) and will be compared to future entrainment study results. Previous entrainment studies had indicated the presence of benthic invertebrates in entrainment samples. These benthic results will also be compared to nearshore benthic studies conducted in 2008 in the vicinity of the proposed New Nuclear at Darlington (NND) infill area.

The following general activities will be carried out prior to the Refurbishment outage:

1) Develop a sampling plan for Benthic Invertebrate Community Study in the vicinity of DNGS intake.

2) Conduct Benthic Invertebrates Community study.

3) Document and report findings including a comparison to the 2008 study in the vicinity of NND.

2.4.2 Entrainment Monitoring Prior to Refurbishment Outage

2.4.2.1 Background

In past entrainment studies (e.g., 2004 and 2006), few eggs or larvae were detected. The species observed in the samples were alewife, smelt, freshwater drum and common carp. Losses were estimated in terms of total numbers of larvae and also adult equivalents.

In 2004, it was estimated that 15,631,833 eggs and 1,201,943 larvae were entrained annually. Entrained organisms represented 1,318 age-1 equivalent smelt and alewife. Production foregone (i.e., the biomass which would have been produced if fish were not entrained) was estimated to be 46.2 kg. In 2006, it was estimated that 605,059 eggs and 6,996,246 larvae were entrained annually. Entrained organisms represented 11,548 age-1 equivalent alewife, common carp and freshwater drum. Production foregone was estimated to be 16,925 kg (due to high survival rate of carp). The reported losses in 2004 and 2006 were not considered meaningful to populations of these species.

The 2006 entrainment studies at DNGS included the collection of invertebrates. A total of 263,163 invertebrates were collected over the duration of the study. The most abundant invertebrate taxa collected were copepods/cladocerans (83.5%), spiny water fleas (8.1%), rotifers (6.3%), amphipods (1.6%) and Mysids (<1%). Most of these taxa are plankton (copepods/cladocerans, spiny water fleas, rotifers). Plankton are drifting organisms - plant (phytoplankton), animal (zooplankton) – which inhabit the open water column (pelagic zone) and are usually microscopic in size. Because of their small size they are subject to movement by currents, storms and upwelling events. Power plant studies conducted elsewhere have shown high entrainment survival rates for aquatic invertebrates and plankton (e.g. Mayhew et al. 2000).

The 2004 and 2006 study methodology has been criticized due to the small sample size relative to intake water volume. Thus the proposed EA follow-up program includes development of an entrainment method to improve characterization of the intake losses.

Table 2.4-2: Entrainment Monitoring Prior to Refurbishment Outage

Activity Description	Monitor entrainment associated with the DNGS intake
Environmental Component	Aquatic Habitat/Biota
Related Potential Environmental Effect	Aquatic organisms will be entrained at the station during continued operation, but the residual effect is considered negligible in terms of population abundance and conservation.
EA Conclusion	No significant residual adverse effects to aquatic biota as a result of entrainment.
Phase	Pre-refurbishment Outage
Objective	• Characterize early life stages of fish and macroinvertebrates being entrained by station operation. The sampling should be conducted in a manner sufficient to reflect the diel and seasonal cycles in organism abundance within the capture zone of the intake; • Monitor at a level capable of detecting fish Species at Risk and aquatic species of conservation concern that have been identified by provincial or federal agencies. Sampling should target species based on life history characteristics and potential for interaction with station operation; and, • Determine the total fish and macroinvertebrate losses and associated impact.
Parameters	Entrainment (including invertebrates): total numbers of larvae and adult equivalents, extrapolated to consider cooling water flows to determine annual losses.
Proposed Locations	Unit Pumphouses
Frequency	Based on the sampling plan.
Threshold	To be developed as described in Section 2.4.2.2
Follow-up Program Endpoint	Refer to Section 2.4.3
Relationship to Other Programs, Standards, etc.	CSA N288 standards (CSA 2010, CSA 2011, CSA 2012), and Government of Canada Recommendation 30 and 33 for Darlington New Build (CEAA 2012).

