Canadian Nuclear Safety Commission
Commission canadienne de sûreté nucléaire

CMD 18-H4.1

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Written submission from Bruce Power Inc.

Mémoire de Bruce Power Inc.

In the Matter of

À l'égard de

Bruce Power Inc. – Bruce A and B Nuclear Generating Station

Bruce Power Inc. - Centrale nucléaire de Bruce A et Bruce B

Request for a ten-year renewal of its Nuclear Power Reactor Operating Licence for the Bruce A and B Nuclear Generating Station

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

Commission Public Hearing – Part 1

Audience publique de la Commission – Partie 1

March 14, 2018

Le 14 mars 2018

Bruce Power

February 12, 2018

NK21-CORR-00531-14126
NK29-CORR-00531-14817
NK37-CORR-00531-02906

Mr. M. Leblanc
Commission Secretary
Canadian Nuclear Safety Commission
P.O. Box 1046
280 Slater Street
Ottawa, Ontario
K1P 5S9

Dear Mr. Leblanc:

Application for
the Renewal of the Power Reactor Operating Licence: Supplemental Material

The purpose of this letter is to:

- submit a statement of Bruce Power's intention to appear at public hearing 2018-H-02, pursuant to the CNSC Rules of Procedure, Section 18(1)(a); and,
- file the written submission for the March 14, 2018 Part-1 public hearing 2018-H-02, pursuant to the CNSC Rules of Procedure, Section 18(1) and in accordance with Reference 1.

Bruce Power plans to appear at public hearing 2018-H-02, to be held March 14, 2018 (Part 1) in Ottawa and May 30-31, 2018 (Part 2) in the vicinity of the Bruce site.

Additionally, Bruce Power has prepared supplementary material to support the Commission with respect to this hearing. This supplementary material includes updates on items believed to be of interest to the Commission, as provided in Attachment A, as well as an update to the Performance Review, provided in Attachment B. To assist the Commission in reviewing the update, a copy of the Performance Review as originally submitted has been appended as Enclosure 1.

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If you require further information or have any questions regarding this submission, please contact Mr. Maury Burton, Department Manager, Nuclear Regulatory Affairs, at 519-361-2673 extension 15291, or maury.burton@brucepower.com.

Yours truly,

Frank Saunders
Vice President Nuclear Oversight and Regulatory Affairs
Bruce Power

cc: CNSC Bruce Site Office (Letter only)
G. Frappier, CNSC - Ottawa
L. Sigouin, CNSC - Ottawa

Attach.
Encl.

References:

1. Letter, L. Levert to F. Saunders, "Application for the Renewal of the Power Reactor Operating Licence Number 18.00/2020 (PROL) for the Bruce Nuclear Generating Station", August 3, 2017, E-DOC#5298515, NK21-CORR-00531-13758 / NK29-CORR-00531-14417 / NK37-CORR-00531-02823.
2. Letter, F. Saunders to M. Leblanc, "Application for the renewal of the Power Reactor Operating Licence", June 30, 2017, NK21-CORR-00531-13493 / NK29-CORR-00531-14085 / NK37-CORR-00531-02768.

Attachment A

Application for the Renewal of PROL 18.00/2020: Supplemental Material

NK21-CORR-00531-14126
NK29-CORR-00531-14817
NK37-CORR-00531-02906

APPLICATION FOR RENEWAL OF PROL 18.00/2020: SUPPLEMENTAL MATERIAL

January 2018

Table of Contents

1.0 INTRODUCTION

This supplemental submission has been prepared to summarize some of the detailed information provided in earlier submissions and to provide updates on selected items of interest to the Commission, in order to support Bruce Power's application for renewal of the Power Reactor Operating Licence (Reference A1).

2.0 BUSINESS PLAN (2018-2028)

Bruce Power will continue to maintain the plant so as to ensure safe and reliable plant operation. System, structure, and component monitoring focuses on ensuring those systems, structures, and components are performing as required and that repairs are completed in a timely manner. Life cycle management plans focus on the long-term health of systems, structures, and components and ensures that required larger maintenance and replacement activities are accurately forecasted and planned. This is more generally referred to as asset management. The Major Component Replacement (MCR) program is a portion of the life cycle management program that deals with maintenance or replacement of components requiring outages greater than six months to complete.

Over the next 10-year period of the proposed operating licence, MCR activities will be completed on three of 6 units, and will be in progress on two additional units. This will build on work as part of Bruce Power's overall life extension program, which is currently underway and commenced on January 1, 2016.

A long-term agreement to provide Ontario with reliable baseload electricity to 2064 was established in December 2015 providing a commercial framework for the company to advance this work consistent with Ontario's Long Term Energy Plan (LTEP). In order to ensure safe, reliable operation of the reactor units to 2064, MCR activities will be required for Bruce A (Units 3 and 4) and Bruce B (Units 5 through 8). MCR outages will begin in 2020 with Unit 6 and will continue through 2033 (see Figure 1). MCR outages are in addition to a range of other ongoing investments in the facility, which overall comprise of a $13 Billion ($2014) Life Extension program.

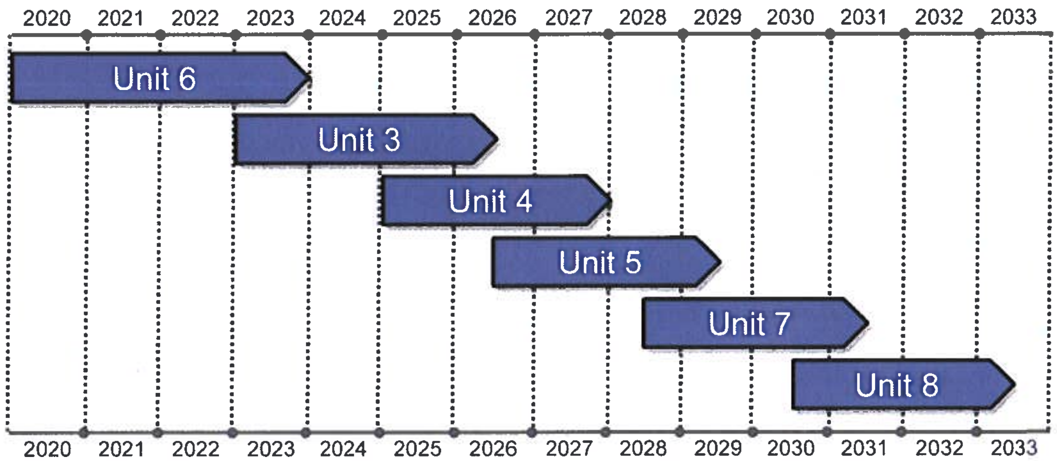


Figure 1. Planned schedule for Life Extension Outages (subject to change)

Overall, the MCR program has the following goals:

- Maintain existing assets and operations to ensure continued protection of the public and environment;
- Maintain safe operation and ensure that, following MCR, units have the equal or improved margin of safety;
- Meet Ontario's long-term energy supply mix requirements, as outlined in the Long-Term Energy Plan;
- Provide clean energy to Ontario to help achieve Climate Change Action Plan goals;
- Ensure a safe and reliable operational life of Units 3-8 to 2064;
- Sustain direct and indirect employment opportunities in order to effectively sequence work.

In addition to MCR, asset management activities will continue in a planned way to support safe and reliable operation. These activities have been underway since January 1, 2016. Asset management activities will be planned and completed during various outages including outages scheduled before, during, or after the MCR outage for each respective unit.

Bruce Power has and will continue over the 2018-2028 period to invest in improvement efforts including:

- Site infrastructure, Fukushima response, security, fire protection, and preparations for increased construction activities;
- Continuous improvement, including initiatives to maximize equipment reliability, to sustain industry top-quartile operating performance, and to safely complete outages on budget and schedule;

- Enhancements that deliver improved project management, to safely deliver high-quality projects on time and on budget; and,

- Monitoring the health of critical positions and management of resource pipelines through robust succession planning and leadership development programs.

- Foster strong support from the region around the site, including Indigenous communities, through a range of programs in place related to Corporate Social Responsibility, Economic Development and Community Outreach/Communications;

- Promote innovation and collaboration with the community, suppliers, unions, and industry partners to find new ways to improve operations and to deliver activities safely, with no consequential human performance errors; and,

- Work in partnership with Ontario Power Generation, allowing both organizations the opportunity to leverage experience in operations, refurbishment, and advocacy.

Having returned the Bruce site to eight-unit operation after completing major component replacement for Units 1 and 2, Bruce Power is now focused on work required to ensure safe and reliable operation of Units 3-8 to 2064.

Through many maintenance outages since 2001, Bruce Power has successfully carried out hundreds of thousands of tasks and investment programs, resulting in industry-leading success, both in improving the performance of the Bruce Power units and in extending their operational lives. Over the last five years (2013-2017), Bruce Power invested $1.9 billion in a range of nuclear and non-nuclear systems in each unit, such as:

- Bruce A and Bruce B Primary Heat Transport pump motor refurbishment (in progress),

- Bruce B Condenser Steam Discharge Valve overhaul and actuator upgrades (2016-2017),

- Bruce B generator rotor rewinds (2015-2017),

- Bruce A Unit 2 generator stator and rotor rewind (2016),

- Bruce A Unit 3 and 4 Main Output Transformer replacements (2014-2015),

- Bruce A Low Pressure Turbine replacements (completed 2016),

- Bruce A Instrument Air Compressor replacement (completed 2017),

- Bruce B Main Boiler Feed Pump refurbishments/replacements (completed 2017),

- Bruce A and Bruce B Safety System Monitoring Computer replacements (in progress), and,

- Bruce B Fuel Handling Inverter replacements (completed 2016).

In addition, Bruce Power has invested approximately $400 million in preparation for the MCR program on Unit 6 in 2016 and 2017, and by the end of 2018 will have invested $800 million.

This is in addition to approximately $800 million invested in 2016 and 2017 as part of Asset Management and ongoing capital programs consistent with the Life Extension program.

