

DARLINGTON REFURBISHMENT PROGRAM

OVERVIEW

1.0 PROGRAM SUMMARY

The Darlington Refurbishment Program (the “Program” or “DRP”) is a multi-year, multi-phase mega-project that will enable the Darlington Generating Station (“Darlington”) to continue safe and reliable operation until approximately 2055. The Program includes the replacement of life-limiting critical components, the completion of upgrades to meet applicable regulatory requirements, and the rehabilitation of components at Darlington’s four units. The Program is comprised of individual projects of various scales and sizes that will be executed during multi-year outages.

In this application, OPG provides an update on the progress of the DRP and evidence to support its request for approval of in-service additions through 2021, including the in-service additions related to Unit 2 refurbishment. More specifically, OPG’s pre-filed evidence demonstrates that:

- OPG has successfully performed the detailed planning that is necessary to determine Program scope and to establish high-confidence schedule (“schedule”) and cost estimates for safely completing the Unit 2 refurbishment by February 2020 and refurbishment of the other three units thereafter; and
- OPG has in place the resources, organization and processes necessary to execute the refurbishment of Unit 2, and the Program in its entirety, safely, on time, on budget, and to the required quality level.

As part of the work completed during the Definition Phase of the Program, all major contracts required to execute the scope of the DRP have been awarded. The detailed planning conducted by OPG and its contractors during the Definition Phase has enabled the development of a four-unit budget and schedule for the successful execution of the DRP. Critical to OPG’s planning efforts during this phase have been the construction of a full scale reactor mock-up and other training facilities which have been brought into service in this phase, as well as the Retube and Feeder Replacement tooling development and testing in

1 the mock-up. Equally important has been the completion of the Unit 2 detailed engineering
2 for each design modification package for all committed scope that is part of the DRP. Based
3 upon this work, OPG prepared a detailed four-unit budget and schedule (the "Release
4 Quality Estimate" or "RQE"), which was finalized in November 2015 (as discussed in Ex. D2-
5 2-8).

6
7 Refurbishment of all four Darlington units will take place over a total span of 112 months
8 (October 2016 to February 2026), including 40 months for Unit 2 from October 2016 to
9 February 2020. Based on the significant effort that went into developing the RQE, which was
10 approved by OPG's Board of Directors on November 13, 2015, OPG has a high level of
11 confidence in the DRP cost estimate of \$12.8B, which includes contingency, capitalized
12 interest and escalation. The RQE establishes a four-unit, program-level control budget that
13 serves as the baseline against which the success of the DRP will be measured. Subsequent
14 to receiving approval from OPG's Board of Directors, the RQE was provided to the Minister
15 of Energy, who announced the Province's endorsement of the DRP on January 11, 2016.¹

16
17 A simplified breakdown showing the Program components included in RQE and their budget
18 is provided in Chart 1, below, followed by brief descriptions of the listed components. Life to
19 date expenditures (to the end of 2015) are \$2.2B, inclusive of interest and escalation.

¹ See: <https://news.ontario.ca/mei/en/2016/01/ontario-moving-forward-with-nuclear-refurbishment-at-darlington-and-pursuing-continued-operations-at.html>.

Chart 1

Simplified Breakdown of Total DRP Release Quality Estimate²

Program Component	RQE Total Cost (Billion \$)	RQE Total Cost (%)
Major Work Bundles	5.54	43
Safety Improvement Opportunities	0.20	2
Facilities & Infrastructure Projects	0.64	5
OPG Functional Support	2.23	17
Early Release Funds	0.11	1
Contingency	1.71	13
Interest & Escalation	2.37	19
Total Cost Estimate	12.8	100

Major Work Bundles are logical groupings of work scope, each consisting of a number of individual projects, defined by OPG for purposes of effectively contracting work to outside contractors and assigning project management accountabilities. The work to be undertaken through the major work bundles consists of the replacement and rehabilitation of components, inspections and the completion of upgrades directly related to unit refurbishment. The major work bundles are (1) Retube and Feeder Replacement (“RFR”), (2) Turbines, Generators and Auxiliaries (“Turbine Generator”), (3) Fuel Handling and Defueling, (4) Steam Generators, and (5) Balance of Plant.

Safety Improvement Opportunities (“SIO”) are initiatives which OPG committed to in the Environmental Assessment (“EA”) for the DRP, primarily to address beyond-design basis or four-unit events. The need for this work was established through the EA, which was filed with the Canadian Nuclear Safety Commission (“CNSC”). To meet required in-service dates, OPG commenced execution of SIO work early in the Definition Phase of the Program. The SIO are useful to OPG’s current and future nuclear operations independent of whether the DRP is completed.

² The vast majority of these amounts are capital, but included in these amounts are some amounts (e.g. removal costs) that are expensed as OM&A. OM&A costs associated with the DRP are set out in Ex. F2-7-1.

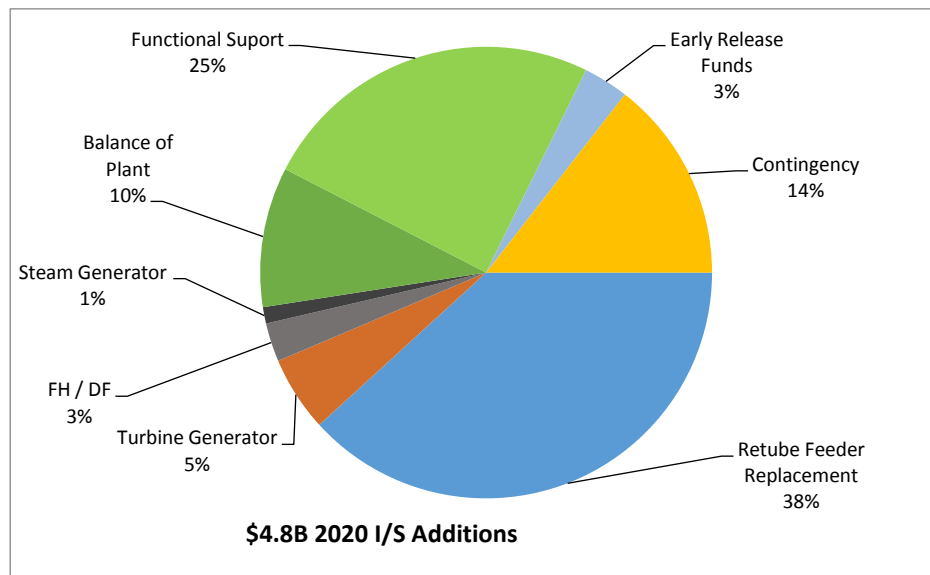
1 *Facilities and Infrastructure Projects ("F&IP")* are projects that do not involve the
2 refurbishment of units but which are necessary to enable execution of the unit
3 refurbishments. A number of the F&IP involve upgrades to Darlington site infrastructure to
4 ensure it can effectively support continued operations for 30 or more years. Other F&IP
5 involve facilities that are needed to support DRP activities during the life of the Program. To
6 meet required in-service dates, OPG commenced the F&IP work early in the Definition
7 Phase of the Program. The F&IP are expected to remain useful to OPG's current and future
8 nuclear operations independent of whether the DRP is completed.

9
10 *OPG Functional Support* refers to work carried out by groups (referred to as "Functions")
11 within OPG's DRP organization. The Functions provide a broad range of support that is
12 critical for the success of the major work bundles and the Program as a whole, including
13 oversight, coordination and integration among the various contractors and ongoing station
14 operations. The largest of the groups, the Operations and Maintenance Function, is distinct
15 from the others because it is both a functional and execution organization in that it provides
16 functional support to the major work bundles and also directly carries out work at the station,
17 particularly for the purpose of ensuring that refurbishment activities do not adversely impact
18 Darlington's other operating units. It is largely through the Functions that OPG performs its
19 vital role as the Program owner, with overall responsibility for Program management,
20 deliverables, costs and schedule, as well as full integration with the operating units in order
21 to comply with all CNSC regulations and safe work practices, including permits and work
22 control, radiation protection, chemistry and environmental controls.

23
24 The remaining Program components consist of: (i) *Early Release Funds*, which are costs
25 incurred during the Preliminary Planning Phase, such as with respect to EA and CNSC
26 approvals work, that cannot be attributed to particular major work bundles or Functions; (ii)
27 *Contingency*, which is an element of the cost estimate that is allocated to manage
28 uncertainty and risk throughout the life of the Program, and which is expected to be spent
29 based on OPG's in-depth assessment of the DRP risks and uncertainties that cannot be
30 avoided or fully mitigated; and (iii) *Interest and Escalation*, which are included in the RQE to
31 reflect costs associated with the passage of time during the life of the Program.

As noted above, the total four-unit budget to refurbish the four Darlington units is \$12.8B. Within the 2017-2021 period, all of the F&IP and SIO will be placed in service and the Unit 2 refurbishment will be completed and placed in service. For the purpose of OPG's request for approval of in-service additions, \$4,800.2M is forecast to come into service in 2020 for the Unit 2 refurbishment. A simplified breakdown showing the components of the Unit 2 amount is provided in Figure 1, below. While actual costs for particular components shown in Figure 1 may ultimately be higher or lower than forecast, OPG will complete the Unit 2 refurbishment within the total envelope budgeted for Unit 2 and OPG's performance with respect to cost should be considered on this basis.

Figure 1
Simplified Breakdown of Unit 2 In-Service Amounts³



OPG plans to issue annual status reports to the public for the duration of the Program. This reporting will include a range of measures, including construction completion, cost performance, schedule performance and safety performance, and is described in greater detail in section 7 of Ex. D2-2-9.

³ Interest and escalation for in-service amounts are included in major work bundle costs.

2.0 APPROVALS SOUGHT

In the current application, OPG seeks the following OEB approvals for the DRP:

- In-service additions to rate base of: (i) \$350.4M in the 2016 Bridge Year; and (ii) for the test period, \$374.4M in 2017, \$8.9M in 2018, \$4,809.2M in 2020, and \$0.4M in 2021 on a forecast basis. These amounts reflect the addition to rate base of \$4,800.2M related to Unit 2 in-service addition in 2020 and 2021, as well as \$743.1M related to Unit Refurbishment Early In-Service Projects⁴, Safety Improvement Opportunities, and Facilities & Infrastructure Projects. If actual additions to rate base are different from forecast amounts, the cost impact of the difference will be recorded in the Capacity Refurbishment Variance Account ("CRVA") and any amounts greater than the forecast amounts added to rate base will be subject to a prudence review in a future proceeding; and
- OM&A expenditures of \$41.5M in 2017, \$13.8M in 2018, \$3.5M in 2019, \$48.4M in 2020, and \$19.7M in 2021 (Ex. F2-7-1).

OPG also seeks recovery of the contribution of the DRP to the Capacity Refurbishment Variance Account ("CRVA") 2015 balance, as discussed in Ex. H1-1-1.

3.0 EVIDENCE ROADMAP

To understand the rationale underlying the evidence roadmap set out below, it is important to understand that OPG has approached the DRP in a manner that is consistent with generally accepted methods for planning and implementing mega-projects. This process of planning and implementing the DRP provides the broad framework for presentation of this evidence.

More particularly, given the Program's complexity and in order to successfully complete the DRP on time and on budget, OPG must have in place a number of elements that are essential for Program development, execution and completion. This includes appropriate structure, both with respect to OPG's contractual relationships as well as organizationally, to ensure the appropriate allocation of risk and cost responsibility and an effective and

⁴ See section 2.2 of Ex. D2-2-10 for more information on Unit Refurbishment Early In-Service Projects.