2.4.2.2 Monitoring Program

The overall objectives of the monitoring program are:

- Characterize early life stages of fish and macroinvertebrates being entrained by station operation. The sampling should be conducted in a manner sufficient to reflect the diel and seasonal cycles in organism abundance within the capture zone of the intake;
- Monitor at a level capable of detecting fish Species at Risk and aquatic species of conservation concern that have been identified by provincial or federal agencies. Sampling should target species based on life history characteristics and potential for interaction with station operation; and,
- Determine the total fish and macroinvertebrate losses and associated impact.

In order to achieve these objectives, an entrainment sampling methodology will be developed and applied to entrainment sampling. Prior to the Refurbishment outage, the following general activities will be carried out:

1) Develop a sampling plan which includes entrainment sampling methodology using larger sample volume to improve estimation of intake aquatic biota losses. The selected methodology will consider methodologies from other jurisdictions.

   Sampling plan should include development of performance threshold(s) for impingement and entrainment (i.e. unacceptable levels of impingement and entrainment losses especially in reference to Species at Risk and aquatic species of conservation concern) through consultations with regulatory agencies and other stakeholders.

2) Using the methodology developed from activity 1), conduct entrainment study prior to start of the refurbishment outage.

3) Document and report findings.

2.4.3 Impingement and Entrainment Monitoring Following Restart

2.4.3.1 Background

DNGS was the first OPG generating station where fish protection issues were considered in the decision making process for both the design and location of the offshore lake bottom intake. The CCW intake incorporates features in its design to prevent entrapment of large schools of fish. For instance, flow near the intake was made heterogeneous and designed so that velocities do not exceed the swimming capacities of prevalent schooling species such as alewife and rainbow smelt. The intake

is also located offshore where studies demonstrated that fish distribution and abundance were lower than in inshore locations. Studies conducted in 1990s established that the intake design met design requirements and the station impinged few fish. More recently, the DNGS intake has been confirmed to meet the intake velocity requirements in the U.S. to reduce fish impingement (e.g., USEPA Section 316b, Phase 2 Draft Rule, Cooling Water Intake Structures of the U.S. Clean Water Act).

Impingement sampling was recently conducted between May 2010 and April 2011. Analysis of impingement data at DNGS indicated that alewife, round goby, slimy sculpin and rainbow smelt contributed over 99% of impinged fish counts and overall biomass. The overall annual biomass impinged in 2010-11 was 2,362 kg.

Compared to previous sampling years, an increase in impingement numbers was observed. The increase can be attributed to newly installed higher efficiency travelling screens and the increase in invasive goby abundance (was only 8.5% of total impingement in 2006-7 compared to 55% in 2010-11).

Using biological and economic metrics to evaluate the 2010-11 impingement data, the following is noted:

- Lost fishery yield was relatively small (89 kg) and consisted almost exclusively of rainbow smelt (almost 98%);
- The production foregone of alewife and rainbow smelt are negligible when considering the biomass of each species available in Lake Ontario; and,
- Losses in terms of economic value were considered negligible when considering recent commercial harvest estimates (suckers, brown bullhead, yellow perch, and sunfish).

A relatively small number of fish and aquatic macroinvertebrates will comprise intake loss associated with impingement and entrainment during continued operation due to the effectiveness of the intake design and placement. These losses are not expected to result in measurable changes to population size, production or status of VEC indicator species. For small numbers of individuals removed from the respective populations, compensatory mechanism of recruitment, growth and survival in the remaining population are expected to offset losses. Given this assessment is based upon information representative of present conditions and in recognition that Lake Ontario is an ecosystem that can change (e.g., the presence of invasive round goby in the last decade), an impingement and entrainment study during the continued operation phase will serve to confirm the baseline condition and conclusions.