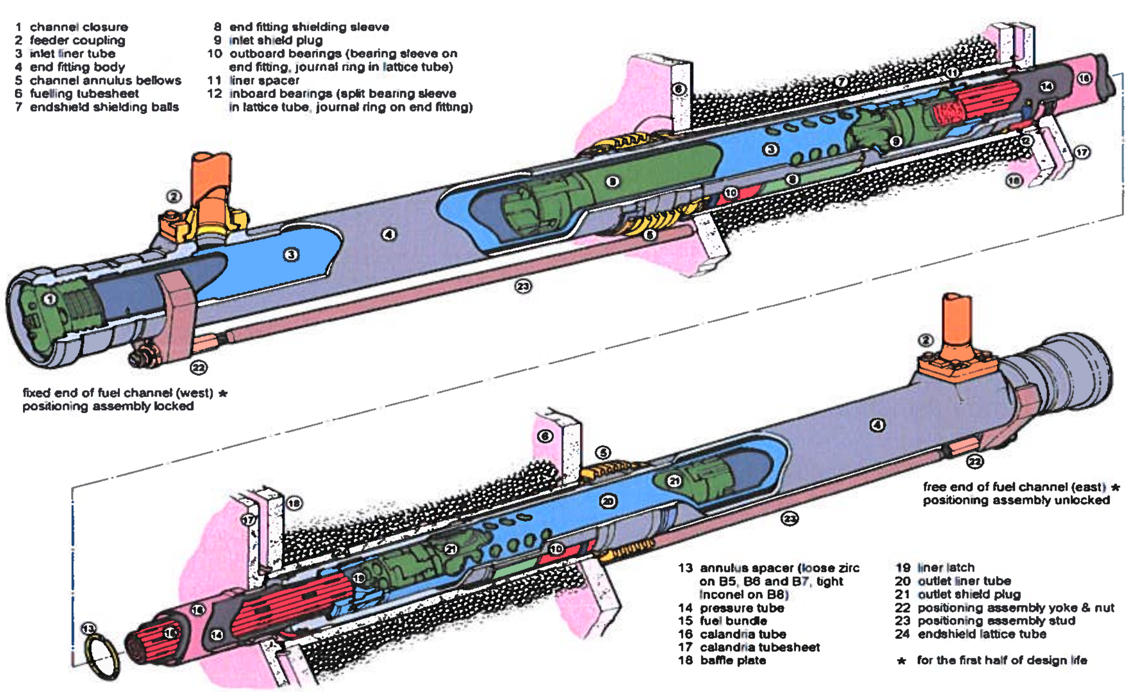
Over the period 2018-2028, Bruce Power is expecting to spend $12.8 billion on the total scope of asset management and ongoing capital investment programs, including MCR. These investments will ensure the units continue to operate safely and reliably over the licensing period and will set the foundation for many years of successful operation.

3.0 FITNESS FOR SERVICE OF PRESSURE TUBES

The fitness-for-service of fuel channel assemblies (Figure 2) was discussed in References A1 and A3. In this section, the information previously provided to the Commission has been summarized and updated to provide a current overview of fitness-for-service with respect to pressure tubes.

At this time, operation of the fuel channels beyond 247,000 Equivalent Full Power Hours (EFPH) is not permitted without Commission approval. Bruce Power has submitted a request and technical basis for approval to operate to 300,000 EFPH (Reference A3).

Bruce Power communicates regularly with CNSC staff, through semi-annual updates and industry meetings, regarding fitness-for-service of the pressure tubes. Information with respect to key aspects of fuel channel life management will continue to be provided to the CNSC as part of requirements defined by relevant CSA standards, Integrated Implementation Plan commitments and reports (Reference A4), and as indicated in the Licence Conditions Handbook.



Bruce B Fuel Channel Assembly

Figure 2. Fuel channel assemblies (Bruce B)

3.1 Asset Management

Bruce Power's Equipment Reliability business program includes the implementation of life cycle management plans (LCMPs) for major assets. LCMPs include long-term maintenance plans and are developed based on a sound understanding of aging mechanisms, with information incorporated from inspection results, internal and external operating experience, research programs, and joint industry projects.

Bruce Power uses LCMPs to manage aging, proactively, throughout the lifecycle of a particular asset. LCMPs are used to develop operating scenarios and to support strategic business planning. Accordingly, Bruce Power maintains its commitment to the safety of persons and the environment, while implementing efficient and economic business plans.

Bruce Power's LCMP for fuel channel assemblies includes the following information:

- Detailed description of aging on elements of the fuel channel assemblies (see additional information provided in Section 3.2);
- Predictions of time for the first fuel channel in each unit to reach specified criteria; and,
- Inspection and maintenance activities on a unit-by-unit and year-by-year basis to the planned replacement date for the fuel channel assemblies in the MCR schedule (see additional information provided in Section 3.3).

In addition to ongoing inspections, the LCMP for fuel channel assemblies is supported through extensive research and joint industry projects that are addressing a variety of aging mechanisms with respect to key components of the fuel channel assemblies. In this update, we highlight the "burst test" program, in which pressure tubes are tested to provide data for ongoing model validation and continued fitness-for-service (see Section 3.4).

3.2 Aging of pressure tubes

The fuel channel component most affected by operational conditions is the pressure tube.

During operation, pressure tubes experience high temperature, high pressure, neutron irradiation, corrosion, material wear, and uptake of deuterium. These stressors cause changes in the dimensions and properties of the pressure tubes, as summarized in Table 1.

Increased deuterium concentrations reduce fracture toughness over time which results in increased susceptibility for crack initiation.

The primary objectives with respect to pressure tube fitness for service is demonstration that the degradation mechanisms are well understood, pressure tubes are periodically monitored, and any changes are predicted with sound engineering models and analytical tools. Fitness-for-service evaluation also includes defense-in-depth evaluation of leak-before-break in the unlikely event that a through-wall penetration occurs in the pressure tube. (Under this scenario, leakage would be detected, and the reactor would be shutdown as per operating procedures.)

The latest projections (prepared in January 2018) of deuterium uptake, in terms of hydrogen equivalent concentration, [H_{eq}], are provided in Table 2. In order to demonstrate fitness-for-service of the pressure tubes until the target operating life, Bruce Power and the nuclear industry has developed fracture toughness models as discussed in Section 3.4.

Table 1. Primary degradation mechanisms, results, and approach to ensuring fitness-for-service for pressure tubes

Degradation mechanism	Result	Approach to ensuring fitness-for-service
Uptake of deuterium	Reduction of fracture toughness and flaw tolerance; increased susceptibility to crack initiation	Flaw assessments, probabilistic core assessments for flaws and leak-before-break; evaluations of protection against fracture. Monitor deuterium uptake through scrape sampling; validate models to predict hydrogen equivalent concentrations.
Material wear (passage of fuel bundle bearing pads, trapped debris)	Fretting, crevice corrosion	Detection of flaws with ultrasound to monitor local stress concentrators and to prevent crack initiation. If necessary, remove tube.
Neutron irradiation	Deformation	
	• Pressure tube axial elongation (fuel channel moves off-bearing)	• Monitor fuel channel positions, and update models of elongation. If necessary, shift, reconfigure, and defuel fuel channels to ensure on-bearing operation.
	• Pressure tube sag (reduced pressure tube to calandria tube gap; reduced calandria tube to liquid injection shutdown nozzle gap)	• Monitor pressure tube sag and gaps. If necessary, address and prevent contact through repositioning spacers and gap measurements.
	• Pressure tube diametral expansion	• Monitor diameter with ultrasound; determine rates of expansion and compare with design value. Monitor fuel bundle flow by-pass against design limit.
	• Pressure tube wall thinning (does not limit the operational life of pressure tubes)	• Monitor wall thickness with ultrasound; determine wall thinning rates and compare with design value.

Table 2. MCR outage date, target operating life (EFPH), and projected maximum [H_{eq}] at the outlet rolled joint region for Bruce units 3-8.

Unit(s)	MCR outage date	Projected operating life	Maximum [H_{eq}]
3	2023	245,000 EFPH	102 ppm
4	2025	255,000 EFPH	104 ppm
5	2026	300,000 EFPH	151 ppm
6	2020	245,000 EFPH	121 ppm
7	2028	300,000 EFPH	147 ppm
8	2030	300,000 EFPH	139 ppm

Note: projections of [H_{eq}] were made for each individual fuel channel assembly, based on the temperature and pressure in that channel.

3.3 Demonstrating Fitness-for-Service

Pressure tube fitness-for-service is demonstrated primarily through periodic inspections, in accordance with the life cycle management plan, that meet or exceed the requirements of CSA N285.4-09, Update 2, *Periodic inspection of CANDU nuclear power plant components*. CSA N285.4 requires both in-service periodic inspections as well as the periodic removal of pressure tubes to perform direct measurements of material properties (i.e., material surveillance).

If inspection results do not satisfy the conservative (unconditional) acceptance criteria of CSA N285.4, Bruce Power applies evaluations and dispositions (Reference A2) to meet the acceptance criteria of CSA N285.8, *Technical requirements for in-service evaluation of zirconium alloy pressure tubes in CANDU reactors* (see Table 3). Dispositions may include corrective actions or further targeted monitoring. Dispositions must be accepted by the CNSC prior to operation.

These inspections and dispositions ensure that cracks in the pressure tubes do not occur.

As further defense-in-depth, additional assessments are performed to ensure a low probability of pressure tube rupture, even in the unlikely event of crack initiation. Key evaluations and assessments required by N285.8 are summarized in Table 3.

Table 3. Key evaluations and assessments, as per CSA N285.8

Items to be evaluated/assessed	Evaluation/assessment
Detected flaws	Evaluations of crack initiation from flaws due to delayed hydride cracking, fatigue, and hydrided region overload condition (demonstrates that the flaw will not initiate a crack).
Pressure tube to calandria tube contact	Probabilistic pressure tube to calandria tube contact assessment: ensures that pressure tube blisters do not crack.
Reactor core	• Fracture protection assessment: evaluation of hypothetical undetected flaw or penetration (ensuring that the undetected flaw does not lead to a pressure tube rupture). Deterministic fracture protection assessments are currently used. Bruce Power and its nuclear industry partners are working to obtain CNSC acceptance of the methodology to perform probabilistic fracture protection assessments. Probabilistic fracture protection assessments maintain the design intent but will reduce unnecessary constraints on the operating pressure-temperature envelope. • Probabilistic core assessment: assesses integrity of pressure tubes in entire reactor core (demonstrates very low probability of pressure tube rupture); provided to CNSC staff for informational purposes. Updated on a 3-year cycle. • Leak-before-break assessment: demonstrates safe operation even in the unlikely event of through-wall crack penetration. Provides assurance that pressure tubes will not fail without prior detection of a leak. Currently this is a probabilistic assessment.
Material surveillance	Obtains pressure tube material parameters (i.e., fracture toughness): used as inputs for fitness-for-service and reactor core assessments

3.4 Fracture toughness models

Bruce Power uses fracture toughness models, summarized in Table 4, to demonstrate that the pressure tubes are safe to operate and meet the design intent to support safe operation now and into the future. These fracture toughness models are key inputs into the leak-before-break and fracture protection assessments, which demonstrate the safe operation of pressure tubes in the unlikely event of a through-wall crack penetration.

Table 4. Description of fracture toughness models

Fracture toughness model	Description
Upper shelf temperature region	Upper shelf temperature region (near or above 250°C, which is the predominant mode of operation)
Cohesive-zone model	Transition temperature region (below 250°C, which is a mode of operation with very limited duration)

The fracture toughness models are valid for their intended use. Since 2014, Bruce Power and the nuclear industry have completed significant analysis and testing activities in order to demonstrate the validity of the assumptions of the models and to demonstrate experimental fracture toughness is bounded by the results of the models. Updates are provided regularly to CNSC staff.

Additionally, the fracture toughness models were reviewed by two independent third-party reviewers, who concluded that the models were adequate for engineering applications with recommendations. These recommendations included performing additional R&D work to better improve understanding of the underlying physical behavior of the pressure tube material and to better understand the effect of the experimental apparatus on the test results.

At the request of CNSC staff, Bruce Power has requested an update from one of the third-party reviewers. The reviewer is satisfied with the work completed to date but has provided additional recommendations, which are currently being addressed. Bruce Power plans to provide an update to CNSC staff by the end of June.