1 functioning working relationship between OPG as Program owner and its contractors.
2 Moreover, OPG must undertake rigorous planning to ensure proper scope and
3 corresponding cost and schedule. However, this is not an end in itself. OPG must also
4 require its contractors to execute the major work bundles in an efficient and cost effective
5 manner and must conduct itself likewise in its capacity as owner. Furthermore, while
6 executing the four-unit refurbishment, OPG must comply with all CNSC regulatory
7 requirements. OPG must also comply with provincial requirements for nuclear refurbishment
8 as set out in the Long Term Energy Plan ("LTEP").
9

10 The Program cannot be viewed through a single lens or by considering a single component.
11 As a result, OPG's evidence is structured so as to enable the OEB to understand that OPG
12 (i) has adopted the most appropriate contracting strategy; (ii) has established an effective
13 organization that aligns with and supports that strategy; (iii) has through that organization
14 and in conjunction with its contractors undertaken extensive planning to define the scope,
15 plan the schedule and estimate the cost of the Program; and (iv) has an effective execution
16 strategy to ensure safe completion of the Program on time and on budget. The evidence is
17 organized as follows:

- 18 • Ex. D2-2-1 (Program Overview) provides a summary of the Program, the approvals
19 sought, this evidence roadmap and a description of the relevant regulatory
20 framework, including recent amendments to Ontario Regulation 53/05, the Province's
21 Long-Term Energy Plan and the relevant requirements of the CNSC;
- 22 • Ex. D2-2-2 (Program Structure) describes OPG's overall commercial strategy for the
23 DRP, which establishes OPG as the Program owner and defines OPG's relationships
24 with its external contractors. In a project of the magnitude of the DRP, it is critical that
25 the responsibilities and accountabilities for project risks and execution be clear. It is
26 also important to ensure alignment between the commercial/contracting strategies
27 and the owner's organizational structure. This schedule describes how OPG has
28 structured itself as the Program owner as well as the management system structures
29 used by OPG to exercise its role as owner;
- 30 • Ex. D2-2-3 (Major Work Bundle Structure and Contracts) describes how OPG has
31 structured the major work bundles, as well as the contracting approaches that OPG

1 has used for each of the major work bundles and the SIO and F&IP projects. The
2 contracting models employed by OPG and the specific contract terms, such as with
3 respect to pricing, will play a significant role in determining how the work will be
4 performed and the overall success of the Program;

- 5 • Ex. D2-2-4 to Ex. D2-2-8 (Program Planning, Program Scope, Program Schedule,
6 Contingency, and Cost) are all related directly to the development and approval of the
7 RQE. Program planning concerns the significant investment in planning made by
8 OPG during the Definition Phase to establish detailed scope, schedule and cost
9 estimates, thereby minimizing the risk of scope creep, schedule delays and resulting
10 increases in cost. OPG's approaches to identifying, defining and developing the
11 Program scope, schedules, contingency amounts and cost estimates are considered
12 in greater detail in these schedules;
- 13 • Ex. D2-2-9 (Program Execution) focuses on how OPG will manage the Program
14 during execution, including the methods by which OPG as Program owner will
15 manage circumstances that affect scope, schedule, cost and quality during
16 refurbishment execution. In particular, this schedule considers the key activities to be
17 carried out by certain OPG functional support groups during execution, as well as
18 other key controlling activities all of which will enable OPG to effectively track
19 progress and manage execution risk; and
- 20 • Ex. D2-2-10 (In-Service Amounts) describes the capital in-service additions, including
21 for Unit 2 refurbishment, unit refurbishment early in-service projects, SIO and F&IP
22 projects, as well as applicable variance analysis.

23
24 A detailed breakdown of the DRP evidence structure is included in Attachment 1.

25
26 OPG has also engaged independent experts to review and verify key aspects of the
27 Program. The following independent expert reviews are provided in support of the evidence:

- 28 • KPMG review of risk management and contingency development process (Ex. D2-2-
29 7, Attachment 1);
- 30 • KPMG review of the governance and processes to develop the RQE (Ex. D2-2-8,
31 Attachment 2);

- Modus Strategic Solutions Canada Company and Burns & McDonnell Canada Ltd. Review of the RQE development process (Ex. D2-2-8, Attachment 3); and
- an expert panel, comprised of four individuals with retube and feeder replacement experience, review of the cost estimate for retube and feeder replacement (Ex. D2-2-8, Attachment 4).

In addition, two independent experts have been engaged to give evidence as follows:

- Concentric Energy Advisors, Inc. to provide an independent, updated assessment of their report filed in EB-2013-0321 of the commercial strategies developed for the RFR work package (Ex. D2-2-11, Attachment 1); and
- Pegasus Global Holdings, Inc. to provide an independent and objective assessment of the degree to which OPG's plan and approach to execution of the Program are consistent with the way other megaprojects and mega programs of comparable magnitude, scale and complexity have been carried out (Ex. D2-2-11, Attachment 3).

4.0 REGULATORY FRAMEWORK

4.1 Amendments to O. Reg. 53/05

On January 1, 2016, Ontario Regulation 53/05, *Payments Under Section 78.1 of the Ontario Energy Board Act* (O. Reg. 53/05) was amended to include additional provisions that deal with nuclear refurbishment costs and to define the scope of the OEB's jurisdiction in considering this application. In relation to the DRP, the amendments concern the following key aspects:

- The need for the DRP has been established by the regulation. As set out in the regulation, in setting nuclear payment amounts during the period from January 1, 2017 to the end of the DRP, the OEB shall accept the need for the DRP in light of the Ministry of Energy's 2013 LTPE and the related policy of the Minister endorsing the need for nuclear refurbishment.⁵

⁵ O. Reg. 53/05, s. 6(2), para. 12(v).

- If the OEB is satisfied that costs of the DRP were prudently incurred and financial commitments were prudently made, the OEB must ensure that OPG recovers its capital and non-capital costs and firm financial commitments incurred for the DRP.⁶
- The OEB must permit OPG to establish a rate smoothing deferral account for the DRP.⁷
- In setting payment amounts for the deferral period (i.e. from January 1, 2017 to the end of the DRP), the OEB must determine, on a five year basis for the first ten years of the deferral period, and thereafter on such periodic basis as the OEB determines, the portion of the approved nuclear revenue requirement for each year that is to be deferred for purposes of making more stable the year-over-year changes in the nuclear payment amount.⁸ OPG's rate smoothing proposal is discussed in Ex. A1-3-3.

4.2 Long Term Energy Plan

As stated by the Minister of Energy in Ontario's LTEP: "[t]he government is committed to nuclear power. It will continue to be the backbone of our electricity system, supplying about half of Ontario's electricity generation."⁹ The Minister further stated in the LTEP:

The government will ensure a reliable supply of electricity by proceeding with the refurbishment of the province's existing nuclear fleet taking into account future demand levels. Refurbishment received strong, province-wide support during the 2013 LTEP consultation process. The merits of refurbishment are clear:

- Refurbished nuclear is the most cost-effective generation available to Ontario for meeting base load requirements.
- Existing nuclear generating stations are located in supportive communities, and have access to high-voltage transmission.
- Nuclear generation produces no greenhouse gas emissions.¹⁰

⁶ O. Reg. 53/05, s. 6(2), para. 4.

⁷ O. Reg. 53/05, s. 5.5.

⁸ O. Reg. 53/05, s. 6(2), paras. 12(i) and (ii).

⁹ Government of Ontario, *Achieving Balance – Ontario's Long Term Energy Plan*, December 2013, p. 30.

¹⁰ LTEP, page 29.

1 The LTEP sets out a number of principles with respect to the nuclear refurbishment
2 process.¹¹ As highlighted in Attachment 2 below, OPG's plans for the DRP include a number
3 of specific elements that align with each of these principles, which are as follows:

- 4 • minimize the commercial risk on the part of ratepayers and government;
- 5 • mitigate reliability risks by developing contingency plans that include alternative
6 supply options if contract and other objectives are at risk of non-fulfillment;
- 7 • entrench appropriate and realistic off-ramps and scoping;
- 8 • require OPG to hold its contractors accountable to the nuclear refurbishment
9 schedule and price;
- 10 • make site, project management, regulatory requirements and supply chain
11 considerations, and cost and risk containment, the primary factors in developing the
12 implementation plan; and
- 13 • take smaller initial steps to ensure there is opportunity to incorporate lessons learned
14 from the refurbishment including collaboration by operators.

16 **4.3 Minister's Support for DRP**

17 In addition to issuing clear policy statements regarding the need for nuclear refurbishment,
18 the Government of Ontario's support for the DRP has been affirmed through the Minister's
19 announcement on January 11, 2016¹² endorsing OPG's plan to refurbish the four Darlington
20 units.

22 **4.4 CNSC Regulatory Framework**

23 The CNSC exercises ongoing regulatory and licensing oversight over nuclear power plants in
24 Canada. Continued operation of Darlington is largely dependent on the work that is required
25 for long term safe operation.

26
27 The CNSC's regulatory expectations for proposed refurbishment and life extension projects
28 at the time that OPG began to undertake the DRP required that OPG systematically identify
29 and address all environmental and safety concerns, carry out an Integrated Safety Review

¹¹ LTEP, page 29.

¹² See footnote 1.

1 (“ISR”) and integrate them into a Global Assessment Report (“GAR”) and an Integrated
2 Implementation Plan (“IIP”) in accordance with all CNSC regulations, including the
3 requirements from Regulatory Document RD-360 (Life Extension of Nuclear Power Plants).¹³
4 In December 2015, the CNSC ruled that OPG has completed an ISR, GAR and IIP as set out
5 in Regulatory Document RD-360. Regulatory Document REGDOC-2.3.3 (Periodic Safety
6 Reviews) has superseded Regulatory Document RD-360 relating to the life extension of
7 nuclear plants. As part of Darlington’s renewed Nuclear Power Reactor Operating Licence
8 (discussed further below), in accordance with REGDOC-2.3.3 (Periodic Safety Reviews), the
9 CNSC ruled that OPG must conduct a periodic safety review in support of OPG’s next
10 Nuclear Power Reactor Operating Licence application to confirm that the facility remains
11 consistent with a set of modern codes and standards to demonstrate that the safety basis
12 remains valid. CNSC’s Regulatory Document REGDOC-2.3.3: Periodic Safety Reviews can
13 found in Attachment 3, and Regulatory Document RD-360: Life Extension of Nuclear Power
14 Plants can be found in Attachment 4. In addition, OPG is required to adhere to the
15 requirements of the *Nuclear Safety and Control Act*, the *Canadian Environmental*
16 *Assessment Act*, all associated regulations, and conditions under its operating license for
17 Darlington.

18
19 The EA Screening Report for the DRP was submitted to the CNSC on December 1, 2011.
20 The CNSC released its decision regarding the EA on March 14, 2013. The overall finding of
21 the CNSC was that the DRP will not result in any significant adverse environmental effects
22 given the proposed mitigation measures. As required by the OEB’s Decision in EB-2013-
23 0321, OPG is filing as part of this application updates of actual costs of the EA follow-up
24 studies. These updates are provided in Attachment 5.

25

¹³ As set out in Regulatory Document RD-360, for a nuclear life extension project, the CNSC expects the licensee to demonstrate that the following objectives are met:

- The technical scope of the project is adequately determined through an IIP that takes into account the results of an EA and an ISR;
- Programs and processes that take into account the special considerations of the project are established; and
- The project is appropriately planned and executed.

(See: CNSC, RD-360: Life Extension of Nuclear Power Plants, Section 4.0.)

1 On December 23, 2015, the CNSC issued a renewed Darlington Nuclear Power Reactor
2 Operating Licence effective January 1, 2016 until November 30, 2025. OPG's Nuclear Power
3 Reactor Operating Licence application included the proposed refurbishment of Darlington.
4 The CNSC concluded that OPG is qualified to carry on the proposed refurbishment project.
5 The CNSC's Record of Proceedings, Including Reasons for Decisions was issued on March
6 2, 2016.¹⁴

¹⁴ The CNSC Reasons for Decision can be found on the CNSC website as e-Doc 4920689 at:
<http://www.nuclearsafety.gc.ca/eng/the-commission/pdf/2015-11-02-CompleteDecision-OPG-Darlington-e-edoc4920689.pdf>.