Table 2.4-3: Impingement and Entrainment Monitoring

Activity Description	Monitor impingement and entrainment associated with the DNGS intake
Environmental Component	Aquatic Habitat/Biota
Related Potential Environmental Effect	Aquatic organisms will be impinged and entrained at the station during continued operation, but the residual effect is considered negligible in terms of population abundance and conservation.
EA Conclusion	No significant residual adverse effects to aquatic biota as a result of impingement and entrainment.
Phase	Continued Operations (two years following restart of all reactors)
Objective	• Characterize early life stages of fish and macroinvertebrates being entrained and fish impinged by station operation. The sampling should be conducted in a manner sufficient to reflect the diel and seasonal cycles in organism abundance within the capture zone of the intake; • Monitor at a level capable of detecting fish Species at Risk and aquatic species of conservation concern that have been identified by provincial or federal agencies. Sampling should target species based on life history characteristics and potential for interaction with station operation; and, • Determine the total fish and macroinvertebrate losses and associated impact.
Parameters	Impingement: Identification and enumeration of fish by species, age class and weight Entrainment (including invertebrates): Identification and enumeration of larvae and eggs including identification of species
Proposed Locations	Unit Pumphouses.
Frequency	Based on the sampling plan.
Threshold	To be developed as described in section 2.4.2.2.
Follow-up Program Endpoint	Follow-up concludes with completion of the impingement and entrainment sampling for two years of monitoring after restart of all reactors. However, if performance threshold(s) are exceeded, an assessment of economically achievable mitigation options will be completed and future monitoring requirements will be reviewed and implemented. Future impingement and entrainment monitoring (if needed) will be reported in the Environmental Monitoring Program (EMP) report.
Relationship to Other Programs, Standards, etc.	CSA N288 standards (CSA 2010, CSA 2011, CSA 2012) and Government of Canada Recommendation 30 and 33 for Darlington New Build (CEAA 2012).

2.4.3.2 Monitoring Program

The overall objectives of the monitoring program are:

- Characterize early life stages of fish and macroinvertebrates being entrained and fish impinged by station operation. The sampling should be conducted in a manner sufficient to reflect the diel and seasonal cycles in organism abundance within the capture zone of the intake;
- Monitor at a level capable of detecting fish Species at Risk and aquatic species of conservation concern that have been identified by provincial or federal agencies. Sampling should target species based on life history characteristics and potential for interaction with station operation; and,
- Determine the total fish and macroinvertebrate losses and associated impact.

The following general activities will be carried out:

1) Prepare sampling plan for impingement and entrainment.

2) Conduct impingement and entrainment monitoring according to the sampling plan.

3) Document and report findings. If the performance threshold(s) are exceeded, review available mitigation options to determine if additional technically and economically feasible opportunities are available to further reduce the potential for effects (see Section 3.3).

2.5 Program Element 5: Probabilities Associated with Safety Improvement Opportunities

This follow-up program element corresponds with program element reference number 5 in Table 1.4-1.

2.5.1 Background

The Probabilistic Risk Assessment (PRA) at OPG Nuclear is to provide an integrated review of the adequacy of the safety of the current station design and operation. The PRA is only one of a group of tools used to estimate and manage risk. A key benefit of PRA is the identification of areas for improvement and assessing the relative benefits/risks of different improvement options. The station PRAs are required to meet the CNSC Standard S-294 (CNSC 2005).

A PRA identifies the various sequences that lead to radioactivity releases, and calculates their frequencies of occurrence and consequences. Additionally, the PRA is

used to identify the major sources of risk and assess the magnitude of radiological risks to the public from accidents due to operation of nuclear reactors while at power as well as during outage. The PRA is a comprehensive model of the plant incorporating knowledge about plant design, operation, maintenance, testing and response to abnormal events. To the extent possible, the PRA is intended to be a realistic model of the plant.

Table 2.5-1: Probabilistic Risk Assessment (PRA) Update

Activity Description	Update the station PRA to reflect the detailed design and as-installed configuration of the Safety Improvements for DNGS Refurbishment Project
Environmental Component	Malfunctions and Accidents
Related Potential Environmental Effect	Not Applicable
EA Conclusion	The predicted individual and population doses would be well within appropriate guideline from the potential effects of the hypothesized nuclear accident.
Phase	Refurbishment Outage and Continued Operations
Objective	To confirm the assignment of probabilities to represent the SIO design changes are judged to be sufficient to approximate the reduction in accident frequencies.
Parameters	Not Applicable
Proposed Locations	Not Applicable
Frequency	Not Applicable
Threshold	Not Applicable
Follow-up Program Endpoint	CNSC acceptance of submitted EA closure document
Relationship to Other Programs, Standards, etc.	CNSC S-294

The DNGS PRA, referred to as the Darlington Risk Assessment (DARA) was used to carry out sensitivity analyses in support of the EA and the ISR, which included four safety improvements opportunities (SIOs) that will be implemented as part of the refurbishment of Darlington NGS. These SIOs will further improve the safety of the plant as a result of Refurbishment Project, as well as address post-Fukushima follow-up commitments and activities. The four SIOs considered in the DARA model are:

1) Containment Filtered Venting System;
2) Powerhouse Steam Venting System;
3) Third Emergency Power Generator;

4) Provision of an alternate and independent supply of water as an Emergency Heat Sink.