Bruce Power has undertaken an enhanced uncertainty analysis of the cohesive-zone fracture toughness model, in accordance with CSA N285.8-15, Update 1, *Technical Requirements for In-Service Evaluation of Zirconium Alloy Pressure Tubes in CANDU Reactors*. The uncertainty analysis will provide insight into influential model parameters and may provide insight into further refinement of the burst test R&D program. The uncertainty analysis will be provided to CNSC staff near the end of 2018.

3.5 Ongoing research program (burst tests)

Fracture toughness models are validated with rising pressure "burst" tests, in which pressure tube segments are tested to failure. These tests are conducted on "as received" pressure tubes removed from operating units, as well as on irradiated pressure tubes with artificially-added levels of hydrogen uptake.

Pressure tube burst tests require artificial hydriding processes, specialized test rigs and procedures, qualified personnel, and hot-cell facilities. Currently, industry capability to perform hydrided burst tests is available at Canadian Nuclear Laboratories (CNL) in Chalk River.

The main objective of the burst test program to provide additional data in order to quantify fracture toughness with increased hydrogen concentration. The resulting data is used to verify the validity of fracture toughness models and provides the means for Bruce Power to evaluate fitness-for-service of pressure tubes at higher hydrogen concentrations.

Detailed technical information was provided to the Commission in Reference A3. In past years (2016 and earlier), burst tests were conducted on pressure tubes with artificial hydrogen concentrations up to 126 ppm. However, Bruce tubes are predicted to have hydrogen equivalent concentrations (at a small region of the outlet of the pressure tube) of 120 ppm (or greater) at the time the unit is take out of service for MCR work. Based on the latest channel-specific predictions, some of these are expected to have hydrogen equivalent concentrations up to approximately 150 ppm at the MCR date (see Table 2).

In order to support operating in the short term beyond 126 ppm, and in the long-term to 150 ppm, it is necessary to conduct pressure tube burst tests with artificial hydrogen equivalent concentrations up to concentrations expected at the MCR date.

In 2016 and 2017, two burst tests were completed with high hydrogen equivalent concentrations at 144 ppm and 204 ppm, respectively, yielding results consistent with the predictions from the fracture toughness model. These tests demonstrate adequate fracture toughness of pressure tubes at normal operating conditions and at hydrogen equivalent concentrations that are well above that expected for Bruce tubes at the MCR date for each unit.

Burst tests are planned through 2022 and may be planned for 2023 and beyond, following evaluation of the test results. A summary of the planned burst tests is provided in Table 5; the detailed test plan was provided in Reference A3. In the short-term (2018-2020), burst tests will primarily focus on lower hydrogen equivalent concentrations, to improve the understanding of the effects of chlorine and oriented hydrides on fracture toughness at the inlet (front end) section of the pressure tube. While some tests will continue to be conducted at higher hydrogen equivalent concentrations (160 ppm), most of these tests will take place in 2021 or 2022.

It is important to note that the burst test program is not the only research program that supports validation of the fracture toughness models. An extensive suite of experimental and analytical R&D is underway, and updates are provided to the CNSC regularly (Reference A5).

Table 5. Summary of planned burst tests (2017-2022)

Target hydrogen concentration	Primary goal
160 ppm	Evaluate fracture toughness at replacement date for Bruce tubes (additional tests needed to address tube-to-tube variability)
60-70 ppm	Evaluate effect of chlorine and orientation of deposited hydrides (most relevant for lower [H_{eq}] concentrations at the inlet or front endsection)
As received	Evaluate baseline fracture toughness in tubes removed from operating reactors

3.6 Conclusion

It is important to note that fitness-for-service of pressure tubes is verified <u>every</u> maintenance outage through appropriate inspections. Inspection results must satisfy acceptance criteria or be dispositioned in accordance with CSA standards. Additionally, Bruce Power has robust processes to address relevant operating experience that could impact fuel channel fitness-for service or plant operability.

Additionally, Bruce Power has a validated model for fracture toughness, which is used as an input into assessments used to support safe operation. This model is continuing to be further validated through experimental R&D and the burst test program.

Accordingly, Bruce Power has demonstrated fitness-for-service of the pressure tubes and Bruce Power will continue to demonstrate fitness-for-service on an ongoing basis (up to 300,000 EFPH).

4.0 PROBABILISTIC SAFETY ASSESSMENT (WHOLE-SITE RISK)

Detailed information with respect to probabilistic safety assessments (PSA; also known as probabilistic risk assessment) was provided in the Performance Review (Reference A1). Additional information on the history and purpose of the probabilistic safety assessment is provided below, and results previously shown in the Performance Review are reproduced here for convenience.

4.1 History, present, and future of the PSA

Since its beginning in 2001, Bruce Power has utilized the PSA to monitor plant risk, optimize maintenance practices, and maximize the reliability of systems, structures, and components.

The initial focus of PSA development included models for internal events during at-power and outage states; this included consideration of multi-unit impacts. These models were used with software tools to determine risks for at-power and outage plant configurations and to perform "what-if" assessments for design and operational changes.

Unavailability models were also developed for systems important to safety in order to assess system reliability and to optimize testing and maintenance.

The CNSC issued S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*, in 2005. S-294 provided regulatory requirements to consider internal and external events, at-power and outage states, and releases from the plant (known as a Level 2 PSA). Methodologies and tools were developed to address these requirements. PSA models for internal events, internal fires, internal floods, high winds, and seismic events were developed and updated; additional internal and external events were assessed and screened.

Although the potential for an initiating event and for additional failures to affect more than one reactor unit was already explicitly accounted for in the PSA, the results are expressed on a per-reactor basis.

In response to the Fukushima event, the CNSC issued REGDOC-2.4.2, *Safety Analysis: Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*. Accordingly, Bruce Power worked closely with industry and international organizations in order to develop appropriate methodology, which includes appropriate aggregation of PSA impacts across a four-unit station.

With the update of PSA models to comply with REGDOC-2.4.2 requirements, there is an opportunity to further integrate PSA capability into operations and maintenance activities. The risk summary information can be used to identify potential risks when planning work, and then efforts can be taken to further reduce these risks (where practicable). Bruce Power is working with its industry partners, through COG, to develop the required guidelines and tools for enhanced operational decision making.

Recently Bruce Power utilized the consequence analysis performed in support of Level 2 PSA to set the scope, to categorize releases, and to familiarize staff involved with the development and use of the plume dispersion modelling software discussed in the Performance Review (Reference A1, Attachment B, Section 15.15.3). This emergency response projection tool is used to assist in making recommendations for the protection of the public in the event of possible releases from the site during an accident.

Going forward, the PSAs will be updated on a 5-year cycle in accordance with REGDOC-3.1.1. The installation of a passive Containment Filtered Venting System (CFVS) will positively impact the PSA results. Analyses will be undertaken to quantify the impact once the final system design is complete. In general, the CFVS system will reduce the predicted quantity of radioactive releases in any circumstance where containment failure is currently a factor.

4.2 Results

The PSA results for internal and external hazards are shown in Table 6. These results include some credit for Emergency Mitigating Equipment (EME) installed, or scheduled for installation in the near future, in response to the Fukushima event.

The Bruce Power safety goals were met for each of the Bruce A and Bruce B PSAs; for additional details, see the Performance Review (Reference A1).

The single-unit and station aggregation results for Bruce A and Bruce B are shown in Figure 3 and Table 7 (as previously provided in the Performance Review). These results also include a conservative credit for the CFVS, which will maintain containment pressure below the containment failure pressure and will filter radioactive releases for certain accident scenarios (the CFVS is discussed further in Section 5.1, as well as in the Performance Review, Reference A1, Attachment B, Section 15.14.8).

The results show that the overall risk is dominated by the Fire PSA results. However, no singular risk-dominant fire sequences were identified for mitigation.

Additional information was provided in the Performance Review.

Table 6. PSA results for internal and external hazards

	Severe Core Damage Frequency[1]			Large Release Frequency[1]		
Event	**Safety goal**	**Bruce A**	**Bruce B**	**Safety goal**	**Bruce A**	**Bruce B**
Internal						
At power[2]	1.0×10^{-4}	3.8×10^{-6}	5.2×10^{-6}	1.0×10^{-5}	1.5×10^{-6}	6.9×10^{-7}
During shutdown	1.0×10^{-4}	1.3×10^{-5}	8.3×10^{-6}	1.0×10^{-5}	-	-
Internal flood[2]	1.0×10^{-4}	5.5×10^{-7}	4.6×10^{-7}	1.0×10^{-5}	-	-
Internal fire[2]	1.0×10^{-4}	8.7×10^{-6}	4.1×10^{-6}	1.0×10^{-5}	7.3×10^{-6}	8.7×10^{-7}
External						
Seismic[2,3]	1.0×10^{-4}	1.7×10^{-6}	7.2×10^{-7}	1.0×10^{-5}	1.7×10^{-6}	7.2×10^{-7}
High winds[2,3]	1.0×10^{-4}	4.8×10^{-6}	6.2×10^{-6}	1.0×10^{-5}	4.8×10^{-6}	6.2×10^{-6}

Note 1: per reactor per year.
Note 2: includes some credit for Emergency Mitigating Equipment
Note 3: up to a 1-in-10,000-year event

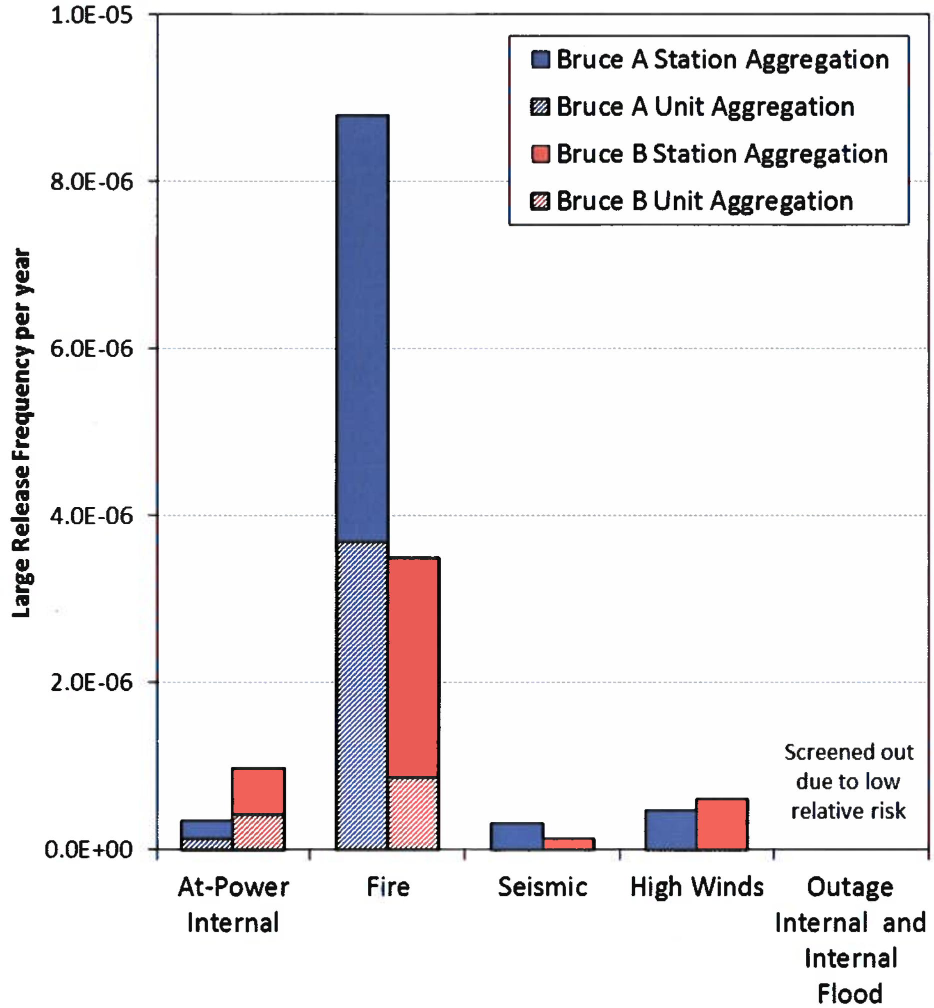


Figure 3. Bruce A and Bruce B PSA results for Large Release Frequency. Modeling is realistic for At-Power Internal and conservative for Fire, Seismic, and High Winds. Uncertainty is low for At-Power Internal and Moderate for Fire, Seismic, and High Winds.