ATTACHMENTS

1

2

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|---|---------------|--|
| 3 | Attachment 1: | Detailed Breakdown of Evidence Structure |
| 4 | Attachment 2: | OPG Actions Taken/Planned in Alignment with LTEP Principles |
| 5 | Attachment 3: | Regulatory Document REGDOC-2.3.3: Periodic Safety Reviews |
| 6 | Attachment 4: | Regulatory Document RD-360: Life Extension of Nuclear Power Plants |
| 7 | Attachment 5: | Costs of Environmental Assessment Follow-up Studies |

DETAILED BREAKDOWN OF EVIDENCE STRUCTURE

The Darlington Refurbishment Program (“DRP”) evidence is organized into ten different Schedules as follows:

Ex. D2-2-1: Darlington Refurbishment Program Overview

- 1.0 Program Summary
- 2.0 Approvals Sought
- 3.0 Evidence Roadmap
- 4.0 Regulatory Framework
 - 4.1 Amendments to O. Reg. 53/05
 - 4.2 Long Term Energy Plan
 - 4.3 Minister’s Support for DRP
 - 4.4 CNSC Regulatory Framework

Attachments:

- Attachment 1: Detailed Breakdown of Evidence Structure
- Attachment 2: OPG Actions Taken/Planned in Alignment with LTEP Principles
- Attachment 3: Regulatory Document REGDOC-2.3.3: Periodic Safety Reviews
- Attachment 4: Regulatory Document RD-360: Life Extension of Nuclear Power Plants
- Attachment 5: Costs of EA Follow-up Studies

Ex. D2-2-2: Program Structure

- 1.0 Overview
- 2.0 Commercial and Contracting Strategies
- 3.0 OPG Structure as Owner
 - 3.1 Project Management Teams
 - 3.2 Functional Support Groups

- 10 3.2.10 Operations and Maintenance Function

12 Attachments:

- 16 Attachment 2: Program Management System Structure and Program Charter

18 **Ex. D2-2-3: Major Work Bundle Structure & Contracts**

- 29 3.6 Balance of Plant

30

1 Attachments:

- 2 Attachment 1: Summary of EPC Contract for RFR with SNC/AECON JV
- 3 Attachment 2: Summary of ESES Contract for Turbine Generators with
- 4 Alstom
- 5 Attachment 3: Summary of EPC Contract for Turbine Generators with
- 6 SNC/AECON JV
- 7 Attachment 4: Summary of EPC Contract for Steam Generators with
- 8 BWXT/CANDU JV
- 9 Attachment 5: Summary of ESMSA Contract
- 10 Attachment 6: EPC Contract for RFR with SNC/AECON JV
- 11 Attachment 7: ESES Contract for Turbine Generators with Alstom
- 12 Attachment 8: EPC Contract for Turbine Generators with SNC/AECON JV
- 13 Attachment 9: EPC Contract for Steam Generators with BWXT/CANDU JV
- 14 Attachment 10: ESMSA with SNC/AECON JV

15
16 **Ex. D2-2-4: Program Planning**

- 17 1.0 Overview
- 18 2.0 Planning
 - 19 2.1 Investment in Planning
 - 20 2.1.1 Lessons Learned
 - 21 2.1.2 Engineering Completion
 - 22 2.1.3 Reactor Mock-Up, Tool Fabrication and Testing

23
24 Attachments:

- 25 Attachment 1: Detailed Description of Program Phases

26
27 **Ex. D2-2-5: Program Scope**

- 28 1.0 Overview
- 29 2.0 Significance of Scoping to Program Success
- 30 3.0 Approach to Work Scope Definition
 - 31 3.1 Engineering Modifications

1	3.2	Regulatory Scope
2	3.3	Work Bundles
3	4.0	Scope for Major Work Bundles
4	4.1	Retube and Feeder Replacement
5	4.1.1	RFR Definition Phase Work
6	4.1.2	Retube Waste Processing Building
7	4.1.3	RFR Execution Phase Work
8	4.2	Turbine Generators
9	4.2.1	Turbine and Auxiliaries Work
10	4.2.2	Moisture Separator Reheater Work
11	4.2.3	Generator and Auxiliaries Work
12	4.3	Fuel Handling and Defueling
13	4.3.1	Defueling Work
14	4.3.2	Power Track Work
15	4.3.3	Reactor Area Bridge and Carriage Refurbishment
16	4.3.4	Irradiated Fuel Bay Heat Exchanger Plate Replacement
17	4.4	Steam Generators
18	4.5	Balance of Plant

Ex. D2-2-6: Program Schedule

21	1.0	Overview
22	2.0	Schedule Development
23	3.0	Multi-Level Scheduling Approach
24	4.0	Critical Path and Schedule Overview
25	5.0	Planned Outage Duration versus High Confidence Schedule

Attachments:

Attachment 1:	Project Schedule Diagram
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Ex. D2-2-7: Contingency

1.0	Overview
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- 1 2.0 Contingency
- 2 3.0 Contingency Development
- 3 4.0 Contingency Amounts
- 4 4.1 DRP Contingency Amounts
- 5 4.2 Unit 2 Contingency Amounts
- 6

7 Attachments

- 8 Attachment 1: KPMG Report on Contingency
- 9

10 **Ex. D2-2-8: Cost**

- 11 1.0 Overview
- 12 2.0 Release Quality Estimate
- 13 3.0 DRP Cost Breakdown
- 14 4.0 Unit 2 Cost Breakdown
- 15 4.1 Major Work Bundle Costs
- 16 4.1.1 Retube and Feeder Replacement
- 17 4.1.2 Turbine Generators
- 18 4.1.3 Fuel Handling and Defueling
- 19 4.1.4 Steam Generators
- 20 4.1.5 Balance of Plant
- 21 4.2 Functional Cost
- 22

23 Attachments:

- 24 Attachment 1: Execution Phase Business Case Summary
- 25 Attachment 2: BMCD/Modus Report on RQE
- 26 Attachment 3: KPMG Report on RQE
- 27 Attachment 4: Expert Review Panel Report on RFR
- 28
- 29

30 **Ex. D2-2-9: Program Execution**

- 31 1.0 Overview

- 1 2.0 Project Execution Support Function
- 2 3.0 Work Control Function
- 3 4.0 Operations and Maintenance Function
- 4 5.0 Change Management
- 5 6.0 Cost Performance Monitoring
- 6 7.0 Reporting
- 7 8.0 Oversight

8

9 Attachments:

- 10 Attachment 1: OPG's Change Management Process
- 11 Attachment 2: BMCD/Modus Final Quarterly Oversight Report to the OPG
- 12 Board of Directors

13

14 **Ex. D2-2-10: In-Service Amounts**

- 15 1.0 Overview
- 16 2.0 Capital In-Service Amounts
 - 17 2.1 Unit Refurbishment - Unit 2 In-service Amount
 - 18 2.2 Unit Refurbishment – Early In-service Projects
 - 19 2.2.1 RFR - Tooling for Removal Activities
 - 20 2.2.2 Fuel Handling - Irradiated Fuel Bay Heat Exchanger Plate
 - 21 Replacement
 - 22 2.2.3 Balance of Plant - Negative Pressure Containment
 - 23 2.2.4 Balance of Plant – Heavy Water Islanding Modifications
 - 24 2.2.5 Balance of Plant – Low Pressure Service Water
 - 25 2.2.6 Early In-service Projects <\$5M
 - 26 2.3 Safety Improvement Opportunities
 - 27 2.3.1 Third Emergency Power Generator
 - 28 2.3.2 Containment Filtered Venting System
 - 29 2.3.3 Powerhouse Steam Venting System Improvements
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**OPG ACTIONS TAKEN/PLANNED IN ALIGNMENT
WITH LTEP PRINCIPLES**

2013 LTEP – Nuclear Refurbishment Principles	OPG Actions Taken/Planned in Alignment with LTEP Principles
Minimize commercial risk on the part of ratepayers and government	• Locked down project scope well in advance of starting construction; • Fully developed engineering and planning of the work so that it is 100 per cent complete prior to the start of construction; • Built a full-scale mock-up of the Darlington reactor and vault and used them to fully test the tools and determine tooling durations in order to build a reliable schedule. All workers will be trained using the tools in the mock-up prior to working in the plant; • In phases, developed a Release Quality Estimate that incorporates a high-confidence budget and schedule for the work; • "Unlapped" Unit 2 from subsequent units so that the focus can be on planning and construction of a single unit to ensure its success while documenting lessons learned from the first unit and applying them to work processes on subsequent units; • Utilizing target price contracts for the execution phase that are based on developing cooperation, transparency, and risk sharing with key vendors; • Utilizing fixed price contracts for certain execution phase scope that is well defined and where risk transfer to a third party is appropriate; • Negotiated various off-ramps and stages into contracts; and • Established a robust risk management process to directly identify and administer commercial risks.
Mitigate reliability risks by developing contingency plans that include alternative supply options if contract and other objectives are at risk of non-fulfillment	• Decision to "unlap" Unit 2 from the other unit refurbishments, which predated the LTEP, was intended to mitigate performance risk and allow the DRP team to focus on refurbishing the first unit prior to commencing subsequent units. If the first unit is not successful, off-ramps are in place; the second unit refurbishment will not commence until the first unit is successfully returned to service. • Risk assessment and appropriate contingency and mitigation plans for each execution work package have been developed. • OPG's investment in the reactor mock-up is being used to perform full integration and commission testing of tools needed for refurbishment; lessons are being learned on the mock-up,

	not on the unit. The results of the mock-up testing have been incorporated into the tooling performance guarantee, which sets the target schedule and price, with the RFR vendor.
Entrench appropriate and realistic off-ramps and scoping	• OPG has engaged in a deliberate process with numerous off-ramps for the definition phase including Board of Directors oversight and annual releases of funds. • Each contract has off-ramp provisions allowing OPG to terminate, with or without cause; OPG would be accountable to reimburse contractors only for any reasonably incurred costs. • Scope review process in place to minimize scope of work performed in refurbishment period to address things that must be done to extend life or that can only be done in drained/defueled state. • OPG has fully examined the scope of the Unit 2 refurbishment project and optimized the work based on OPG's regulatory commitments and/or analysis of the best time to perform the work.
Require OPG to hold its contractors accountable to the nuclear refurbishment schedule and price	• OPG, in implementing all of its contracts, is highly focused on achieving value for money; there are incentives and disincentives related to achieving the cost and schedule set out in the contracts. • Contracts with major contractors have been developed and vetted utilizing a deliberate, staged and gated process with requirements for budget, schedule, scope, and risk identification at each gate. • Contracts have specific negotiated incentives and disincentives that are calculated toward promoting the contractor's (and OPG's) responsible management of the work. • OPG is implementing a detailed, integrated Level 3 schedule that will encompass all of the contractors' and OPG's work, as well as a rolled-up Level 2 Control and Coordination Schedule that is used as a higher level interfacing tool. • OPG has implemented cost control systems that are geared toward holding contractors accountable. These systems include earned value and budget controls, as well as validation of progressive project plans, through a gated process. • OPG performs analysis of all pricing and checks estimates for contractors' work. • OPG's senior management have established separate regular steering committees with each of the major contractors' executives which provide senior level leadership with a forum to discuss progress, potential and real issues impacting performance and commercial issues.
Make site, project management,	• RQE fully considered all of the factors listed in advance of execution of the work.

regulatory requirements and supply chain considerations, and cost and risk containment, the primary factors in developing the implementation plan	• Taking lessons from Pickering A, the DRP team completed the identification of all regulatory requirements well in advance of final design and construction. • OPG has completed the design and proving of the RFR tools. • Procurement of all long lead materials commenced well in advance of the start of the first unit refurbishment with all deliverable dates confirmed to be well in advance of the need dates. Mitigation plans are in place for any material that is not on hand well in advance of the need date. • OPG has implemented, in accordance with Project Management Institute standards and Association for Advancement of Cost Engineering best practices, project controls and risk management programs, as well as a continuous improvement focus, to refine these tools as the outage nears. • OPG has retained external oversight and engaged other corporate functions in providing input and assurance that the DRP team is meeting its commitments.
Take smaller initial steps to ensure there is opportunity to incorporate lessons learned from refurbishment including collaboration by operators.	• To fully incorporate lessons learned from the refurbishment of the first unit (Unit 2), the start of refurbishment work on the second unit (Unit 3) has been delayed until the completion of the first unit. While Unit 2 is underway, lessons learned will be captured and incorporated into Unit 3 planning. • OPG has filled key positions in its project management team with individuals having direct experience with prior CANDU refurbishments. • OPG has contracted with SNC/Aecon, whose subsidiary CANDU Energy (formerly AECL) has been associated with each of the prior refurbishments. • OPG and its contractors have studied lessons learned and operating experience from prior projects and incorporated those into the DRP. • OPG routinely collaborates with other CANDU operators directly and through the CANDU Owner's Group. OPG established a Memorandum of Understanding with Bruce Power to support collaboration.



Operating Performance **Periodic Safety Reviews**

REGDOC-2.3.3

April 2015



Canadian Nuclear
Safety Commission

Commission canadienne
de sûreté nucléaire

Canada

Operating Performance: Periodic Safety Reviews

Regulatory Document REGDOC-2.3.3

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Preface

This regulatory document is part of the CNSC's operating performance series of regulatory documents, which also covers commissioning, construction and severe accident management. The full list of regulatory document series is included at the end of this document and can also be found on the [CNSC's website](#).

Regulatory document REGDOC-2.3.3, *Periodic Safety Reviews*, sets out the CNSC's requirements for the conduct of a periodic safety review (PSR) for a nuclear power plant (NPP). It is consistent with the International Atomic Energy Agency's Safety Standards Series, Specific Safety Guide No. SSG-25, *Periodic Safety Review for Nuclear Power Plants* [1]. REGDOC-2.3.3 supersedes RD-360, *Life Extension of Nuclear Power Plants*, published in February 2008.

A PSR involves an assessment of the current state of the plant and its performance to determine the extent to which it conforms to applicable modern codes, standards and practices, and to identify any factors that would limit safe long-term operation.

Operating experience in Canada and around the world, new knowledge from research and development activities, and advances in technology, are taken into account. This enables the determination of reasonable and practical improvements that should be made to structures, systems and components, and to existing programs, to ensure the safety of the facility to a level approaching that of modern nuclear power plants, and to ensure continued safe operation. A PSR is a rigorous safety assessment that is complementary to, and does not replace, routine and non-routine regulatory reviews, inspections, mid-term reports, event reporting and investigations, or other CNSC compliance and verification activities.