Since the analysis was carried out based on conceptual design features rather than specifics of installed equipment, as per the requirements of CNSC S-294, the station PRA will be updated to reflect the detailed design and as-installed configuration.

2.5.2 Review Program

The objective of this follow-up element will be to update the station PRA to confirm that the assignment of probabilities appropriately represent the SIO changes. This will take place after the station design has been finalized, all the design changes with supporting Safety Analysis and procedural documents (e.g., Emergency Operating Procedures, Abnormal Incident Manual) and the plant modifications declared Available for Service (AFS) are complete prior to bringing the refurbished units back on-line. The PRA will be updated and reported to the CNSC as per S-294 requirements.

For the purpose of follow-up reporting, the SIO implementation status update will be provided prior to the restart of each the refurbished units. Once all of the refurbished units are back on-line, the PRA will be updated to reflect the plant changes in all units. A review of the PRA results will be completed to confirm that the event frequencies predicted in the EA based on conceptual design features are consistent with the installed equipment.

2.6 Program Element 6: Review of Liquefaction Potential in Protected Area

This follow-up program element corresponds with program element reference number 6 in Table 1.4-1.

2.6.1 Background

Liquefaction is a soil behavior phenomenon wherein a saturated soil loses a substantial degree of strength due to high pore-water pressure generated by earthquake-induced ground shaking. Because of its association with subsurface instability, this discussion of liquefaction is framed in terms of the seismically induced hazard and summarized in Section 8.4 of the Screening Report (CNSC, DFO 2012).

The DN site lies within the western Lake Ontario region in the tectonically stable interior of the North American continent, which has been characterized by low rates of seismicity. The updated PRA for the station concluded that the DNGS structures, systems and components can safely shut down, remove decay heat, maintain containment function, monitor control systems and limit radioactive material releases

following the mean 1 x 10^{-4} per year earthquake ground motion. Therefore, no residual adverse effects due to the seismic hazard are expected.

Table 2.6-1: Review of Liquefaction Potential

Activity Description	Review available documentation regarding fill materials and their liquefaction potential on the relevant safety related systems, structures, and components. Should sufficient verification not be realized for the prediction of low liquefaction potential, undertake a liquefaction assessment of fill materials as appropriate.
Environmental Component	Effects of the Environment on the Project
Related Potential Environmental Effect	Potential liquefaction and associated instability of fill materials in the Protected Area.
EA Conclusion	No residual adverse effects to the Project due to seismically-induced geotechnical effects of the environment.
Phase	Prior to restart of refurbished reactors.
Objective	To confirm the liquefaction potential of fill materials in the Protected Area is acceptably low.
Parameters	Soil liquefaction potential
Locations	Protected Area
Frequency	One-time evaluation
Threshold	Geotechnical characteristics of soils relative to shear strength and resistance to liquefaction (detailed thresholds established through data review).
Follow-up Program Endpoint	CNSC acceptance of submitted EA closure document
Relationship to Other Programs, Standards, etc.	Integrated Safety Review (ISR)

Consistent with industry practice and regulatory guidance, other seismically induced hazards that could also potentially affect the DN site and DNGS structures, systems and components, were also evaluated during the EA and ISR. These included tsunamis, seiches and geotechnical hazards such as slope instability and potential for liquefaction. The Screening Report concluded that the other seismically-induced hazards were satisfactorily considered in the EA and did not represent a residual adverse effect of the environment on the Project.

The Screening Report did, however, require that the EA follow-up program include an element to verify the low potential for subsurface liquefaction in the Protected Area. The investigation described in the following section is intended to confirm the potential for

liquefaction was sufficiently addressed based on a detail review of documentation regarding fill material at the DN site.

2.6.2 Review Program

This investigation is an ISR item which will be resolved in accordance with the ISR Gap Resolution Process and all resulting actions will be implemented in accordance with the IIP Change Control process. The objective of this review is consistent with the EA Follow-up requirements; that is, to compile and evaluate existing information with respect to liquefaction potential in the Protected Area and reach conclusions concerning the acceptability of the associated risk of failure of relevant safety-related systems, structures and components.