Table 7. Multi-unit aggregation of PSA Large Release Frequency results

Purpose

The purpose is to summarize the safety assessment based on the Large Release Frequency for each of Bruce A and Bruce B, defined as the frequency of accidents causing a release to the environment greater than 10^{14} Bq of Cesium-137.

Parametric uncertainty	Modeling uncertainty	Completeness uncertainty
• Mean values represented in results	• Low uncertainty for internal failures at power and during outage • Conservative assumptions for fire initiating events • Conservative modeling for external hazards seismic and high winds	• Comprehensive scope/screening of internal and external reactor hazards. PSA performed for hazards not screened out. • External hazards cutoff frequency $1x10^{-4}$ per year. Margins assessed for lower frequency events. • Spent fuel events addressed deterministically and in the process of being screened for PSA.

Overall results characterization

- Individual hazard category results meet the LRF PSA goal of $1x10^{-5}$ per reactor per year
- Sum of internal events LRF = $3.8x10^{-6}$ per reactor per year for Bruce A and $1.3x10^{-6}$ per reactor per year for Bruce B. Both meet LRF PSA goal of $1x10^{-5}$ per reactor per year.
- LRFs for seismic and high winds are small in comparison to aggregated internal events LRF.

Multi-unit considerations

- Fire hazard category dominates both single unit and multi-unit results at both stations

Defence-in-depth characterization

- Defence-in-depth improvements implemented or in progress based on Fukushima lessons learned, including fire protection improvements such as early smoke detection

Safety margin characterization

- No vulnerabilities identified. No risk dominant sequences identified in Fire PSA.
- Seismic results do not increase significantly until severity exceeds that associated with 1 in about 40,000 year frequency.
- High wind SCDF doubles for frequencies greater than 1 in 140,000 years.

Performance monitoring

- Bruce Power governance ensures potential design or operational changes are evaluated for impact on PSA results
- Bruce Power governance requires review if average or instantaneous PSA goals are exceeded
- PSAs are updated every 5 years or sooner if major changes occur

Integrated decision-making inputs

PSA goal met?	*Defence-in-depth*	*Safety margins*	*Multi-unit implications*	*Performance monitoring*
Yes	Confirmed	Dominated by fire hazard category	Fire still the dominant hazard category. No additional insights.	Annual average and instantaneous LRF monitoring

Conclusions

- Individual hazard categories and the sum of results for internal hazards meet the LRF goal
- Large margins exist for external hazards with frequencies 1 in 10,000 years or greater
- Fire dominates LRF. Results credit EME and improvements in fire detection equipment. There are no risk-dominant sequences.

5.0 EMERGENCY PREPAREDNESS

Based on lessons learned from Fukushima, Bruce Power has implemented numerous enhancements to emergency preparedness, including physical enhancements to the nuclear facilities and supporting infrastructure, enhancements for data retrieval and sharing, and training. These enhancements were implemented through a stepped approach, with demonstration prior to implementation and a focus on improving operability, interoperability, and continuity of operations.

Overall, the improvements to emergency preparedness mean that Bruce Power has an improved capability to respond to all hazards, including beyond design basis accidents. Bruce Power can provide backup cooling water and backup power to the nuclear facilities, and can maintain communications even in the event of infrastructure outages. With respect to off-site monitoring data, Bruce Power has improved situational awareness through the sharing of real-time monitoring data with all response agencies, allowing for quicker, more effective decision-making. With respect to on-site plant data, Bruce Power is undertaking a feasibility study to include reliable real-time data sharing with off-site agencies through the DLAN system.

Physical enhancements to the nuclear facilities for mitigation of risk are described in Section 5.1 and Table 8. These physical enhancements include implementation of additional cooling through quick connects (for pumper trucks, which are part of EME) as well as interunit feedwater ties, portable backup power, enhancements to severe accident management guidelines including unit kits, passive autocatalytic hydrogen recombiners, and (in progress) passive filtered containment venting.

Enhancements to supporting site infrastructure are also summarized in Section 5.1 and Table 8. These enhancements include implementation of a new Emergency Management Centre, supported with alternate facilities and a mobile unit. Bruce Power also implemented new and upgraded systems to provide improved and backup communications. Bruce Power is working with response agencies in the Bruce-Grey-Huron region as part of a government-funded study to develop an emergency response interoperability plan for enhancing rural emergency response interoperability in the region around the Bruce site.

Enhancements to data retrieval and sharing include implementation of off-site remote radiation monitoring, improved plume modelling, (in progress) an emergency management dashboard (DLAN; see Section 5.4), and (in progress) software to track equipment location through real-time geolocation technology.

Enhancements to training include implementation of a new fire training facility, a five-year drill/exercise plan, a major exercise with relevant federal and provincial agencies every 3 years, and annual exercises and simulations. Additionally, this includes the implementation (in progress) of simulation software that uses a three-dimensional site model to support analysis of events and response. This software will allow for improvements to emergency response training as well as provide analysis of the probability of successful deployement of EME in a variety of extreme external events.

5.1 Post-Fukushima Modifications

Bruce Power developed enhancement plans in response to the Fukushima incident and CNSC-issued Fukushima Action Items. Since that time, Bruce Power has provided regular updates to the CNSC on its enhancement plans, in alignment with the Fukushima Action Items.

The enhancement plans included physical modifications to the nuclear generating stations and supporting facilities. The enhancements include:

- Short-term enhancements (strengthening defence-in-depth) to provide maximum safety benefits in the shortest time;
- Longer-term enhancements (strengthening defence-in-depth) that required completion of relevant analyses, assessments, and modifications; and,
- Enhancements to emergency response facilities and processes.

The relevant physical modifications are listed in Table 8, including the location (by station or unit), final in-service date, and status of the modification. Multi-unit modifications will have been completed in some units prior to the final in-service date for all units. This information was previously provided in Reference A1, Attachment B, Section 15.14; however, the information has been clarified and incorporates progress made during 2017.

The Fukushima modifications were scheduled such that those aimed at preventing events were completed first followed by those that mitigate consequences of events. As noted in the table the majority of actions have been completed and the remainder are scheduled for the near future. Sections 5.1.1 through 5.1.3 provide additional discussion for modifications which are currently in progress.

Table 8. Fukushima modifications

Modification	Station/unit[1]	In-service[2]	Status[3]
Short-term actions to provide make-up water	–	–	–
Installation of dry hydrants	AB	2012	Complete
Redundant EME connections to steam generators	AB	2013	Complete
Redundant EME connections to irradiated fuel bays	AB	2013	Complete
Procurement of EME	n/a	2012	Complete
Strengthening defence in depth	–	–	–
Additional provisions for make-up water	–	–	–
EME connection to Primary Heat Transport System	56	2019	In progress: 1234 78
EME connection to Moderator System	56[4]	2019	In progress: 1234 678
SAMG connection to Primary Heat Transport System	1234 5678	2016	Complete
SAMG connection to Moderator System	1234 5678	2016	Complete
SAMG connection to Shield Tank	1234 5678	2016	Complete
Installation of Shield Tank overpressure protection	5[4]6	2019	In progress: 1234 578
Wide-range ECI sump level indication	A	2018	In progress
External power supply enhancements	–	–	–
Procurement of portable generators, cables, trailers	AB	2011	Complete
Installation of receptacle panel for quick connections	AB	2012	Complete
Connecting quick-connect panel to QPS/EPS buses	AB	2012	Complete
Passive filtration for containment	–	–	–
Installation of containment venting connection point	AB	2016	Complete
Installation of filtered containment venting system	AB	2022	In progress
Passive Autocatalytic Recombiners	0A1234 0B5678	2015	Complete
Enhancing emergency response	–	–	–
New Emergency Management Centre (EMC)	–	–	–
Commissioning of new state-of-the-art facility	n/a	2014	Complete
Procurement of mobile emergency centre	n/a	2013	Complete
Backup power for emergency facilities, equipment	–	–	–
Portable generator for EMC	n/a	2014	Complete
Fuel truck, portable generator for fuel transfer pumps	n/a	2012	Complete
Communications upgrades	–	–	–
Radio, satellite phone upgrades at EMC, CMLF	n/a	2014	Complete
Installation of VSAT at EMC	n/a	2014	Complete
Offsite monitoring capability	–	–	–
Installation of remote gamma monitors	n/a	2014	Complete
Installation of remote aerosol monitors	n/a	2015	Complete

Note 1: affected station or units, as applicable, in which the modification is complete. "A" and/or "B" are listed when the modification is applicable to the station as a whole; otherwise, individual units are listed.
Note 2: actual or anticipated in-service date.
Note 3: affected units for which the modification is to be installed.
Note 4: installation was partially completed.

5.1.1 Makeup water to Primary Heat Transport, Moderator System, and Shield Tank (in progress)

This project is intended to provide complementary design features which allow emergency makeup water to be added to the primary heat transport systems and moderator systems. The water is provided by portable EME pumps which are stored at a higher elevation in a building adjacent to the site.

This enhancement includes the following:

- Installation of permenant EME quick-connect couplings to allow emergency water to be added to the Primary Heat Transport System of each unit (complete in Units 5 and 6; installation in progress in Unit 1);

- Installation of permanent EME quick-connect couplings to allow emergency water to be added to the Moderator System (calandria) of each unit (complete in Unit 5 and partially complete in Unit 6; installation in progress in Unit 1);

- Deployment of SAMG toolkits (connection hardware and tooling) to allow emergency water to be added to the Primary Heat Transport System, Moderator System (calandria), and Shield Tank in each unit (complete at Bruce A and Bruce B); and,

- Installation of overpressure protection for the Shield Tank (partially complete in Unit 5, and complete in Unit 6; installation in progress in Unit 1).

Enhanced shield tank overpressure protection will prevent Shield Tank overpressure failure in the extremely unlikely event of a severe accident which has degraded to the point where the Shield Tank is acting as the primary heat removal medium.

Installation of the Shield Tank overpressure protection was partially completed in Unit 5. The installation was not completed due to the detection of an unanticipated concentration of hydrogen gas. As a consequence, the installed piping prior to the Shield Tank connection was left in a safe state; installation in Unit 5 will resume in 2019. The resolution of this issue was successfully implemented during the next planned installation, which resulted in the full installation of the Shield Tank overpressure protection in Unit 6.