Conduct of a PSR is intended to be a requirement that can be aligned with licence renewals and form part of the licensing basis for a regulated facility or activity within the scope of this document. It is intended for inclusion in licences, either as part of the conditions and safety and control measures in a licence, or as part of the safety and control measures to be described in a licence application and the documents needed to support that application.

For existing nuclear power plants, the requirements contained in this document do not apply unless they have been included, in whole or in part, in the licence or licensing basis.

An applicant or licensee may put forward a case to demonstrate that the intent of a requirement is addressed by other means and demonstrated with supportable evidence.

The requirements and guidance in this document are consistent with modern national and international practices addressing issues and elements that control and enhance nuclear safety.

Guidance contained in this document exists to inform the applicant, to elaborate further on requirements or to provide direction to licensees and applicants on how to meet requirements. It also provides more information about how CNSC staff evaluate specific problems or data during their review of licence applications. Licensees are expected to review and consider guidance; should they choose not to follow it, they should explain how their chosen alternate approach meets regulatory requirements.

A graded approach, commensurate with risk, may be defined and used when applying the requirements and guidance contained in this regulatory document. The use of a graded approach is not a relaxation of requirements. With a graded approach, the application of requirements is commensurate with the risks and particular characteristics of the facility or activity.

Important note: Where referenced in a licence either directly or indirectly (such as through licensee-referenced documents), this document is part of the licensing basis for a regulated facility or activity.

The licensing basis sets the boundary conditions for acceptable performance at a regulated facility or activity, and establishes the basis for the CNSC's compliance program for that regulated facility or activity.

Where this document is part of the licensing basis, the word "shall" is used to express a requirement to be satisfied by the licensee or licence applicant. "Should" is used to express guidance or that which is advised. "May" is used to express an option or that which is advised or permissible within the limits of this regulatory document. "Can" is used to express possibility or capability.

Nothing contained in this document is to be construed as relieving any licensee from any other pertinent requirements. It is the licensee's responsibility to identify and comply with all applicable regulations and licence conditions.

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Periodic Safety Reviews

1. Introduction

REGDOC-2.3.3, *Periodic Safety Reviews*, sets out the CNSC's requirements for the conduct of a periodic safety review (PSR). A PSR is a comprehensive evaluation of the design, condition and operation of a nuclear power plant (NPP, plant). It is an effective way to obtain an overall view of actual plant safety and the quality of the safety documentation, and to determine reasonable and practical improvements to ensure safety until the next PSR or, where appropriate, until the end of commercial operation.

PSRs have been effective in achieving improvements in safety. Adopting PSRs in support of licence renewal will ensure the continued improvement of NPP safety. Past experience with life-extension projects gives the CNSC and the Canadian nuclear industry a large degree of familiarity with the PSR process. As such, the application of a PSR in Canada represents an evolution of a current practice, as opposed to the adoption of a new one.

1.1 Purpose

This regulatory document sets out the CNSC's requirements for the conduct of a PSR. Guidance is also provided on how these requirements may be met.

1.2 Scope

This document is intended for nuclear power plants. However, it can be used by other nuclear facilities applying a graded approach.

1.3 Relevant regulations

The following provisions of the *Nuclear Safety and Control Act* (NSCA) and regulations made under the NSCA that are relevant to this regulatory document:

1. Subsection 24(4) of the NSCA states that "No licence shall be issued, renewed, amended or replaced – and no authorization to transfer one given – unless, in the opinion of the Commission, the applicant (a) is qualified to carry on the activity that the licence will authorize the licensee to carry on; and (b) will, in carrying on that activity, make adequate provision for the protection of the environment, the health and safety of persons and the maintenance of national security and measures required to implement international obligations to which Canada has agreed"
2. Subsection 24(5) of the NSCA states that "A licence may contain any term or condition that the Commission considers necessary for the purposes of this Act..."
3. Section 3 of the *General Nuclear Safety and Control Regulations* states the general licence application requirements
4. Paragraphs 12(1)(c), (f) and (i) of the *General Nuclear Safety and Control Regulations* state that "Every licensee shall
 - (c) take all reasonable precautions to protect the environment and the health and safety of persons and to maintain security of nuclear facilities and of nuclear substances; ...
 - (f) take all reasonable precautions to control the release of radioactive nuclear substances or hazardous substances within the site of the licensed activity and into the environment as a result of the licensed activity; ...
 - (i) take all necessary measures to facilitate Canada's compliance with any applicable safeguards agreement;"

5. Sections 3 and 6 of the *Class I Nuclear Facilities Regulations* state the general licence application requirements specific to Class I nuclear facilities and the information required to apply for a Class I nuclear facility operating licence

1.4 National and international standards

Key principles and elements used in developing this regulatory document are consistent with national and international standards, guides and practices. In particular, this regulatory document is consistent with the International Atomic Energy Agency's (IAEA) Safety Standards Series, Specific Safety Guide No. SSG-25, *Periodic Safety Review for Nuclear Power Plants* (SSG-25) [1].

2. General Requirements

The licensee shall conduct a PSR in accordance with this regulatory document for the period until the next PSR or, if applicable, until the end of commercial operation of the plant. The PSR shall be conducted according to the following four phases:

1. preparation of a PSR basis document
2. conduct of the safety factors reviews and identification of findings
3. analysis of the findings and their integral impact on the NPP's safety (global assessment)
4. preparation of a plan of safety improvements (integrated implementation plan)

Guidance

The objectives of a PSR are to determine:

1. the extent to which the facility conforms to modern codes, standards and practices
2. the extent to which the licensing basis remains valid for the next licensing period
3. the adequacy and effectiveness of the programs and the structures, systems and components (SSCs) in place to ensure plant safety until the next PSR or, where appropriate, until the end of commercial operation
4. the improvements to be implemented to resolve any gaps identified in the review and timelines for their implementation

The PSR approach is outlined in SSG-25. The complex process of conducting a PSR can be facilitated by subdividing it into tasks that are identified as safety factors. These safety factors are intended to cover all aspects that are important to the safety of an operating nuclear power plant. The terms "safety factor" and "safety factor reports" are an adoption of the SSG-25 terms, with the addition of a safety factor for radiation protection. Safety factor reports are discussed further in sections 3 and 4.

The licensee first prepares the PSR basis document which defines the scope and methodology for the PSR. This is then used to conduct the review, prepare the safety factor reports, and the global assessment report. The results of the PSR are used to establish the corrective actions and safety improvements to be included in the integrated implementation plan.

The documentation submitted to the CNSC includes:

1. PSR basis document
2. reports on the review of each safety factor (safety factor reports)
3. global assessment report (GAR)
4. integrated implementation plan (IIP)

In accordance with SSG-25 and international practice, 10 years is considered an appropriate interval between PSRs to identify any factors that would limit the NPP's continued safe operation and determine the extent to which it conforms to applicable modern codes, standards and practices. The next PSR interval may deviate from 10 years when it includes the end of commercial operation. The licensee may propose an alternative interval when the proposed operating strategy includes the end of commercial operations within or shortly after the 10-year interval.

It is expected that the effort necessary to carry out a second (or subsequent) PSR of an NPP will often be considerably less than for the first. In general, subsequent PSRs will focus on changes in requirements, facility conditions, operating experience and new information, rather than repeating the activities of previous reviews.

The PSR is complementary to, and does not replace, regulatory activities required and/or performed by the CNSC, including routine and non-routine regulatory reviews and inspections, mid-term reports, event reporting and investigations, or any other CNSC licensing and verification activities.

3. Periodic Safety Review Basis Document

The PSR basis document is an essential instrument that governs the conduct of the PSR. It ensures that the licensee and the CNSC have the same expectations for the PSR's scope, methodology and outcomes.

The PSR basis document shall be submitted to CNSC staff for acceptance. The required elements of the PSR basis document are:

1. statement of current licensing basis, including exemptions and acceptable deviations
2. statement of the proposed operating strategy of the facility
3. description of scope of the PSR
4. description of the methodology for the performance of the PSR, including the period for which the PSR is valid
5. statement of applicable modern codes, standards and practices
6. description of the methodology for the identification, dispositioning and tracking of gaps
7. description of the methodology for the global assessment
8. PSR governance

3.1 Current licensing basis

The licensee shall provide a description of the current nuclear power plant licensing basis at the time of initiation of the PSR, which will be used as a baseline for the conduct of the PSR.

3.2 Proposed operating strategy of the nuclear power plant

In the PSR basis document, the licensee shall state the proposed operating strategy of the plant.

Guidance

The PSR is performed to assess the condition of the NPP and the adequacy of the programs, including aging management programs, which are in place to maintain reactor safety. The review is forward-looking and the operating strategy of the plant should be considered to identify potentially lifetime-limiting features of the plant. The licensee is expected to identify whether the operating strategy is operation beyond the next 10-year interval or the end of commercial operations.

The operating strategy is expected to be reflected in the methodologies described in the PSR basis document.

3.3 Scope of the periodic safety review

The licensee shall describe the scope of the PSR in the PSR basis document. The licensee shall:

1. address all safety factors of the NPP including any interdependencies
2. identify all facilities and associated SSCs to be covered by the PSR
3. address unit-specific and site-specific issues
4. for multi-unit NPPs, address interdependencies on common SSCs not covered by item 1
5. consider all expected modes of operation; for a multi-unit facility, taking into consideration the operational state of each unit
6. include a comprehensive review of current licensing issues applicable to the safety factors

Guidance

The scope of the PSR should include a review of each of the following safety factors:

1. plant design
2. actual condition of SSCs important to safety
3. equipment qualification (environmental and seismic)
4. aging
5. deterministic safety analysis
6. probabilistic safety assessment
7. hazard analysis
8. safety performance
9. use of experience from other NPPs and research findings
10. organization, the management system and safety culture
11. procedures
12. human factors
13. emergency planning
14. radiological impact on the environment
15. radiation protection

SSG-25 describes 14 safety factors that have been selected on the basis of international experience and are intended to cover all factors important to NPP safety. The scope, tasks and methodologies of these 14 safety factors are considered to meet the CNSC's expectations for corresponding safety factors 1–14 listed above. The CNSC has included an additional safety factor on radiation protection; the licensee should refer to Appendix A for guidance on the scope and tasks for the review of this safety factor. The PSR basis document should include, in the scope and tasks, how the intent of each task listed for a safety factor will be addressed.

It is expected that the required effort to carry out a subsequent PSR of an NPP will often be considerably less than for the first; however, the subsequent PSR should consider explicitly if the earlier PSR conclusions remain valid (for example, in light of the time elapsed since it was performed).

3.4 Methodology for the performance of the periodic safety review

The licensee shall specify the methodology for:

1. conducting assessments that confirm that the plant will continue to meet its licensing basis until the next PSR cycle or, where appropriate, the end of commercial operation
2. conducting assessments against applicable modern codes, standards and practices
3. conducting a global assessment of facility safety in view of all PSR gaps and strengths
4. identifying any corrective actions and safety improvements that are necessary to address PSR findings to improve the level of safety

Guidance

The methodologies that will be applied for the PSR should be described in the PSR basis document to show how the licensee plans to achieve the PSR objectives as stated in section 2. The methodologies outlined in SSG-25 for performing safety factor reviews provide an acceptable approach.

Since processes and programs have many levels of interdependencies and interrelationships, the reviews should be conducted using internal documents that correctly represent these dependencies and relationships. To ensure this, a freeze date should be established for the internal documents used in the safety factor reviews. The reviews are then carried out using documents that are applicable to the document freeze date.

3.5 Applicable modern codes, standards and practices

The licensee shall state what modern national and international codes, standards and practices will be used in the reviews, including their effective dates, as well as:

1. the criteria for their selection
2. the PSR cut-off date beyond which changes to codes and standards and new information will not be considered
3. the type of review to be performed (clause-by-clause, high level or alternative)

Guidance

An integral element of the PSR is the assessment of the extent to which the NPP would satisfy requirements and expectations set out in applicable modern codes, standards and practices. A list of modern codes, standards and practices with their cut-off dates, should be established before any work is carried out. This ensures a common and consistent expectation for the reviews.

Modern codes, standards and practices should be selected, taking into consideration CNSC's regulatory documents as well as modern international practices and operational experience. Primary consideration for selection of codes and standards should rest with those referenced in licences and applicable CNSC regulatory documents. IAEA documents and other appropriate international standards should also be considered. If an appropriate Canadian code or standard is not available, the licensee should propose a reasonable substitute.

It is expected that all mandatory clauses in a code or standard will be reviewed to determine if the identified requirements are met. Any applicable sub-tier referenced sections in the mandatory clauses to other codes, standards and licensee documentation should also be reviewed and addressed. A clause-by-clause type review should also be performed for new versions of codes and standards referenced by the licence and licence condition handbook. For other codes and standards, licensees may propose other types of reviews.