1) Carry out a review including the following general steps:

   - Compile and review all available data regarding the fill material in the Protected Area where there are relevant safety-related systems, structures and components on their liquefaction potential. This material is readily available from sources accessed for the EA studies and the ISR.

   - For contextual purposes, review the geotechnical conditions relevant to the construction history for DNGS.

   - Based on relevant collected data, undertake an evaluation of the stability of the fill materials with regard for liquefaction potential under seismic and static load conditions. The evaluation criteria will be established based on the objectives, scope and methods adopted for the evaluation program. They will incorporate geotechnical guidance and standards as they are appropriate and applicable.

   - Should sufficient verification not be realized for the prediction of low liquefaction potential, recommendations for further investigation will be provided as appropriate.

2) If required, conduct a liquefaction assessment study based on recommendations of the review in activity 1).

3.0 ADAPTIVE MANAGEMENT

3.1 Adaptive Management Framework

Adaptive management involves a systematic approach to maintain the high performance of environmental management practices by learning from their outcomes. Adaptive management provides the flexibility to identify and implement new mitigation measures or to modify existing measures. In its simplest form, adaptive management as it relates to effects mitigation and environmental monitoring, integrates design, management and monitoring data systematically test assumptions, learn from experience, and apply knowledge gained (i.e., adapt) to subsequent actions.

EA follow-up monitoring program elements are designed to satisfy a specific condition in the EA and are expected to be discontinued when the requirement has been satisfied, at the end of a predetermined period. However, adaptive management will be inherent in the ongoing site monitoring program consistent within the Environmental Management System (EMS) and the systematic processes detailed in the CSA N288 standards for continuously improving environmental management practices. Authorization(s) granted under the *Fisheries Act* will include adaptive management-related requirements to confirm compliance with the authorization.

The adaptive management concept is illustrated in CSA N288.4 (CSA 2010, section 5.3.3) with the requirement for periodic review of the adequacy of the EMP. This review includes an evaluation of the data that has been collected by the EMP, reassessment of the environmental risk and a determination whether the objectives of the EMP have been achieved. As well, a review of the ERA is expected to occur every five years or sooner, if major facility changes are proposed. Changes that would trigger such a review are as follows (CSA 2010, section 5.3.1):

(a) The design or operation of the facility;

(b) The population or land use in the surrounding community;

(c) The scientific understanding of the interactions of the facility with the environment;

(d) The nature of the surrounding environment;

(e) The statues, regulations, licenses, or permits that govern the operation of the facility; or,

(f) The commitments made by the licensee to any regulatory agency or other stakeholders

Since these types of changes have the potential to substantially alter the prediction of the ERA, an update of the site ERA may be warranted. Based on the risks, the monitoring requirements can be revised accordingly.

OPG will design and conduct the EA follow-up program elements with full consideration of an adaptive management philosophy. Adaptive management features will be incorporated into the design and implementation strategies for the aquatic monitoring programs. Details of the adaptive management features will be specific to the scope and nature of each program and will be refined and incorporated into the programs in consultation with the RAs and appropriate FAs.

The general framework proposed to incorporate adaptive management into the follow-up program elements is as follows:

1) Develop monitoring program, including performance thresholds;

2) Implement monitoring program;

3) Review monitoring results; if a performance threshold is exceeded:

    - Assess implementation of economically achievable mitigation options,
    - Implement mitigation, or
    - Implement compensation if warranted.

4) Repeat monitoring per step 2); and

5) Review monitoring program and revise as appropriate (continuous improvement).

The adaptive management approach will be applied to the impingement/entrainment and thermal monitoring programs. These are discussed separately below.

3.2 Adaptive Management – Impingement and Entrainment Monitoring Program

The Screening Report (CNSC, DFO 2012) referenced the draft adaptive management framework for impingement and entrainment monitoring program (SENES, MMM 2012). That framework will be the basis for implementation of the adaptive management response to results of impingement and entrainment monitoring, and details of its elaboration will be incorporated into the scope and methodologies for the monitoring activities.