At time of preparation (January 2018), the Unit 1 maintenance outage is underway. This outage includes installation of EME connections to the Primary Heat Transport System and installation of overpressure protection for the Shield Tank.

5.1.2 Bruce A Wide Range Emergency Coolant Injection Sump Level Indication (in progress)

In response to a beyond design basis accident that results in a loss of heat sink, Bruce Power could add water to the reactor core to prevent fuel melting or to stabilize the accident if core failure has already occurred. Knowledge of the water level inside containment is required to ensure that containment is not breached due to excessive water level in the fuelling machine duct, which runs beneath the reactor units. Adequate level indication can also be used to ensure that any molten corium that has relocated to the concrete floor remains covered, thereby mitigating the corium/concrete interaction. The existing level transmitter has inadequate span for this purpose; this enhancement will upgrade the level transmitter to increase its range.

5.1.3 Passive containment filtered venting system (in progress)

This enhancement will provide a completely passive system for filtration of releases from containment. A conceptual design has been selected, and installation is expected to be completed by 2021 at Bruce B, and 2022 at Bruce A.

5.2 PNERP

Ontario Fire Marshall and Emergency Management (OFMEM) updated the Provincial Nuclear Emergency Response Plan (PNERP) in December 2017.

Changes to the PNERP include:

- Use of Beyond Design Basis Accident criteria as part of the Planning Basis;
- Enhanced alignment with the Ontario Provincial Emergency Response Plan, CSA N1600, *General Requirements for Nuclear Emergency Management Programs*, and REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response*; and,
- Creation of a new Contingency Planning Zone (10-20 km from the nuclear facility) with associated planning and protective actions.

Bruce Power agrees that the update to the PNERP will enhance nuclear emergency response and public safety in Ontario. These changes will primarily impact the municipal response plan due to the creation of the new Contingency Planning Zone. Minimal updates are expected to be made to internal Bruce Power plans.

At this time, Bruce Power is assisting OFMEM with the review and update of the associated Bruce Implementing Plan. Additionally, Bruce Power is supporting the Municipality of Kincardine in ensuring that the municipal response plan is aligned with the updated PNERP, with an anticipated completion date of mid-2018.

5.3 Impact of EME on multi-unit accident analysis

In order to support enhancements to the PNERP by OFMEM and to examine the impact of EME on severe accidents, Bruce Power and OPG obtained third-party accident analysis. This analysis reviewed international practices for establishing Emergency Planning Zones and associated protective actions and also developed accident scenarios to consider potential impacts to the public.

The analysis considered five case studies (see Table 9), ranging from design basis accidents (cases 1 and 2) to multi-unit, beyond design basis severe accidents (cases 3-5). The type and timing of station response varied with scenario. Case 4 and Case 5 were not determined by probabilistic analysis, but were arbitrarily set as severe accident scenarios, despite their highly unrealistic nature, in order to ensure consideration of a worst-case scenario and in order to examine the impact of EME on these severe scenarios.

Table 9. Case studies for accident analysis to support emergency planning

Case	Accident	EME	Result	Details
1	Single-unit	None	Within sheltering PALs (<10 km) Below sheltering PALs (>10 km)	Rapidly-developing large LOCA
2	Two-unit	None	Within sheltering PALs (<10 km) Below sheltering PALs (>10 km)	Loss of heat sink (corium relocates to fueling machine duct)
3	Four-unit	Limited	Within sheltering PALs (<10 km) Below sheltering PALs (>10 km)	Loss of heat sink (station blackout) with no station response that requires power. Assumes limited EME application to mitigate consequences only (emergency moderator makeup two hours after core is uncovered, and end shield tank makeup after 24 hours), and does not include prevention.
4	Four-unit	Very limited	Exceed evacuation PALs (<10 km) Exceed evacuation PALs (>10 km)	Loss of heat sink (station blackout) with no station response that requires power. Assumes very limited EME (end shield tank makeup after 24 hours).
	Note: application of additional EME will reduce dose to levels similar to Case 3.			
5	Four-unit	None	Exceed evacuation PALs (<10 km) Exceed evacuation PALs (>10 km)	Four-unit loss of heat sink (station blackout) with unrealistically-minimal station response.
	Note: application of additional EME will reduce dose to levels similar to Case 3.			

The analysis provided a potential dose for individuals in the various scenarios, and was based on an adult who was assumed to remain at a fixed location, with no protection (an implausibly conservative assumption).

As expected, the dose received within the primary zone for design basis accidents (cases 1 and 2) remains within or below the Protective Action Limits (PALs) established by the PNERP for sheltering and remains below the PAL for evacuation.

Also as expected, the potential dose from a four-unit severe accident—with no installed plant equipment utilized to prevent or mitigate the event, with limited operator action at best (i.e., cases 4 and 5), and with no or very limited application (after 24 hours) of EME—are greater than the PALs established for evacuation at distances beyond the primary zone (>10 km).

However, when very limited operator action and when limited application of EME (as for case 3) are utilized to mitigate the event, the dose received inside the primary zone is within the PALs for sheltering, remains below the PAL for evacuation and is very similar to the design basis scenarios. (This assumes no availability of equipment requiring power, no action is taken to prevent the event, and application of EME is hours into the event). Accordingly, this scenario would result in limited sheltering, but no evacuation.

This demonstrates how effective EME will be in reducing the impact of a beyond design basis accident on public dose, even when truly conservative and unrealistic assumptions are made. The installation of passive CFVS will be built into the modelling when final designs are complete; CFVS is expected to further reduce (likely by orders of magnitude) the quantity of radionuclides that could be released in an event that assumes containment failure, including multiunit severe events.

As described in the Performance Review, EME refers to fire pumpers that draw water from the Condenser Cooling Water outfall via dry hydrants and deliver that water to the steam generators, irradiated fuel bays, or other systems as required through EME connections installed as part of response to Fukushima. Two off-site fire trucks are dedicated to each of Bruce A and Bruce B, with an additional spare truck; the fire trucks are supported by a fuel truck as well as equipment capable of clearing debris.

In the five scenarios, significant radioactive releases do not begin earlier than approximately 20 hours after the initiating event, even in the worst-case scenario. This provides sufficient time to deploy the EME and limit the effect on public dose. The application of EME for case 4 and case 5 will reduce the public dose to level similar to that of case 3, which is within the PALs established for sheltering and comparable to releases envisioned for design basis accidents.

In summary, the analysis demonstrates that worst-case scenarios, if left unmitigated, could exceed the evacuation PALs outside the primary zone (at distances beyond 10 km from the plants). However, even if it is assumed no action is taken to prevent an event, there is sufficient time to deploy EME and mitigate the effects of even the worst-case scenarios. Accordingly, this analysis demonstrates that the PNERP is robust, and the PALs are appropriate, even for accidents deemed to be beyond design basis. (Note that the PALs are set very conservatively and are up to five times lower than ICRP recommendations.)

5.4 DLAN

Detailed information with respect to the development of DLAN was previously provided in the Performance Review (Reference A1). That information is summarized here, with updates on progress through 2017.

Bruce Power has developed a system that obtains and shares key plant data throughout the full range of potential events—from design basis events to beyond design basis, extreme events.

The system is designed to reliably and accurately communicate the status of critical plant systems and parameters under any conceivable circumstance (including loss of local infrastructure) to all corporate and government agencies. The system has been tested in two corporate exercises and has been updated to reflect lessons learned. DLAN is expected to be officially placed in service in March 2018.

The DLAN system is depicted visually in Figure 4.

DLAN uses VSAT technology to address the need for continuity of operations, and data is housed within a secure cloud through remote servers with appropriate back-up systems to ensure 24/7 availability even during large-scale infrastructure outages.

In 2016, Bruce Power initially tested DLAN as a method of sharing data with external agencies. This initial test utilized a manual data verification process to ensure data correctness and availability in the event of plant system challenges.

Based on this successful test, further work was completed in 2017 to implement DLAN as the primary methodology for sharing plant data and emergency response information. Electronic forms (used within the DLAN application) were further developed, and plans are in place to enhance these forms to allow for multi-unit input. Draft emergency response procedures applicable to DLAN were developed. Training is in progress for applicable Emergency Response Organization positions. Updates to the DLAN application itself are being made based on lessons learned from the Bruce A and Bruce B corporate exercises that were conducted in 2017.

Following this implementation, Bruce Power plans to begin a feasibility assessment to investigate options for automating the connectivity to station and site data systems, in order to further reduce operator burden, to support automated sharing of data, and to simplify dose and plume modelling. This will involve testing capabilities to feed data from critical plant systems directly into DLAN, utilizing the more secure environment and back-up power/communications provided to the control rooms of each station. As part of this effort, system security will be reviewed to ensure cloud providers and third-party vendors meet all security requirements.

DLAN will ensure a sustainable system is put in place—one that supports continuity of operations from end-to-end and that supports, as much as possible, automated transfer of multi-unit plant data from qualified and/or critical plant instrumentation to external agencies.