3.6 Methodology for the identification, dispositioning and tracking of gaps

The licensee shall describe the process and methodology for identifying, categorizing, prioritizing and dispositioning gaps. The licensee shall state what decision-making process will be used to evaluate and decide on the various alternatives to disposition the gaps.

To the extent practicable, the licensee shall resolve identified gaps with respect to applicable modern codes, standards and practices. The licensee shall use established processes to resolve identified gaps with the current licensing basis. The licensee shall track dispositioning and resolution of all gaps identified during the PSR through to their resolution.

Guidance

The PSR review should identify the following types of findings:

- **strengths** – current practices are equivalent to or better than those established in modern codes and standards, practices
- **gaps** – current practices are not equivalent to those established in modern codes and standards practices, or do not meet the current licensing basis, or are inconsistent with the operational documentation for plant

The rationale behind identifying the findings and their disposition should be justified using valid arguments and supporting evidence. All gaps should be categorized and prioritized according to their safety significance. While assessing gaps for safety significance, the licensee should consider deterministic and probabilistic safety analyses, engineering judgment or a combination thereof. Suitability for assessment via selected means should be determined by the nature of the finding.

Depending on the nature of the gaps, the licensee may also include considerations such as public radiation safety, plant operability, occupational radiation safety, emergency preparedness, and the environment when prioritizing gaps. The overall priority of a gap should inform the course of action to be taken to establish its recommended disposition. Any gaps representing the plant's non-compliance against the current licensing basis may be resolved through the existing plant programs. The licensee should establish and maintain a database of all gaps identified during the PSR.

3.7 Methodology for the global assessment

The methodology for performing the global assessment shall be described in the PSR basis document. The methodology shall address and include:

1. results of the safety factor reviews, in particular, the findings (both gaps and strengths) of NPP design and operation
2. the interdependencies between gaps and the significance of their aggregate effects
3. recommended corrective actions and safety improvements to address individual and consolidated gaps
4. the extent to which the safety requirements of defence in depth are fulfilled
5. an estimate of global risk associated with facility operation with any unresolved gaps

The results from the global assessment shall be documented in the global assessment report.

Guidance

The objective of the global assessment is to present an overall evaluation of facility safety taking into account a balanced assessment of all findings identified in the PSR. The global assessment should

take into account all the strengths and gaps from the PSR, and the corrective actions and/or safety improvements proposed to improve the overall level of safety.

The review of individual safety factors may indicate that the NPP's safety is acceptable; however, when a review of the interactions, overlaps and gaps between safety factors is performed, new findings may be identified that have an impact on overall level of safety.

3.8 Periodic safety review governance

In the PSR basis document, the licensee shall establish, and describe governance for the conduct of the PSR.

Guidance

The licensee's governance for the conduct of PSR should address that:

1. the PSR team is qualified to carry out the review
2. provisions have been made for peer or independent review of work done
3. controls are in place to ensure that information and data are used consistently across the review
4. requirements for the preparation and verification of documentation are satisfied
5. results are recorded in a systematic and auditable manner

The licensee should develop a project plan for the conduct of the PSR that includes established project management processes and quality management provisions.

4. Performance of the Periodic Safety Review

The licensee shall conduct the PSR in accordance with the accepted PSR basis document following its acceptance by CNSC staff.

Guidance

It is recommended that the licensee does not undertake substantive work on the PSR until such time as CNSC staff has accepted the PSR basis document.

4.1 Safety factor reports

Upon completion of the safety factor reviews, the licensee shall prepare reports for submission to CNSC staff in accordance with the accepted PSR basis document. The licensee shall ensure that each safety factor report documents:

1. objective, scope, tasks and methodology for the review
2. applicable codes , standards and practices
3. overview of applicable facility programs and processes
4. findings of the review which identify gaps and strengths
5. categorized and prioritized gaps
6. interfaces with other safety factor report findings
7. options for corrective actions for each gap

Guidance

The safety factor reports document the findings for specific review tasks. The findings of the assessments and the comparison against applicable modern codes, standards, and practices are included. Any gaps are identified, recorded, categorized, prioritized and dispositioned.

The overall structure of each report should be a summary of the review followed by detailed reporting and conclusions. The report should:

1. clearly indicate the type of review conducted for each review element: a clause-by-clause review, a high-level review or a combination thereof, and provide the rationale for selecting the type of review
2. provide systematic coverage of the expected review tasks with detailed analysis of how the licensee addressed requirements to fulfill licensing bases, as well as the expectations for satisfying applicable, modern codes, standards and practices set out in the basis document
3. clearly indicate the licensee's acceptance of any work done by an outsourced contractor
4. provide enough information to allow CNSC staff to make a regulatory determination based on the information contained in the report

The licensee should prepare the safety factor reports to be as self-contained as practicable, avoiding excessive referencing. Where a code, standard or practice addresses more than one review element, the findings of such reviews should be cross-referenced.

Safety factor reports should be submitted concurrently or in a single package because some reports may be inter-related. For example, the report for aging may be inter-related with the reports on the actual condition of SSCs important to safety and deterministic safety analysis.

5. Global Assessment Report

The licensee shall prepare a report that documents the results of the global assessment. The global assessment report (GAR) shall present the findings of the PSR, both strengths and gaps, to provide an overall assessment of the safety of plant. The GAR shall document the overall conclusions, corrective actions and safety improvements to be considered. It shall be submitted to CNSC staff for review.

Guidance

The GAR should provide a living database that captures the current state of the gaps. The database should be fully traceable so that a change in a gap, or in the assessment of a gap, can be easily tracked to its resolution. The GAR should include the following elements:

1. summaries of the safety factor reports and identified gaps and strengths
2. overlaps, omissions, and interface issues of the findings from the safety factor reports
3. consolidation of gaps into global issues where appropriate
4. safety significance and risk ranking of all gaps (individual and consolidated)
5. corrective actions, safety improvements and appropriate dispositions proposed for all gaps and global issues
6. a global assessment based on the aggregate effect of the findings resulting from all safety factor reports, taking the proposed corrective actions and safety improvements into account, and defence in depth
7. statement of the licensee's assessment of the overall acceptability of operation of the NPP

6. Integrated Implementation Plan

The licensee shall develop an integrated implementation plan (IIP) that addresses the results of the global assessment. The IIP shall be submitted to CNSC staff for acceptance.

In the IIP, the licensee shall:

1. list the corrective actions and safety improvements (including necessary physical NPP modifications) that will address all gaps identified in the PSR, and findings
2. specify the schedule for implementing the corrective actions and safety improvements

Guidance

An overview of the acceptability of safe operation of plant in view of the proposed changes should be included in the IIP, to demonstrate that the outcome of safety improvements serves the intended purpose of the PSR.

In the IIP, the licensee should:

1. demonstrate traceability and provide references to the GAR
2. specify the processes used for determining the detailed scope, including prioritization and scheduling of corrective actions and safety improvements
3. schedule and implement corrective actions and safety improvements commensurate with their safety significance
4. specify processes for identification and management of project risks and controls
5. specify the process to be used to track the progress and completion of the corrective actions and safety improvements

It is encouraged to organize the IIP according to the CNSC's safety and control areas so as to facilitate the CNSC's review. See Appendix B for more information on CNSC's safety and control areas.

To ensure the IIP's success, the licensee should have the following in place:

1. a project organization, structured to execute the IIP
2. governance for IIP delivery
3. scope, schedules and dependencies, at least for the earlier tasks
4. definition of resources and a resourcing plan
5. a mechanism for overall integration, peer or independent review and oversight

Appendix A: Safety Factor for Radiation Protection

As stated in section 3.3 of this document, the scope of the PSR should address the following 14 safety factors set out in the International Atomic Energy Agency's Safety Standards Series, Specific Safety Guide No. SSG-25, *Periodic Safety Review for Nuclear Power Plants* (SSG-25) [1]:

1. reactor facility design
2. actual condition of structures, systems and components important to safety
3. equipment qualification
4. aging
5. deterministic safety analysis
6. probabilistic safety assessment
7. hazard analysis
8. safety performance
9. use of experience from other plants and research findings
10. organization, the management system and safety culture
11. procedures
12. human factors
13. emergency planning
14. radiological impact on the environment

SSG-25 does not address radiation protection (RP) as a separate safety factor because it is considered as a review element of several other safety factors. It is expected that RP-related elements will be integrated into the relevant safety factor reports as described in SSG-25, including safety factors 8 (safety performance), 10 (organization, the management system and safety culture) and 11 (procedures).

Based on experience from previous CNSC reviews, the licensee should address four RP-related review elements separately. These elements are outlined in the following text.

A.1 Objective

The objective of the review of RP is to determine:

- the extent to which RP has been accounted for in the design and operation of the reactor facility
- whether RP provisions (including design and equipment) provide adequate protection of persons from the harmful effects of radiation, and ensures that contamination and radiation exposures and doses to persons are monitored and controlled, and maintained as low as reasonably achievable (ALARA)

A.2 Scope and tasks

The scope of this review will depend on the extent of changes in standards and/or the licensing basis since the previous PSR or the start of operation. The review of RP should include the following tasks:

- reactor design features for RP
- RP equipment and instrumentation for radiation monitoring
- RP aspects during nuclear emergencies
- RP operating experience

A.3 Methodology

The review should be performed systematically by reviewing national and international requirements and standards listed in the PSR basis document and other requirements and standards identified as relevant during the course of the review.

A.3.1 Review of the reactor design features for radiation protection

The review should identify all sources of radiation and radiation exposure pathways, with an evaluation of radiation doses that could be received by workers at the facility with consideration of contained and fixed sources, and potential sources of airborne radioactive material. The review should demonstrate that the ALARA principle has been incorporated in the reactor design and operational programs and arrangements, in order to minimize the number and locations of radiation sources and the radiation fields associated with them.

The review should determine that the design and layout of the reactor facility meets CNSC regulatory requirements and expectations for reactor facilities in the area of RP (e.g., REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants* and RD/GD-369, *Licence Application Guide: Licence to Construct a Nuclear Power Plant*). The review should include RP principles, and how they are incorporated into the reactor design and are of a sufficient depth to demonstrate the following:

- suitable provisions have been made in the design and layout of the reactor facility to keep occupational radiation doses below regulatory limits and ALARA, including:
 - o classification of areas (zoning) and access control
 - o aging of all materials and obsolescence of technology that could impair the radiological safety functions of SSCs
 - o radiological hazard control
 - o decontamination of personnel, equipment and structures
 - o radiological monitoring (in-plant)
- SSCs have been adequately designed so that radiation exposures during all activities are optimized and justified

A.3.2 Review of radiation protection equipment and instrumentation for radiation monitoring

The review of RP equipment and instrumentation for radiation monitoring should demonstrate adequate provisions for monitoring all significant radiation sources, in all activities throughout the lifetime of the reactor facility. These should cover operational states and accident conditions and, as practicable, beyond-design-basis accidents, including severe accidents. The review of the physical condition of RP instrumentation and equipment should be confirmed by walk downs where practicable to verify continued utility and functionality.

A.3.3 Review of radiation protection aspects for nuclear emergencies

The review of RP aspects for nuclear emergencies should demonstrate the effectiveness of RP measures during a nuclear emergency. These measures may be significantly impacted by facility configuration and controls; or for example, the review should consider access controls, habitability controls, communications systems, adequate radiation monitoring capabilities, portable emergency response RP equipment, and radiation personnel protective equipment.

A.3.4 Review of radiation protection related to operating experience

The review of RP-related operating experience (OPEX) should identify OPEX reports from other reactor facilities and relevant national and international experience and research findings. The review should verify that this information has been properly considered in the routine evaluation of OPEX and research developments and that appropriate action has been taken. The review of OPEX should seek to identify good practices and lessons learned elsewhere, and to take advantage of improved knowledge derived from research, in the area of RP.