The review of monitoring results will include an assessment of adaptive management response strategies triggered by losses of aquatic species to regulatory agencies. For example, in the event of an exceedance of a performance threshold for the condenser cooling water (CCW) intake function, potential mitigation options will be evaluated to determine if there are viable approaches to cost-effectively return the system performance to the acceptable level. Mitigation options that may be considered as part of the adaptive management program could include, for example, fish return system, indirect intake modifications (fish deterrent systems) and direct intake modifications to increase physical intake barriers.

If CCW system mitigation options considered through the adaptive management framework are found to be not economically achievable in the future, commensurate with the environmental risk and/or effect, OPG may propose off-setting measures to address the potential loss to the valued fish and fisheries habitat, prioritized as: 1) restoration; 2) creation; and 3) enhancement.

3.3 Adaptive Management – Thermal Monitoring Program

In the event that thermal monitoring was to indicate an exceedance of a performance threshold, OPG would respond in the adaptive management framework generally as described above to ensure that the potential for effects are managed appropriately. This is specifically identified as a future environmental management approach to address potential concerns for round whitefish eggs and larvae, should the potential effects of climate change cause, for example, large increases in winter season lake bottom temperatures.

Adaptive management response to conditions associated with thermal discharges would include a review of available thermal discharge mitigation techniques to determine if additional technically and economically feasible opportunities are available to further reduce the potential for effects during the Continued Operation phase of the Project. Mitigation options that may be considered in the future as part of the adaptive management plan may include modifying the existing cooling water system.

4.0 STAKEHOLDER CONSULTATION

The consultations began with the submission of this EA Follow-up Program, in draft, to the CNSC, as the lead RA for the EA. The CNSC circulated the draft document for review to DFO and Environment Canada (EC). Based on review input, the draft EA Follow-up Program was confirmed to meet the requirements of the Screening Report (CNSC, DFO 2012) and the Record of Proceedings, Including Reasons for Decision (CNSC 2013a). Subsequently, the CNSC held a 30-day public consultation period on the draft document. The Follow-up Program has been finalized by addressing comments as appropriate.

Upon acceptance of the final EA Follow-up Program, OPG will develop the implementation details for the individual program elements following the framework including timing, described in Section 2. In so doing, OPG will engage and consult with appropriate stakeholders in consultation with the CNSC and DFO based on the nature of the activities contemplated. Table 4-1 proposes a preliminary consultation agenda. This agenda will be re-evaluated and modified as the EA follow-up program evolves. Consultation activities will be carried out in appropriate formats (e.g., meetings, workshops).

Table 4-1: Follow-up Program Consultation Preliminary Agenda

Follow-Up Program Element	Agencies and Stakeholders Consulted	Goal of Consultation
Draft EA Follow-up Program	CNSC, DFO, EC, the public and Aboriginal groups.	To ensure Program meets requirements of Screening Report and Record of Proceedings, Including Reasons for Decision.
1. Effluent Characterization	CNSC and DFO (others as determined appropriate, including Environment Canada, Ministry of Environment (Ontario) (MOE), Aboriginal groups).	To establish and confirm program scopes (including parameters).
2. Stormwater Control Study		
3. Thermal Monitoring Program		
4. Benthic Invertebrate Community Study, Impingement and Entrainment Mortality Monitoring	CNSC and DFO (others as determined appropriate, including Ministry of Natural Resources (Ontario), Aboriginal groups).	To establish and confirm program scope (including parameters).
5. Probabilities Associated with Safety Improvement Opportunities	CNSC and DFO	To establish and confirm program scope (including parameters).
6. Review of Liquefaction	CNSC and DFO	To establish and confirm program

Follow-Up Program Element	Agencies and Stakeholders Consulted	Goal of Consultation
Potential in Protected Area		scope (including parameters).

5.0 REPORTING

The six follow-up program elements as described in Section 2 will require studies which may be performed before, during and/or following the refurbishment phase. The results of each of these studies will be compiled in a manner appropriate to the duration and frequency of the individual program elements and submitted to CNSC as the lead RA. The CNSC will share the results with DFO and with other stakeholders as appropriate. In addition, as the project progresses, OPG will provide periodic updates to the CNSC through the IIP process.