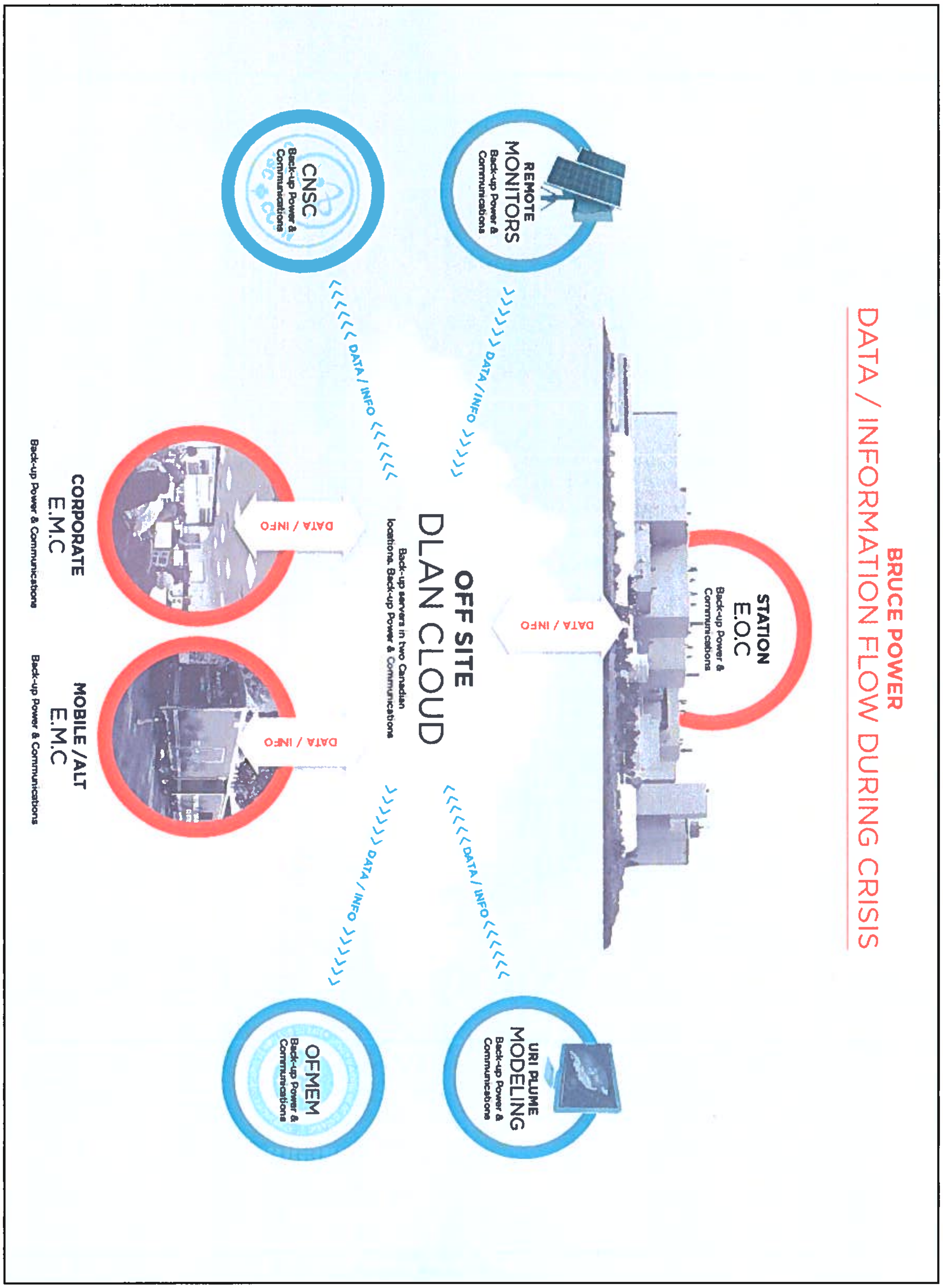


Figure 4. Data transfer with DLAN

5.5 Potassium iodide (KI) tablets

In response to new CNSC requirements, Bruce Power worked with regional municipalities and the Grey Bruce Public Health Unit to pre-distribute potassium iodide (KI) tablets to all households and businesses within 10 km of the Bruce site (primary zone) and to make KI tablets available to residents within 50 km (secondary zone).

The pre-distribution and pre-stocking of KI tablets was completed in two phases as indicated in Table 10.

Table 10. Plan and status for KI tablet distribution

Zone	Plan	Status
Primary (<10 km)	Pre-distribution: KI tablets delivered to all residences, businesses, institutions	Pre-distribution in 2015. Approximately 2/3 of residents requested tablets; tablets were mailed to all other residents.
Secondary (<50 km)	Pre-stocking: KI tablets available for pick-up to all residents.	Safety guide, vouchers, and pick-up locations were provided to all 65,000 residents in 2015. Tablets were distributed to both school boards in 2016.

Phase I (primary zone) began in 2015 to address permanent and seasonal residents (approximately 1500) and local businesses (approximately 30). Information packages and vouchers were mailed to all residents and businesses in the primary zone. Six information sessions were held. Phone calls were made to each local business. Door-to-door distribution was provided for seasonal residents. Bruce Power met with a bishop of a local Amish community to request assistance with distribution of vouchers and KI packages to 13 identified Amish families. One registered child care facility is located within the primary zone, and Bruce Power worked with the owner to ensure this facility's emergency plan included nuclear emergencies. Note that no schools are located within the primary zone.

Every effort was made to make personal contact with residents and business owners. Approximately 1000 residents responded and picked up or received KI packages, while approximately 30 residents actively opted out of participation. Ultimately KI packages were mailed to the remaining 500 non-responding residents; follow-up was conducted for undelivered packages to ensure final delivery. Phase I was completed by July 2015.

During Phase II (secondary zone), all 65,000 residents within the secondary zone received a Community Safety Guide by mail. The guide included a voucher for residents to obtain KI tablets at 11 locations across the secondary zone. During this time, residents had the opportunity to learn more through the "Be Prepared" website (http://www.bepreparedgreybrucehuron.com/) and to participate in webinars. Members of Saugeen First Nations were invited to an afternoon or evening information session with Bruce Power and the Grey Bruce Health Unit at the Mino Bimaadsawin Health Centre in Southampton (one of the pre-distribution centres).

Additionally, KI tablets were also distributed to both school boards for re-distribution to the 52 schools within the secondary zone. Prior to distribution, Bruce Power worked with the school boards to ensure that emergency procedures and policies were updated appropriately. Schools subsequently provided consent forms and information sheets to parents.

With the distribution of tablets to school boards, Phase II was completed in spring 2016.

To sustain this enhancement to emergency preparedness, Bruce Power provides regular updates on emergency preparedness to local municipalities and meets regularly with local Community Emergency Management Coordinators. Bruce Power provides an annual update to the Community Safety Guide for all residents within the primary and secondary zones (<50 km of the Bruce site), to ensure residents moving into the area receive appropriate information; the 2018 update is planned to be mailed in April. Updates are regularly made to the "Be Prepared" website. Additional information is also found at the Bruce Power Visitors' Centre (open to the public during weekdays) as well as libraries and some tourist information areas in Kincardine, Port Elgin, and nearby provincial parks.

Finally, the tablets initially distributed in 2015 will expire in 2025; accordingly, Bruce Power plans to develop an appropriate exchange program prior to this time.

6.0 COMMUNITY AND INDIGENOUS RELATIONS

Bruce Power is committed to open and transparent communication with Indigenous groups and the broader public. Since the end of 2015, Bruce Power has actively communicated with members of the public as well as local Indigenous groups on its intent to extend the life of Units 3 through 8. As part of this process, Bruce Power has provided multiple avenues to obtain information and to express concerns.

This Section outlines in detail the engagement and consultation efforts the company has taken with respect to the public and Indigenous community standpoint (see summary in Table 11).

Bruce Power respects the unique rights of Indigenous groups. Accordingly, Bruce Power has made efforts to communicating in an appropriate fashion with Indigenous groups, as described in Sections 6.5, 6.6 and 6.7.

Members of the public are encouraged to submit any items of concern in relation to the PROL renewal application to an inquiry email box: info@brucepower.com. This mailbox is monitored during normal business hours. To date, 29 technical inquires have been received from members of the public in relation to the PROL renewal application. Bruce Power targets to acknowledge the request within 24-48 hours, and to provide a full response within one week (unless more time is required due to the complexity of the question).

Table 11. Tools to communicate with members of the public regarding the PROL renewal application

Communication tool (launch date)	Additional information
Detailed publications (August 2016; September 2017)	*Bruce Power's Role in Ontario: The Road Ahead: Our Relicensing & Environmental Activities* *2018 Licence Renewal Briefing: Playing a Role in the Future of our communities*
Webpage (August 2016)	Webpage acts as a hub of information related to MCR and licence renewal; over 600 hits recorded including almost 300 with respect to the 2018 licence renewal publication
YouTube video (Fall 2016)	*Bruce Power's Major component Replacement Project* (over 3600 views)
Facebook group (Fall 2017)	2018 Licence Renewal (over 160 members)
Community workshops (October 2016; Jan 2018)	Invited, focused stakeholder workshops
Webinars (Dec 2016, Sep 2017, Oct 2017, Nov 2017, Jan 2018)	Webinars are available on the website and are archived for 12 months.
Community engagement sessions (Sep 2017, Oct 2017, Nov 2017, Jan 2018)	Face-to-face sessions in Port Elgin or Kincardine; open to the public
Fact sheets (Jan 2018)	14 fact sheets in key topic areas of interest to the public
Public inquiries (ongoing)	29 technical inquiries related to licence renewal have been received. Inquiries are acknowledged within 24-48 hours. Full responses are provided within one week where possible.
Public attitude research (Fall 2016, Spring 2017, Fall 2017)	500-1500 people surveyed across Grey, Bruce, and Huron counties in each survey
Summer bus tour program (Summer 2017)	Information on MCR provided during bus tours (4400 visitors in 2017)
Information placed in a free local publication (October 2017)	13,000 people received free local publication with information on MCR and engagement opportunities
Visitors' Centre display on MCR and Life Extension (2016)	20,000 visitors since 2016
Community update mailing (Q3 2017)	Over 100,000 people (52,000 households) received community update, which highlighted the licence renewal process.

6.1 Community Engagement 2016

In August 2016, Bruce Power launched a community conversation about the company's future role in Ontario's electricity system to advance the multi-year investment plan announced in December 2015. As part of this launch, Bruce Power released a comprehensive community report, which provided an in-depth review of licensing and environmental activities. Additionally, Bruce Power created a webpage to provide information related to relicensing activities (originally www.brucepower.com/theroadahead but later updated to http://www.brucepower.com/licencerenewal2018/).

In October 2016, Bruce Power hosted a community workshop. Invitations were extended to over 100 people in the local community, including members of the Saugeen Ojibway Nation (SON), the Métis Nation of Ontario (MNO), the Historic Saugeen Métis (HSM), non-governmental organizations, Counties of Grey, Bruce and Huron, and local municipalities (including but not limited to Kincardine, Saugeen Shores, North Bruce Peninsula, and Brockton). Over 25 people took part in this session, in which Bruce Power leaders provided an in-depth conversation on the current MCR project.

In December 2016, Bruce Power hosted a webinar, which provided a compressed version of the engagement session presentation, as well as a video overview of MCR (Figure 3.0). This video was later posted onto the YouTube and has been viewed over 3,500 times.

Figure 5. Example advertisement for engagement sessions and webinars.

6.2 Community Engagement 2017

The PROL renewal application was submitted to the Commission in June 2017. Subsequently, Bruce Power posted the application on its licence renewal webpage and kicked off the second phase of public engagement with the release of a detailed publication summarizing the technical content in the licence application.

Bruce Power led a series of face-to-face engagement sessions and webinars in the fall and launched a Facebook group.

Advertisements for the engagement sessions events were placed in local newspapers and magazines (covering Kincardine, Saugeen Shores, and Walkerton), posted on the Facebook group and through Facebook advertisements, and provided in the Bruce Power e-newsletter (1600 subscribers in fall 2017).

The face-to-face engagement sessions and webinars were each attended by 1-10 individuals, who raised no concerns. Members of the CNSC attended the community engagement sessions held in Kincardine (October) and in Port Elgin (November).

The Facebook group currently has 165 members. Three questions have been posted (and answered) on the topics of purchase service agreements, OPG's involvement in the licensing process, and Bruce Power's generation capacity.

The Bruce Power community update (distributed in the summer of 2017) included a front page article on licence renewal. This update is mailed to 52,000 households in the local community.

6.3 Community Engagement 2018

Three face-to-face engagement sessions and one webinar were scheduled for January 2018. Two engagement sessions were attended by nearly 50 people each. Approximately 30 individuals have expressed interest in attending a third session at the end of January, with another 30 registered for a webinar.