Appendix B: CNSC Safety and Control Areas

Safety and Control Area	Description
Management system	The framework that establishes the processes and programs required to ensure an organization achieves its safety objectives, continuously monitors its performance against these objectives, and fosters a healthy safety culture.
Human performance management	The activities that enable effective human performance through the development and implementation of processes that ensure a sufficient number of licensee personnel are in all relevant job areas and have the necessary knowledge, skills, procedures and tools in place to safely carry out their duties.
Operating performance	This includes an overall review of the conduct of the licensed activities and the activities that enable effective performance.
Safety analysis	Maintenance of the safety analysis that supports the overall safety case for the facility. Safety analysis is a systematic evaluation of the potential hazards associated with the conduct of a proposed activity or facility and considers the effectiveness of preventative measures and strategies in reducing the effects of such hazards.
Physical design	The activities that impact the ability of structures, systems and components to meet and maintain their design basis given new information arising over time and taking changes in the external environment into account.
Fitness for service	The activities that impact the physical condition of structures, systems and components to ensure that they remain effective over time. This area includes programs that ensure all equipment is available to perform its intended design function when called upon to do so.
Radiation protection	The implementation of a radiation protection program in accordance with the <i>Radiation Protection Regulations</i> . This program must ensure that contamination levels and radiation doses received by individuals are monitored and controlled, and maintained as low as reasonably achievable (ALARA)
Conventional health and safety	The implementation of a program to manage workplace safety hazards and to protect personnel and equipment.
Environmental protection	The programs that identify, control and monitor all releases of radioactive and hazardous substances and effects on the environment from facilities or as the result of licensed activities.
Emergency management and fire protection.	The emergency plans and emergency preparedness programs which exist for emergencies and for non-routine conditions. This area also includes any results of participation in exercises.
Waste management	The internal waste-related programs that form part of the facility's operations up to the point where the waste is removed from the facility to a separate waste management facility. This area also covers the planning for decommissioning.
Security	The programs required to implement and support the security requirements stipulated in the regulations, in the license, in orders, or in expectations for the facility or activity.
Safeguards and non-proliferation	The programs required for the successful implementation of the obligations arising from the Canada/IAEA safeguards agreements, as well as all other measures arising from the <i>Treaty on the Non-Proliferation of Nuclear Weapons</i> .
Packaging and transport	The programs that manage the safe packaging and transport of nuclear substances and radiation devices to and from the licensed facility.

Glossary

aging management

Engineering, operations, inspection, and maintenance actions to control, within acceptable limits, the effects of physical aging and obsolescence of structures, systems and components.

ALARA (as low as reasonably achievable)

A principle of radiation protection that holds that exposures to radiation are kept as low as reasonably achievable, social and economic factors taken into account. Section 4 of the *Radiation Protection Regulations* stipulates licensee requirements with respect to ALARA.

corrective actions

Measures taken to eliminate the cause of a detected nonconformity or other undesirable situation to prevent reoccurrence.

global assessment

An overall risk judgment on the acceptability of continued operation of a nuclear facility.

integrated implementation plan (IIP)

A plan that considers the scope and schedule of safety improvements to support continued operation of a facility, based on the results of a periodic safety review.

licensing basis

A set of requirements and documents for a regulated facility or activity comprising:

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

management system

A set of interrelated or interacting elements (system) for establishing policies and objectives and enabling the objectives to be achieved in an efficient and effective way. The management system integrates all elements of an organization into one coherent system to enable all of the organization's objectives to be achieved. These elements include the structure, resources, and processes. Personnel, equipment, and organizational culture as well as the documented policies and processes are parts of the management system. The organization's processes have to address the totality of the requirements on the organization as established in, for example, IAEA safety standards and other international codes and standards.

nuclear power plant

A nuclear facility consisting of any nuclear fission reactor installation that has been constructed to generate electricity on a commercial scale.

Note: An NPP may include more than one nuclear reactor.

periodic safety review (PSR)

A comprehensive assessment of nuclear power plant design and operation that deals with the cumulative effects of aging, modifications, operating experience, technical developments and siting factors, and aims at ensuring a high level of safety throughout the operating life of plant.

periodic safety review (PSR) basis document

The information that sets out the scope and methodology for the conduct of the periodic safety review.

safety improvements

Measures taken that result in more effective implementation of the safety objectives of a nuclear power plant.

safety significance

The significance of a situation, event or issue with respect to the impact on meeting the nuclear safety objectives as defined by the IAEA in document No. SF-1 *Fundamental Safety Principles* [2]. In general, a situation, event or issue has safety significance if it denotes a deviation from the safety case accepted in the licence, in a direction detrimental to safety, such as but not limited to:

- reducing margins to (or exceeding) the accepted limits
- increasing risk to the health, safety and security of persons and the environment
- impairments (various degrees) of the special safety systems or of the safety functions for accident mitigation
- reduction in defence in depth
- events causing radioactive releases and spills of hazardous substances, injuries to workers or the public, etc.

structures, systems and components (SSCs)

A general term encompassing all of the elements (items) of a facility or activity that contribute to protection and safety. Structures are the passive elements: buildings, vessels, shielding, etc. A system comprises several components, assembled in such a way as to perform a specific (active) function. A component is a discrete element of a system. Examples are wires, transistors, integrated circuits, motors, relays, solenoids, pipes, fittings, pumps, tanks, and valves.

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3. CNSC, P-242, *Considering Cost-benefit Information*, Ottawa, 2000.
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5. IAEA, Safety Standards Series, Safety Guide NS-G-2.12, *Ageing Management for Nuclear Power Plants*, Vienna, Austria, 2009.
6. IAEA, Safety Standards Series, Safety Guide NS-G-2.6, *Maintenance, Surveillance and In-Service Inspection in Nuclear Power Plants*, Vienna, Austria, 2002.
7. IAEA, INSAG 12, *Basic Safety Principles for Nuclear Power Plants*, 75-INSAG-3 Rev.1, A report by the International Nuclear Safety Advisory Group, Vienna, Austria, 1999.

CNSC Regulatory Document Series

Facilities and activities within the nuclear sector in Canada are regulated by the Canadian Nuclear Safety Commission (CNSC). In addition to the *Nuclear Safety and Control Act* and associated regulations, these facilities and activities may also be required to comply with other regulatory instruments such as regulatory documents or standards.

Effective April 2013, the CNSC's catalogue of existing and planned regulatory documents has been organized under three key categories and twenty-five series, as set out below. Regulatory documents produced by the CNSC fall under one of the following series:

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- | | | |
|--------|-----|--|
| Series | 1.1 | Reactor facilities |
| | 1.2 | Class IB facilities |
| | 1.3 | Uranium mines and mills |
| | 1.4 | Class II facilities |
| | 1.5 | Certification of prescribed equipment |
| | 1.6 | Nuclear substances and radiation devices |

2.0 Safety and control areas

- | | | |
|--------|------|--|
| Series | 2.1 | Management system |
| | 2.2 | Human performance management |
| | 2.3 | Operating performance |
| | 2.4 | Safety analysis |
| | 2.5 | Physical design |
| | 2.6 | Fitness for service |
| | 2.7 | Radiation protection |
| | 2.8 | Conventional health and safety |
| | 2.9 | Environmental protection |
| | 2.10 | Emergency management and fire protection |
| | 2.11 | Waste management |
| | 2.12 | Security |
| | 2.13 | Safeguards and non-proliferation |
| | 2.14 | Packaging and transport |

3.0 Other regulatory areas

- | | | |
|--------|-----|----------------------------------|
| Series | 3.1 | Reporting requirements |
| | 3.2 | Public and Aboriginal engagement |
| | 3.3 | Financial guarantees |
| | 3.4 | Commission proceedings |
| | 3.5 | Information dissemination |

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Regulatory Document

RD-360

Life Extension of Nuclear Power Plants

February 2008

CNSC REGULATORY DOCUMENTS

The Canadian Nuclear Safety Commission (CNSC) develops regulatory documents under the authority of paragraphs 9(b) and 21(1)(e) of the *Nuclear Safety and Control Act* (NSCA).

Regulatory documents provide clarifications and additional details to the requirements set out in the NSCA and the regulations made under the NSCA, and are an integral part of the regulatory framework for nuclear activities in Canada.

Each regulatory document aims at disseminating objective regulatory information to stakeholders, including licensees, applicants, public interest groups and the public on a particular topic to promote consistency in the interpretation and implementation of regulatory requirements.

A CNSC regulatory document or any part thereof becomes a legal requirement when it is referenced in a licence or any other legally enforceable instrument.

Regulatory Document

RD-360

LIFE EXTENSION OF NUCLEAR POWER PLANTS

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Life Extension of Nuclear Power Plants

Regulatory Document RD-360

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The document can be viewed on the CNSC web site at www.nuclearsafety.gc.ca. Copies may be ordered in English or French using the contact information below:

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LIFE EXTENSION OF NUCLEAR POWER PLANTS

1.0 PURPOSE

This regulatory document is one of a suite of regulatory documents that cover the life cycle of Canadian nuclear power plants from siting and design to operation and decommissioning. The purpose of this regulatory document is to inform licensees about the steps and phases to consider when undertaking a project to extend the life of a nuclear power plant (NPP).

2.0 SCOPE

This regulatory document addresses:

1. Key elements to consider when establishing the scope of the life extension project; and
2. Considerations to be taken into account in planning and executing a life extension project.

3.0 RELEVANT LEGISLATION

The following provisions of the *Nuclear Safety and Control Act* (NSCA) and related regulations are relevant to this regulatory document:

1. Section 3 of the NSCA provides for, “the limitation, to a reasonable level and in a manner that is consistent with Canada’s international obligations, of the risks to national security, the health and safety of persons and the environment that are associated with the development, production and use of nuclear energy...”;
2. Section 9 of the NSCA provides the objects of the Commission, which are, “to regulate the development, production and use of nuclear energy and the production, possession and use of nuclear substances, prescribed equipment and prescribed information...”;
3. Subsection 24(4) of the NSCA stipulates that, “No licence may be issued, renewed, amended or replaced unless, in the opinion of the Commission, the applicant
(a) is qualified to carry on the activity that the licence will authorize the licensee to carry on; and
(b) will, in carrying on that activity, make adequate provision for the protection of the environment, the health and safety of persons and the maintenance of national security and measures required to implement international obligations to which Canada has agreed”;
4. Subsection 24(5) of the NSCA provides that, “a licence may contain any term or condition that the Commission considers necessary for the purposes of the Act...”;

5. Section 3 of the *General Nuclear Safety and Control Regulations* contains the general licence application requirements;
6. Paragraph 12(1)(c) of the *General Nuclear Safety and Control Regulations* says that every licensee shall, “take all reasonable precautions to protect the environment and the health and safety of persons and to maintain security”;
7. Paragraph 12(1)(f) of the *General Nuclear Safety and Control Regulations* says that every licensee shall, “take all reasonable precautions to control the release of radioactive nuclear substances or hazardous substances within the site of the licensed activity and into the environment as a result of the licensed activity”;
8. Paragraph 12(1)(i) of the *General Nuclear Safety and Control Regulations* stipulates that every licensee shall, “take all necessary measures to facilitate Canada's compliance with any applicable safeguards agreement”;
9. Section 3 of the *Class I Nuclear Facilities Regulations* outlines the general licence application requirements specific to nuclear power plants; and
10. Section 6 of the *Class I Nuclear Facilities Regulations* stipulates the information that is required in an application for a nuclear power plant operating licence.

Regulations associated with the *Canadian Environmental Assessment Act* will also be applicable to a life extension project. Other relevant legislation is listed in the Associated Documents section at the end of this regulatory document.

4.0 INTRODUCTION

Nuclear power plants in Canada are subject to the ongoing regulatory oversight of the Canadian Nuclear Safety Commission (CNSC, the Commission), including periodic licence renewal. However, the NPP licensee may choose, for the purpose of long-term operation, to implement a life extension project. Continued operation of the NPP is largely dependent on the work that will be required for long term safe operation of the plant.

A life extension project may involve the replacement or refurbishment of major components, or substantial modifications to the plant, or both. As such, these projects represent a commitment to long-term, continued operation of the facility. In keeping with the objectives of the NSCA, the Commission is mandated to ensure that facility operation continues to pose no unreasonable risk to health, safety, security, or the environment, and will conform to Canada's international obligations.

The Commission therefore considers it to be in the public interest that licensees address modern high level safety goals, and meet applicable regulatory requirements for safe and secure long-term operation. To this end, NPP licences are amended to introduce specific licence conditions for the regulatory control of life extension projects. The licensee is expected to adhere to the requirements of the NSCA and the *Canadian Environmental Assessment Act*, and all associated regulations, and to all licence conditions throughout the life extension project and subsequent reactor operation.

Approval for return-to-service is contingent upon demonstration by the licensee that all licence conditions have been met.

In keeping with its regulatory mandate, the Commission expects the licensee to demonstrate that the following objectives are met for any life extension project:

1. The technical scope of the project is adequately determined through a Integrated Implementation Plan that takes into account the results of an environmental assessment (EA), where required, and an Integrated Safety Review (ISR);
2. Programs and processes that take into account the special considerations of the project are established; and
3. The project is appropriately planned and executed.

5.0 PROJECT INITIATION

The licensee formally advises the Commission of the intention to conduct a life extension project, and submits a project description with this notification. The project description indicates the licensee's initial understanding of the project, and includes:

1. Definition of project scope and objectives;
2. Status of current plant design and operation;
3. Project components and structures (such as permanent and temporary structures, infrastructure, construction equipment, etc.);
4. Expected project activities (such as operational phases, timing and scheduling of each phase, etc.);
5. Site information (such as location, environmental features, and land use);
6. Waste issues; and
7. Anticipated milestones.