6.0 REFERENCES

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7.0 DEFINITIONS AND ACRONYMS

7.1 Definitions

Adaptive Management	The integration of design, management, and monitoring to systematically test assumptions in order to adapt and learn, and apply and implement.
Biomass	The total quantity or weight of organisms in a given area or volume.
Biota	The animal and plant life of a region.
Condenser circulating/cooling water (CCW)	Water pumped through a heat exchanger to condense (i.e., cool) the steam from the turbine exhaust back into water.
Constituent of Potential Concern	A constituent of potential concern (COPC) is a chemical constituent in the environment that may be of potential concern for ecological receptors. A chemical is identified as a COPC when it has a concentration in the environment higher than a given criterion, which typically includes background concentrations and regulatory criteria. All radionuclides are considered COPC.
Diffuser	A submerged structure consisting of a manifold with multiple ports through which the effluent is discharged into the receiving water to promote initial mixing.
Environmental Risk Assessment	A process for identifying potential adverse biological effects and for predicting the magnitude, probability, and significance of the identified effects on both ecological and human components of the environment.
Effluent	Discharge from an industrial process.
Emission	Release to the environment, such as air, noise, radioactivity and water.
Entrainment	Occurs when aquatic invertebrates, fish eggs and fish larvae are drawn into a water intake and cannot escape.

Environmental Assessment (EA)	A process for identifying project and environment interactions, predicting environmental effects, identifying mitigation measures, evaluating significance, reporting and following-up to verify accuracy and effectiveness. Environmental Assessment is used as a planning tool to help guide decision-making, as well as project design and implementation.
Environmental effect	As defined in the *Canadian Environmental Assessment Act.*
Impingement	Occurs when an entrapped fish is held in contact with the intake screen and is unable to free itself.
Intake structure	The hydraulic structure on the bottom of Lake Ontario offshore of the DN site through which water is drawn into the intake tunnel and then into the station to provide process water (e.g. cooling water, service water) to the plant.
Mitigation	An action or design intended to reduce the severity or extent of an environmental impact.
Plume (thermal)	Plume within a water body resulting from a heated discharge, such as cooling water; its behaviour is governed by density differences and buoyancy conditions and momentum. Typically reported as a temperature difference from ambient conditions.
Species at Risk	As defined in the federal *Species at Risk Act.*
Stormwater	Water that originates during precipitation events (rainfall or snowmelt) and either infiltrates into the ground or becomes surface runoff that flows directly into surface water bodies (lakes, rivers, etc.) or is channelled into storm sewer systems.
Surface water	Water found in ponds, lakes, streams, rivers, and inland seas.

7.2 Acronyms

CANDU	CANada Deuterium Uranium (trademark of Atomic Energy of Canada)
CCW	Condenser Cooling Water
CEA Act	*Canadian Environmental Assessment Act*
CNSC	Canadian Nuclear Safety Commission
COG	CANDU Owners Group
COPCs	Constituents of Potential Concern
CSA	Canadian Standards Association
DARA	Darlington Risk Assessment
DFO	Department of Fisheries and Oceans
DN	Darlington Nuclear
DNGS	Darlington Nuclear Generating Station
DWMF	Darlington Waste Management Facility
EA	Environmental Assessment
ECA	Environmental Compliance Approval
EcoRA	Ecological Risk Assessment
EIS	Environmental Impact Statement
EMP	Environmental Monitoring Program
EMS	Environmental Management System
ERA	Environmental Risk Assessment
FA	Federal Authority
GAR	Global Assessment Report
HHRA	Human Health Risk Assessment
IIP	Integrated Implementation Plan
ISR	Integrated Safety Review
MOE	Ministry of Environment (Ontario)
MISA	Municipal/Industrial Strategy for Abatement
NND	New Nuclear at Darlington
NSCA	*Nuclear Safety and Control Act*
OPG	Ontario Power Generation
PRA	Probabilistic Risk Assessment
PROL	Power Reactor Operating License
PWQOs	Provincial Water Quality Objectives
QA/QC	Quality Assurance/Quality Control
RAs	Responsible Authorities
RWAP	Round Whitefish Action Plan
SIO	Safety Improvement Opportunities
SSA	Site Study Area
TRV	Toxicity Reference Value
TSDs	Technical Support Documents
USEPA	United States Environmental Protection Agency
VEC	Valued Ecosystem Component

WWMF Western Waste Management Facility