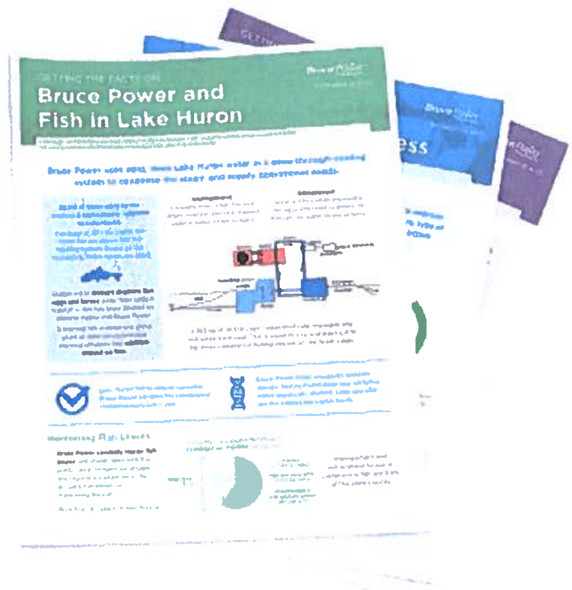


Figure 6. Example factsheets

The face-to-face engagement sessions and webinar were advertised in local newspapers (Kincardine, Saugeen Shores, Owen Sound, Lucknow, Goderich, Wingham, Walkerton, and Mildmay), through Facebook advertisements, and through the licence renewal webpage. Technical experts from Bruce Power attended and responded to questions related to economics, emergency preparedness, education, and health care.

During these sessions, participants were provided with factsheets on key areas of public interest. These fact sheets are available on the licence renewal webpage.

6.4 Surveys and polling

Since 2001, Bruce Power has evaluated its impact on local economies, health care, Indigenous communities, culture, agriculture, and other areas through studies, public inquires, and polling. In 2016 and 2017, Bruce Power conducted polls and surveys to understand the key areas of concern in the local and regional areas. As identified by respondents, the issues of most concern for local residents include education, jobs, and health care.

Local residents are generally familiar with Bruce Power, with 76% of respondents indicating they were "very" or "somewhat" familiar with Bruce Power (similar to 2014, although the percentage of respondents indicating "very" familiar increased from 15% to 21%).

Support for the Bruce facility is high among local residents (85%; increased from 79% in 2014). Job creation is the primary reason that local people support the refurbishment of the Bruce nuclear generating station (20%). With respect to residents who do not support the refurbishment project, the primary reasons for not supporting the refurbishment include concerns about safety, costs, and potential alternatives for energy.

The main community issues based on the 2016-2017 polling and surveys are highlighted below. Fact sheets addressing many of these issues have been created and posted on our Licence Renewal website www.brucepower.com/factsheets.

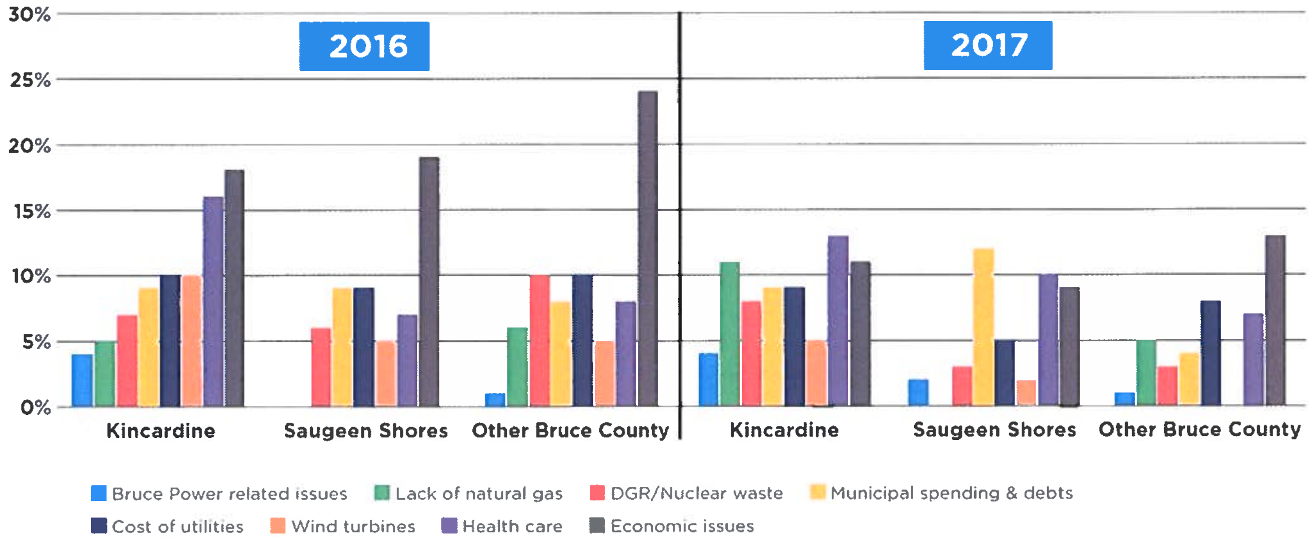


Figure 7. Summary of community issues (2016-2017)

6.5 Saugeen Ojibway Nation

On December 1, 2015, Bruce Power wrote a formal letter to Chief Nadjiwon and Chief Roote, providing them Bruce Power's 5-year regulatory look ahead, including a presentation entitled "2016-2020 Regulatory Overview". The presentation described provincial and federal regulatory activities over the next 5 years, including the regulatory processes that are part of the ongoing operations of the Site.

Both the letter and the enclosed presentation clearly outlined the anticipated MCR of the six remaining unrefurbished units, including the anticipated process relating to the refurbishment and licensing requirements of the CNSC. This presentation indicated that the Canadian Environmental Assessment Act, 2012 is not applicable but a comprehensive environmental review would be part of the process. This 5-year review was notably provided in direct response to concerns raised by the SON about the need to have more advanced notice of upcoming regulatory proceedings so that they can plan and prepare accordingly. Given the SON's concerns, in addition to what would be part of a CNSC process to provide notice of key process milestones in a transparent manner, Bruce Power has sought to engage with the SON as early as possible and to do so in a way that was consistent with the terms of the 2011 SON/Bruce Power Agreement with the SON.

Since December 2015, Bruce Power has regularly engaged with the SON on numerous matters and provided further updates on the MCR, including on September 15, 2016, February 8, 2017 and April 13, 2017. The SON were also invited to participate in a widely publicized community engagement program on the life extension launched in August 2016 but declined to do so. After September 2016, Bruce Power made several requests to meet the SON to develop an overall work plan for engagement on several regulatory items including MCR and the Fisheries Act Authorizations. Bruce Power continues to engage SON, has recently had some progress advancing further dialogue, and looks forward to continuing this dialogue.

On June 30, 2017, Bruce Power filed its application for the renewal of the Power Reactor Operating Licence. The application included evaluation of the Life Extension scenario which will see the operation of the Bruce site out to 2064. On July 26, 2017, Bruce Power provided the SON with a copy of the application and a draft proposed engagement plan and requested a meeting in early September. Bruce Power followed up several times after sending the Application and an initial meeting was scheduled and held on December 21, 2017.

Bruce Power provided the SON with SON/Bruce Power Agreement capacity funding at the December 21, 2017, meeting. This capacity funding was provided to ensure continued progress of the community with respect to application analysis. Anything above and beyond such amount is considered regulatory top-up and Bruce Power again requested that the SON provide them with a review plan and estimate for additional capacity funding for regulatory top-up.

Bruce Power is hopeful that a path forward can be developed and remains ready, willing, and able to engage with the SON about any concerns or questions that they have regarding the application. Similar to 2016 and 2017, Bruce Power extended the invites for all public engagement sessions, webinar and stakeholder workshop occurring in January to the SON. To date they have not indicated participation.

6.6 The Métis Nation of Ontario

On December 1, 2015, Bruce Power wrote to the MNO to provide a 5-year regulatory look ahead, which included a presentation entitled '2016-2020 Regulatory Review'. The presentation described provincial and federal regulatory activities over the next 5 years, including the regulatory processes that are part of the ongoing operations of the Site. Both the letter and the enclosed presentation expressly mentioned the anticipated MCR of the six remaining unrefurbished units, including the anticipated timeline. This presentation was subsequently delivered in person at a meeting between the MNO and Bruce Power on January 29, 2016.

Since December 2015, Bruce Power has regularly engaged with the MNO on numerous matters and provided further updates on the MCR on May 24, 2016, September 23, 2016, December 16, 2016, March 15, 2017, March 22, 2017, and June 28, 2017. The MNO were also invited to participate in a widely publicized community engagement program on the life extension launched in August 2016.

On August 1, 2017, Bruce Power provided the MNO with a copy of the application and a draft proposed engagement plan and requested a meeting in early September. Bruce Power and MNO subsequently exchanged correspondence on several issues and subsequently met with the MNO on December 4, 2017, for their Q4 meeting and discussed the application and draft engagement plan. MNO indicated that they have reviewed the draft engagement plan Bruce Power provided and have created their own engagement plan which they intend to share shortly. The MNO indicated that their plan ensures that all timelines are met and when they compared it to the Bruce Power plan in essence it achieved the same thing. The MNO indicated that they were not yet in a position to provide comments regarding the application, but that they would soon share this information with Bruce Power, although no timeline was set out. During the meeting, Bruce Power requested MNO provide invoicing for the capacity funding in relation to this file so that the funds could be released prior to the end of 2017. MNO indicated that they applied for the Participant Funding Program through the CNSC.

Following the December 4, 2017, meeting, Bruce Power provided the MNO with the supplemental information relating to the application on December 8. Bruce Power and the MNO are in the process of planning the Q1 meeting for 2018, a meeting has been set for February 27, 2018 to further the dialogue on the licence application. Similar to 2016 and 2017, Bruce Power extended the invites for all public engagement sessions, webinar and stakeholder workshop occurring in January to the MNO, they acknowledged receipt of these; however, to date have not indicated participation.

6.7 The Historic Saugeen Métis

On December 1, 2015, Bruce Power wrote to the HSM to provide a 5-year regulatory look ahead, which included a presentation entitled "2016-2020 Regulatory Review". The presentation described provincial and federal regulatory activities over the next 5 years, including the regulatory processes that are part of the ongoing operations of the Site. Both the letter and the enclosed presentation expressly mentioned the anticipated MCR of the six remaining unrefurbished units, including the anticipated process relating to the refurbishment and licensing requirements of the CNSC. This presentation was subsequently delivered in person at a meeting between the HSM and Bruce Power on February 5, 2016.

Since December 2015, Bruce Power has regularly engaged with the HSM on numerous matters and provided further updates on the MCR on May 5, 2016, September 15, 2016, December 16, 2016, February 8, 2017, February 17, 2017 and April 13, 2017. The HSM were also invited to participate in a widely publicized community engagement program on the life extension launched in August 2016.

On July 26, 2017, Bruce Power provided the HSM with a copy of the application and a draft proposed engagement plan and requested a meeting in early September. Bruce Power and the HSM subsequently exchanged correspondence on several issues including the scheduling of a meeting to discuss the proposed engagement plan and the application. The HSM requested that this meeting be deferred to their Q4 quarterly meeting on December 12, 2017. After providing supplemental information relating to the Application on December 8, Bruce Power and the HSM met and discussed the application on December 12. The HSM indicated that they had reviewed the application and were in the process of summarizing the issues that they intended to raise with the Commission. The HSM did not raise any specific concerns about the application with Bruce Power at this meeting. Bruce Power is looking forward to discussing any issues of concern or questions at the next quarterly meeting with the HSM that is currently scheduled for January 25, 2018. Similar to 2016 and 2017, Bruce Power extended the invites for all public engagement sessions, webinar and stakeholder workshop occurring in January to the HSM, they acknowledged receipt of these; to date the HSM have not indicated participation at the webinar.