The project description forms the basis of the EA, and is also used as a point of reference for the project.

Information to assist the licensee in developing the project description is provided in the Canadian Environmental Assessment Agency's publication, *Preparing Project Descriptions under the Canadian Environmental Assessment Act*.

6.0 ESTABLISHING THE INTEGRATED IMPLEMENTATION PLAN

Once the licensee decides to undertake a life extension project, the licensee systematically identifies and addresses all environmental and safety concerns, and integrates them into an *Integrated Implementation Plan*. To do this, the licensee:

1. Participates in the environmental assessment (EA) process (Section 6.1, below);
2. Carries out an Integrated Safety Review (Section 6.2, below); and
3. Applies the results of these assessments to establish the Integrated Implementation Plan (Section 6.3.2, below).

Since the EA and ISR may provide information relevant to each other, these assessments are done in parallel where practicable.

6.1 Environmental Assessment

In accordance with the *Canadian Environmental Assessment Act*, the life extension project may be subject to an environmental assessment. Where an EA is required, a decision that the life extension project will not have significant adverse environmental effects is needed prior to any licensing action being taken under the NSCA.

As the responsible authority for the conduct of the EA process, the Commission is responsible for determining whether an EA is required, and ensuring that the process is carried out appropriately.

6.2 Integrated Safety Review

The *Integrated Safety Review* (ISR) is a comprehensive assessment of plant design, condition, and operation. It is conducted at the time that a licensee is considering life extension of an NPP. Guidance on the ISR is found in the *Periodic Safety Review of Nuclear Power Plants – Safety Guide* (IAEA PSR Guide) published by the International Atomic Energy Agency (IAEA). It is referred to as an ISR due to its application of the *Periodic Safety Review* to the life extension project.

Performed by the licensee, the ISR involves an assessment of the current state of the plant and plant performance to determine the extent to which the plant conforms to modern standards and practices, and to identify any factors that would limit safe long-term operation. Operating experience in Canada and around the world, new knowledge from research and development activities, and advances in technology, are taken into account. This enables determination of reasonable and practical modifications that should be made to systems, structures, and components, and to management arrangements, to enhance the safety of the facility to a level approaching that of modern nuclear power plants, and to allow for long term operation.

The objectives of the ISR are to determine:

1. The extent to which the plant conforms to modern standards and practices;
2. The extent to which the licensing basis will remain valid over the proposed extended operating life;
3. The adequacy of the arrangements that are in place to maintain plant safety for long-term operation; and
4. The improvements to be implemented to resolve safety issues that have been identified.

The ISR should include:

1. Conformity reviews that confirm that the NPP meets and will continue to meet the current plant-specific licensing and design basis;
2. A review against modern standards and practices to assess the level of safety compared to that of modern NPPs (any shortcomings against these modern standards and practices are identified and their safety significance determined);
3. Any modifications that are necessary to improve the level of safety; and
4. A global assessment of plant safety for long-term operation in view of each of the ISR safety factors.

6.2.1 ISR Basis

Prior to performing the ISR, the licensee prepares an *ISR Basis Document*, which sets out the scope and methodology for the conduct of the ISR. The *ISR Basis Document* includes the following information:

1. **The proposed extended life of the facility**

The *ISR Basis Document* clearly defines the full period of proposed extended operation. This information is also included in the project description if an EA is required.

2. **The scope of the ISR**

The safety factors to be addressed in the ISR are listed in the IAEA's safety guide, *Periodic Safety Review of Nuclear Power Plants*. In addition, the scope of the ISR should at least address CNSC safety areas and programs (refer to Appendix A).

The ISR should address site-specific facilities, systems, structures, and components, and any applicable site-wide issues, such as dependencies on common services. The physical status of each unit should be considered separately for an ISR of multiple units of the same design. The adequacy of management arrangements should also be addressed.

In addition, the ISR scope should consider, as appropriate for each safety factor, all expected modes of operation (i.e., normal operation, maintenance, refuelling, shutdown, and start-up activities), to determine whether there is any potential for increased or unacceptable levels of risk.

All generic action items and station-specific actions items should be addressed in the review, with each being resolved to the extent practicable.

3. Statement of modern standards and practices

The set of modern standards and practices that will be used in the review of each ISR safety factor should be provided, including the criteria for the selection of applicable standards and specifications.

Primary consideration should be given to CNSC regulatory documents that would apply to a new facility, as well as to standards currently referenced in licences. The licensee should also consider IAEA or other appropriate modern international standards and practices.

For each document listed, the licensee should indicate whether a high-level review, a clause-by-clause review will be performed, or whether an alternative approach will be taken. The rationale for the selected approach should be outlined.

4. Statement of the plant licensing basis at the time of initiating the ISR

The licensing basis is used in conformity reviews, and also serves as the baseline in the review against the modern standards and practices.

The licensing basis includes the CNSC regulatory framework, the documents referenced in the station-specific licence, the documents submitted by the licensee in support of the licence application, and the documents referenced therein.

5. Process for identifying and addressing gaps

The licensee describes its processes for identifying and addressing gaps between current and desired plant state and performance, documenting the significance of any gaps, and prioritizing corrective actions and safety improvements.

Non-compliance with the current licensing and design basis should be addressed immediately by the licensee. Non-compliance with modern standards and practices should be resolved to the extent practicable. An appropriate justification should be provided for any unresolved shortcomings.

The Commission reviews the *ISR Basis Document* for acceptance.

6.2.2 ISR Safety Factor Reports

The licensee considers all pertinent safety factors and prepares *ISR Safety Factor Reports* for submission to the Commission. The licensee proposes the manner in which the scope of the ISR will be addressed, and either submits reports addressing each ISR safety factor separately, or groups documentation accordingly.

The *ISR Safety Factor Reports* contain the review results, including proposed corrective actions and safety improvements, for the specific topics. The results of the conformity reviews and the comparison against modern standards and practices are also included.

6.2.3 Confirmation of the Adequacy of ISR Safety Factor Reports

The Commission reviews the *ISR Safety Factor Reports* for acceptance. The final results are incorporated in the development of the licensee's *Integrated Implementation Plan*.

6.3 Global Assessment and Integrated Implementation Plan

The licensee incorporates the results of the EA and the *ISR Safety Factor Reports* in a *Global Assessment Report*, which includes an *Integrated Implementation Plan*.

6.3.1 Global Assessment

The *Global Assessment Report* presents significant ISR results, including plant strengths, the *Integrated Implementation Plan* for corrective actions and safety improvements, and an overall risk judgment on the acceptability of continued plant operation. Interactions between safety factors, individual shortcomings, corrective actions, and safety improvements, including compensatory measures, should be considered in assessing the overall plant safety and the acceptability of continued operation. The global assessment should also show the extent to which the safety requirements of the defence-in-depth concept are fulfilled.

6.3.2 Integrated Implementation Plan

When developing the *Integrated Implementation Plan*, the licensee:

1. Identifies a list of shortcomings for each of the safety factors identified in the ISR;
2. Identifies a list of strengths with respect to fulfilling the safety requirements of the defence-in-depth concept;
3. Evaluates the safety significance and ranking of each of the shortcomings and prioritizes corrective measures. Significant safety issues should be addressed immediately. Justification for proposed exemptions from the modern standards and practices should be provided, taking the safety significance, physical practicality, and other information into account, as appropriate;
4. Develops corrective actions and safety improvements for each of the shortcomings, as far as practicable; and
5. In view of each of the ISR safety factors, evaluates the acceptability of plant operation over the next review period in an integrated assessment.

The *Integrated Implementation Plan* indicates the schedule for implementing the safety improvements, which should be completed within a reasonable time frame. The licensee provides justification for deferral of the work if the safety improvements cannot be completed during the nearest outage.

The licensee updates all station documentation such as the safety analysis report, operating and maintenance procedures, and training materials to reflect the outcomes of the ISR.

Licensees may elect to submit cost-benefit information in support of the *Integrated Implementation Plan*.

6.4 Confirmation of the Adequacy of the Global Assessment Report

The Commission reviews the licensee's *Global Assessment Report* for acceptability by assessing:

1. The completeness of the assessment;
2. The significance and ranking of identified safety issues for all assessed safety factors;
3. The adequacy of proposed corrective actions and safety improvements, or justification of proposed exemptions;
4. The adequacy of proposed implementation schedule;
5. The adequacy of the proposed measures for assuring the quality of the life extension activities; and
6. Conformance with the EA results.

The results of the Commission reviews are taken into account in the revision of the *Global Assessment Report*, including the *Integrated Implementation Plan*.

The Commission either accepts the *Global Assessment Report*, or requires changes. Upon acceptance of the *Global Assessment Report*, the licence is amended to include licence conditions to be met in the return-to-service phase of the project.

6.4.1 Integrated Implementation Plan Changes

The licensee should have a well defined process for the control of any changes to the *Integrated Implementation Plan*.

Formal approval is required for:

1. Changes in the plan associated with work that is needed to fulfil the requirements identified by the screening EA; and
2. Changes in the plan for items subject to conditions of the operating licence.

7.0 PROJECT EXECUTION

7.1 Project Execution Planning

The licensee prepares a *Project Execution Plan* that identifies what needs to be done to achieve the desired outcomes for the project. Areas that may require special attention when planning the project execution typically include:

1. Historical design issues;
2. Component obsolescence;
3. Resource requirements;
4. Use of contractors;
5. Unique or unusual plant configurations; and
6. Return to service plans.

7.2 Programs and Processes

To enable project implementation, the licensee needs acceptable programs and processes to control and execute the life extension project. These programs and processes may include consideration of such areas as:

- | | |
|---|---|
| 1. Change control; | 12. Outage management; |
| 2. Commissioning; | 13. Training and personnel qualification; |
| 3. Configuration management; | 14. Procurement; |
| 4. Construction; | 15. Quality management; |
| 5. Emergency preparedness; | 16. Radiation protection; |
| 6. Engineering design; | 17. Safeguards; |
| 7. Environmental protection; | 18. Safety management; |
| 8. Fire protection; | 19. Security; |
| 9. Human factors; | 20. Stakeholder communication; |
| 10. Nuclear criticality safety program; | 21. Waste management; and |
| 11. Occupational health and safety; | 22. Work control. |

The licensee should refer to Commission requirements and appropriate legislation and standards when addressing these considerations, both for guidance in their development, and to determine how program outcomes will be measured.

The adequacy of programs and processes for the control of the life extension project will be assessed by the Commission.

7.3 Project Monitoring

The licensee is expected to monitor the project for progress, safety, and quality at all phases of execution. Items to be monitored may include:

1. Complete redesigns or design modifications;
2. Engineering field changes;
3. Installation rework;
4. Procedural non-compliances;
5. Plant configuration;
6. Missed completion dates;
7. Worker safety events involving injuries, near misses, unsafe practices, unplanned dose uptakes; and
8. Environmental performance.

Project monitoring includes verifying that the work has been done correctly, and may reveal the need for:

1. Creation of new programs and procedures;
2. Revision of existing programs and procedures;
3. Resource changes;
4. Revision of existing training programs or material; or
5. New training programs or material.

The licensee should assess all identified shortcomings to determine their causes and the impact of the shortcomings or their causes on other aspects of the project.

8.0 RETURN TO SERVICE

The licensee needs to establish a *Return to Service Plan* for the life extension project. Return to service involves returning the reactor, the nuclear systems, and the non-nuclear systems, back to commercial operation. Return to service includes demonstration by the licensee that all relevant licence conditions have been met and that the associated work has been done to the satisfaction of the Commission. The licensee is expected to submit design completion and construction completion assurance reports, as well as completion assurance reports for each phase of commissioning.

8.1 Commissioning Phases

Return to service is dependent on the licensee's ability to demonstrate that new and existing plant systems, structures, and components conform to the defined physical, functional, performance, safety, and control requirements, and that management arrangements have been appropriately updated.

This is accomplished through four commissioning phases:

1. **Phase A:** Focuses on ensuring that those systems required to ensure safety with fuel loaded into the reactor have been adequately commissioned. This phase must be successfully completed prior to loading fuel in the reactor;
2. **Phase B:** Focuses on ensuring the fuel is loaded into the reactor safely, and confirming that the reactor is in a suitable condition to be started up and that all prerequisites for permitting the reactor to go critical have been met. This phase must be successfully completed prior to removal of the guaranteed shutdown state (GSS);
3. **Phase C:** Focuses on confirming reactor behaviour at the stage of initial criticality and subsequent low power tests, and includes activities that cannot be done during the GSS; and
4. **Phase D:** Focuses on demonstrating reactor and systems behaviour at higher power levels, including activities that could not be carried out at the power levels in Phase C.

System baseline data from past commissioning activities should be referenced if available, or new baseline data is established. This may include inaugural and baseline inspections of existing and newly installed systems, structures, and components. In addition, the licensee is expected to define the acceptance criteria for the commissioning tests.

8.2 Milestones

Return to service is achieved through the accomplishment of numerous milestones. Milestones that might be reflected in the return to service stage of a life extension project include:

1. Loading fuel;
2. Removing the guaranteed shutdown state;
3. Heat transport operation;
4. Turbine operation;
5. Turbine synchronization to the grid;
6. Full reactor power; and
7. Specific commissioning tests.

8.3 Hold Points

The process of returning to service includes progressing to regulatory hold points. These hold points are typically aligned with commissioning phases, and may include the milestones listed above. Licence conditions are established for the administration of the hold points, which are then incorporated by the licensee in the *Return to Service Plan*.

Commission approval to remove a given hold point is contingent on licensee submission of a *Completion Assurance Document*. This document presents evidence that all project commitments scheduled for completion prior to removal of the respective hold point have been met. The *Completion Assurance Document* must be accepted by the Commission before authorization to remove the hold point can be issued.

8.4 Return to Normal Operation

Once all Commission approvals have been granted and hold points have been removed, the licensee proceeds to normal operation.

9.0 FOLLOW UP

The licensee will be expected to monitor the adequacy of plant performance and new or updated programs after return to service.

GLOSSARY

Design basis

The range of conditions and events taken into account in the design of the facility, according to established criteria, such that the facility can withstand them without exceeding authorized limits for the planned operation of safety systems.

Design life

The period specified for the safe operation of the facility, systems, structures, and components.

Environmental assessment

An assessment of the environmental effects of the project conducted in accordance with the CEAA and its regulations.

Generic action item

Unresolved safety-related issues that have been singled out by the Commission as requiring corrective actions to be taken by the licensees within a reasonable time frame.

Guaranteed shutdown state (GSS)

A set of conditions that provide sufficient guarantee that the reactor will remain in the shutdown state despite any credible failure.

Hold points

Specific milestones that are built into the commissioning plan to separate critical phases during commissioning, and to allow for regulatory review before transition between phases. Hold points further enable verification of the resolution of issues so that proceeding to the next stage will not pose unreasonable risk to health, safety, security, or the environment.

Integrated safety review (ISR)

A comprehensive assessment of plant design and operation performed in accordance with the IAEA's *Periodic Safety Review of Nuclear Power Plants – Safety Guide*.

Licensing basis

Includes the design basis, and is the set of information that demonstrates that:

1. The facility meets all applicable regulatory and safety requirements, and
2. The applicant and licensee are qualified and have made adequate provisions for safe facility operation.

Life extension

Extending the safe operating life of a nuclear power plant beyond its design life. It involves the replacement or refurbishment of major components, or substantial modifications to the plant, or both.

Modern standards

The set of high-level objectives and requirements for the siting, design, construction, commissioning, operation and decommissioning of a nuclear power plant if it were to be built at the time of the initiation of the life extension project.

Nuclear power plant

Any fission reactor installation constructed to generate electricity on a commercial scale. A nuclear power plant is a Class IA nuclear facility, as defined in the *Class I Nuclear Facilities Regulations*.

Practices

The information contained in modern industrial standards, codes, and practices directly associated with the modern standards. Guidelines should take into account operating experience and findings from technical developments (e.g., new knowledge on the cumulative effects of ageing, results of reactor physics research and development, human factors engineering, human reliability, software engineering).

Prescribed

Means prescribed by federal regulations.

Refurbishment

An activity or a set of activities aimed at restoring the condition of one or several systems to a state that is comparable to the condition of a new system.

ASSOCIATED DOCUMENTS

1. *Nuclear Safety and Control Act*, S.C. 1997, c. 9;
2. *Packaging and Transport of Nuclear Substances Regulations*, SOR/2000-208, May 2000;
3. *Radiation Protection Regulations*, SOR/2000-203, May 2000;
4. *Nuclear Security Regulations*, SOR/2000-209, May 2000;
5. *Nuclear Non-proliferation Import and Export Control Regulations*, SOR/2000-210, May 2000;
6. *Nuclear Substances and Radiation Devices Regulations*, SOR/2000-207, May 2000;
7. *Canadian Nuclear Safety Commission Rules of Procedure*, SOR/2000-211, May 2000;
8. CNSC Regulatory Standard S-99, *Reporting Requirements for Operating Nuclear Power Plants*, March 2003;
9. CNSC Regulatory Policy P-242, *Considering Cost-benefit Information*, October 2000;
10. *Canadian Nuclear Safety Commission - Guidelines for Environmental Assessment pursuant to the requirements of the Canadian Environmental Assessment Act*, Revision 2, December 2004;
11. *Nuclear Liability Act*, R.S.C., 1985, c. N-28;
12. *Canadian Environmental Assessment Act*, S.C. 1992, c. 37;
13. *CEAA Exclusion List Regulations*, SOR/94-639;
14. *CEAA Inclusion List Regulations*, SOR/94-637
15. *CEAA Comprehensive Study List Regulations*, SOR/94-638;
16. *Procedures for an Assessment by a Review Panel*, guidelines issued pursuant to the CEAA, November 1997;
17. *Preparing Project Descriptions under the Canadian Environmental Assessment Act*, Canadian Environmental Assessment Agency, August 2000;
18. *CEAA Law List Regulations*, SOR/94-636, October 1994;
19. *Canadian Environmental Protection Act*, S.C. 1999, c. 33;
20. *Nuclear Fuel Waste Act*, S.C. 2002, c. 23;

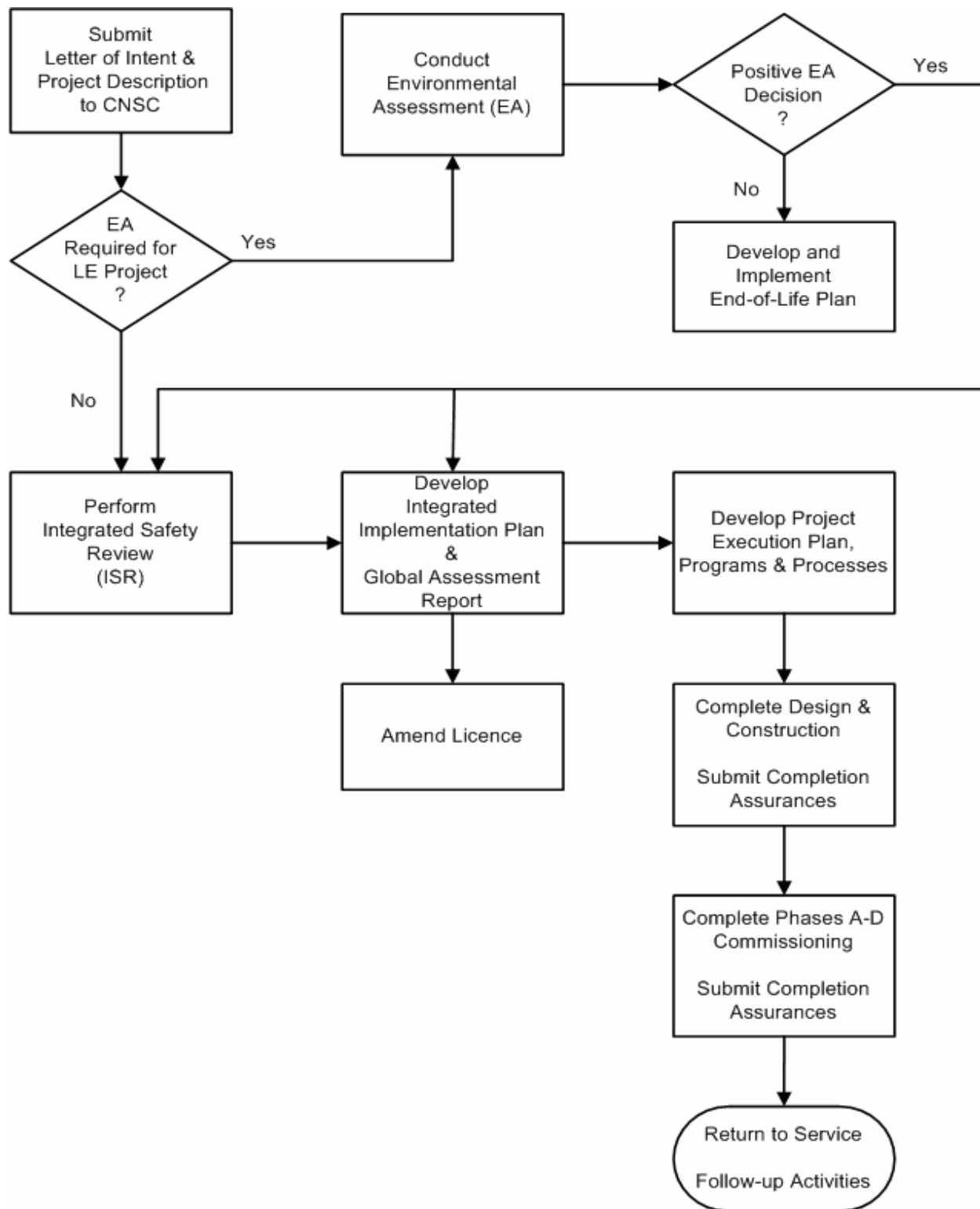
21. *Fisheries Act*, R.S.C., 1985, c. F-14;
22. *Species at Risk Act*, S.C. 2002, c. 29;
23. *Migratory Birds Convention Act*, S.C. 1994, c. 22;
24. *Canada Water Act*, R.S.C., 1985, c. C-11; and
25. *Periodic Safety Review of Nuclear Power Plants—Safety Guide*, Safety Standards Series No. NS-G-2.10, IAEA, Vienna, 2003.

APPENDIX A

CNSC SAFETY AREAS AND PROGRAMS

CNSC Safety Areas	CNSC Programs
1. Operating Performance	1. Organization and Plant Management 2. Operations 3. Occupational Health and Safety (non-radiological)
2. Performance Assurance	1. Quality Management 2. Human Factors 3. Training
3. Design and Analysis	1. Safety Analysis 2. Safety Issues 3. Design
4. Equipment Fitness for Service	1. Maintenance 2. Structural Integrity 3. Reliability 4 Equipment Qualification
5. Emergency Preparedness	1. Emergency Preparedness
6. Environmental Performance	1. Environmental Protection Systems 2. Effluent and Environmental Monitoring
7. Radiation Protection	1. Personnel Exposure 2. Plant Waste Management
8. Site Security	1. Site Security
9. Safeguards	1. Safeguards

APPENDIX B LIFE EXTENSION PROCESS DIAGRAM



COSTS OF ENVIRONMENTAL ASSESSMENT FOLLOW-UP STUDIES

In its decision in EB-2013-0321, the OEB required OPG to file at its next proceeding updates of actual costs of Environmental Assessment (“EA”) follow-up studies.¹ Actual costs related to the environmental studies, monitoring and adaptive management projects required by the Darlington Refurbishment Program EA and follow-up program are provided in Chart A-1 below. There are no adaptive management programs at this stage of the program. They will be developed, if needed, based on the results of initial monitoring studies. It is important to note that these costs are not all for DRP and that these do not reflect all EA costs for the DRP.

Chart A-1

Actual Costs of EA Follow-up Studies

Project Work Package Description		Actual Spent		
		2013	2014	2015
EA Follow-up Studies	Effluent Characterization	\$0 K	\$5 K	\$7 K
	Fisheries Authorization	\$0 K	\$25 K	\$0 K
	Entrainment Study	\$0 K	\$25 K	\$198 K
	Benthic Invertebrate Community Study	\$0 K	\$25 K	\$0 K
	Thermal Monitoring	\$0 K	\$20 K	\$0 K
	Stormwater Control Study	\$0 K	\$0 K	\$0 K
Environmental Monitoring Studies	Groundwater monitoring, sampling and analysis for chemical waste, groundwater wells	\$170 K	\$270 K	\$370 K
	Biodiversity studies and monitoring	\$40 K	\$50 K	\$50 K
	Chemistry laboratory cost for supporting environmental monitoring ²	\$3.1 M	\$3.1 M	\$3.2 M
	Stack and filter testing emission verification	\$285 K	\$190 K	\$160 K
	Radiological Environmental Monitoring Program	\$150 K	\$260 K	\$160 K
Adaptive Management Projects		\$0 K	\$0 K	\$0 K

¹ EB-2013-0321, Decision with Reasons, November 20, 2014, p. 55.

² Chemistry laboratory costs include both environmental monitoring costs and station chemistry control costs. The value in the chart represents 50 per cent of chemistry laboratory costs as an approximation of the costs associated with environmental monitoring.