7.0 REFERENCES

A1. Letter, F. Saunders to M.A. Leblanc, "Application for the Renewal of the Power Reactor Operating Licence", June 30, 2017, NK21-CORR-05031-13493 / NK29-CORR-00531-14085 / NK37-CORR-00531-02768.

A2. Letter, F. Saunders to K. Lafrenière, "Bruce A and B: compliance plan to CSA N285.8-10", April 27, 2016, NK21-CORR-00531-12487 / NK29-CORR-00531-12902.

A3. Letter, F. Saunders to M. Leblanc, "Supplement to the Application for the Renewal of the Power Reactor Operating Licence: Fitness-for-Service of Pressure Tubes", October 13, 2017, NK21-CORR-00531-13854 / NK29-CORR-05031-14517.

A4. Letter, F. Saunders to M. Leblanc, "Supplement to the Application for Renewal of the Power Reactor Operating Licence: Periodic Safety Review Reports", July 19, 2017, NK21-CORR-00531-13543 / NK29-CORR-00531-14165.

A5. Letter, F. Saunders to K. Lafrenière, "2017 Annual COG Research and Development Reporting", June 28, 2017, NK21-CORR-00531-13605 / NK29-CORR-00531-14244.

Attachment B

Application for the Renewal of PROL 18.00/2020: Update to Performance Review

January 2018

NK21-CORR-00531-14126
NK29-CORR-00531-14817
NK37-CORR-00531-02906

APPLICATION FOR RENEWAL OF PROL 18.00/2020: UPDATE TO PERFORMANCE REVIEW

January 2018

Table of Contents

0.0 INTRODUCTION

0.1 Background

As described in Reference B1, Bruce Power submitted a Performance Review based primarily on information available to the end of 2016. In order to support review of this submission, a brief update has been prepared.

In this document, an update is provided for selected sections of the Performance Report, generally to provide more current metrics. Section numbers align with the sections of the Performance Review as previously submitted.

With respect to those sections for which no update is provided, the information previously submitted remains valid.

A copy of the Performance Review, as submitted in Reference B1, is also enclosed for convenience.

0.2 Highlights (2015-2017)

The 2016 draft CNSC ratings for Bruce A and Bruce B were finalized. No change was made to the draft ratings ("Fully Satisfactory" for Bruce A, and "Satisfactory" for Bruce B).

In June 2017, Bruce Power hosted four representatives from the International Atomic Energy Agency (IAEA) to review the progress on 19 items that were identified during the 2015 Bruce B Operational Safety Review Team (OSART) as either recommendations, suggestions, or self-identified areas for improvement. For all items, the OSART team of international experts determined that the items was resolved or that Bruce Power is making satisfactory progress towards resolution.

0.4 Business Plan

An update was provided in the supplemental material (this letter, Attachment A).

1.0 MANAGEMENT SYSTEM

1.1 Management system

As discussed in Reference B1, Bruce Power is transitioning to CSA N286-12, *Management System Requirements for Nuclear Facilities*. Major efforts were undertaken in 2017 to update program-level documents to comply with the new standard, using the PLAN-DO-CHECK-ACT approach. Most program-level documents have now been issued, and the remaining programs are planned to be completed by May 30, 2018. With lower-tier documents being updated on the regular review cycle, the overall transition to CSA N286-12 is expected to be complete by the end of 2018.

2.0 HUMAN PERFORMANCE MANAGEMENT

2.6 Fitness for duty

A detailed description of Bruce Power's approach to managing worker fatigue was provided in Reference B1, Section 2.6. This information is updated here with respect to the publication of REGDOC-2.2.4 and REGDOC-2.2.4, Volume II, version 2.

REGDOC-2.2.4, *Fitness for Duty: Managing Worker Fatigue*, was published in March 2017. Bruce Power plans to implement the requirements of this regulatory document by December 31, 2018.

The nuclear industry is collaborating through COG to analyze shift schedules in order to confirm compliance to the hours-of-work limits or to identify potential improvements. A COG working group has also developed a methodology that Bruce Power is using to conduct a risk-informed analysis of its workforce in order to determine which positions (in addition to certified staff and armed security workers) are considered safety-sensitive and therefore subject to new hours-of-work limits and recovery periods.

Bruce Power has also launched a company project to determine whether the electronic time and attendance reporting system can be updated to better track compliance with fatigue management requirements. Finally, all procedures, checklists, and other governance related to fatigue management are also being reviewed and updated as necessary to ensure alignment with REGDOC-2.2.4, *Fitness for Duty: Managing Worker Fatigue*.

REGDOC-2.2.4, *Fitness for Duty, Volume II: Managing Alcohol and Drug Use, version 2*, was published in December 2017.

While random and pre-placement drug and alcohol testing is consistent with the core values underlying nuclear safety, these requirements are new to the Canadian nuclear workforce. Accordingly, Bruce Power is taking great care to study the issue and to ensure employee dignity and confidentiality are maintained upon implementation.

Immediately after publication, Bruce Power teamed with Ontario Power Generation, Canadian Nuclear Laboratories, and New Brunswick Power to develop an implementation plan that will meet CNSC requirements while respecting the privacy of impacted workers.

A joint industry project was initiated through the CANDU Owners' Group (COG) to analyze industry best practices and to consider approaches to adapt those practices to the Canadian legal and labour landscape. COG has contracted with a management consultant who has experience establishing testing programs for other industries. With the guidance of the consultant, meetings have been scheduled with potential third-party administrators, testing labs, and substance abuse professionals. Industry working groups have also been created to develop communication plans, supervisor and employee training, and governance updates.

Bruce Power plans to provide the CNSC with an update by March 31, 2018.

3.0 OPERATING PERFORMANCE

No update is provided.

4.0 SAFETY ANALYSIS

4.3 Probabilistic safety analysis

An update was provided in the supplemental material (this letter, Attachment A).

5.0 PHYSICAL DESIGN

No updated is provided.

6.0 FITNESS FOR SERVICE

6.7 Fuel channels

An update was provided in the supplemental material (this letter, Attachment A).

7.0 RADIATION PROTECTION

7.5 Estimated dose to the public

At time of preparation (January 2018), the 2017 public dose was not yet available. Accordingly, the maximum dose the public (2007-2016) is reprinted here (see Figure 1).

It is important to note that the maximum dose to the public is a very small fraction of the public dose limit, as emphasized in Figure 2.

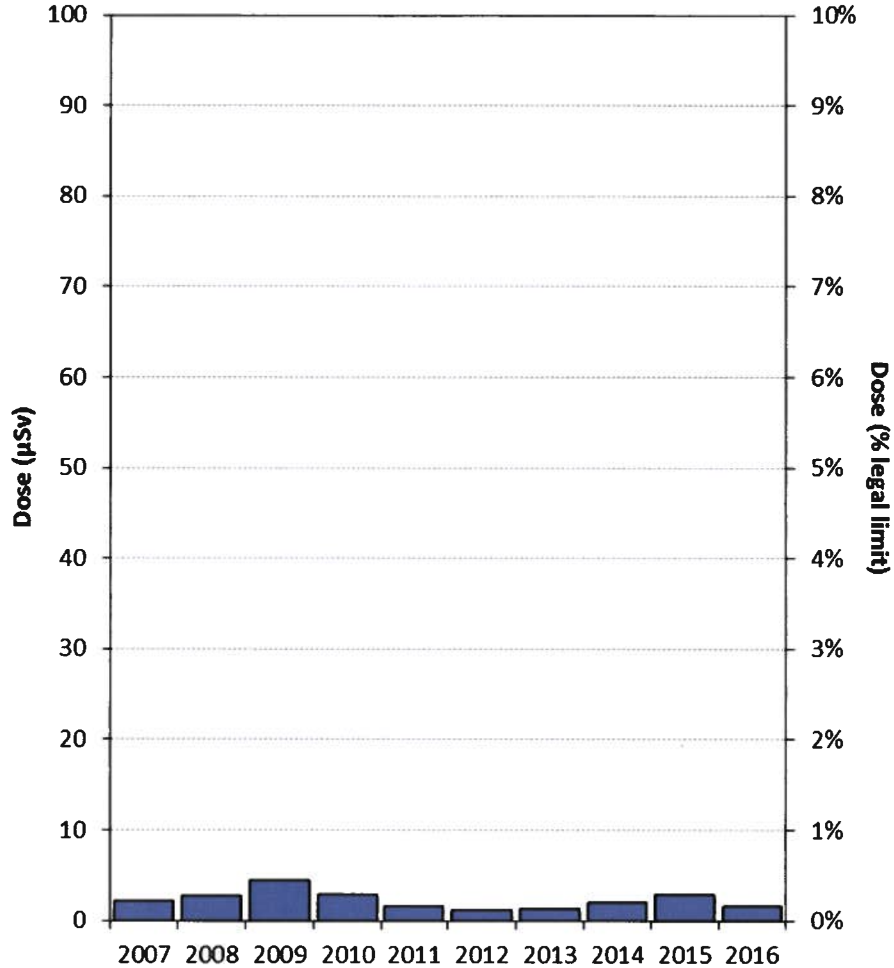


Figure 1. Maximum dose to the public (2007-2015)

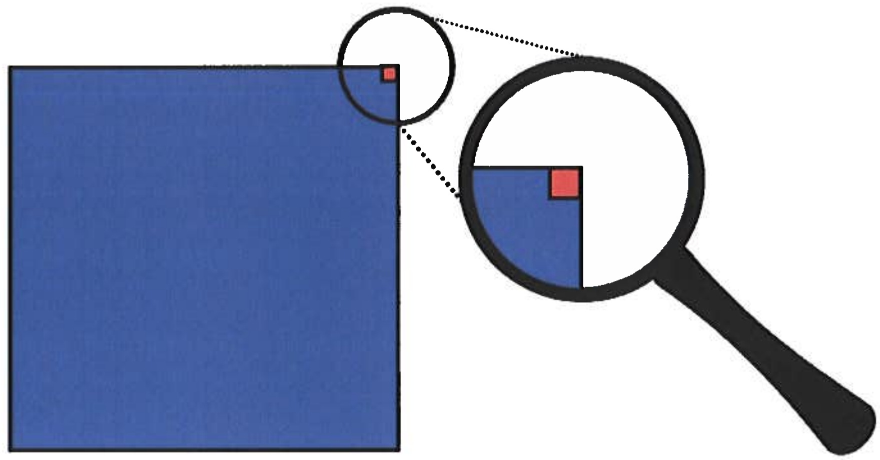


Figure 2. Maximum public dose (small highlighted square) is a very small fraction of the legal dose limit (purple square).

8.0 CONVENTIONAL HEALTH AND SAFETY

8.1 Performance, practices, awareness

The Industrial Safety Accident Rate (ISAR) for 2017 is shown in Figure 3.

Although the ISAR is quite low, corresponding to one lost-time injury in 2016 and two in 2017, Bruce Power takes any accident seriously, consistent with its number one value of "Safety First".

Analysis of these recent events revealed a gap in hazard identification and risk assessment. In response, Bruce Power launched a long-term initiative to align the entire site, including contract workers, around a common message: "*You can count on me—Every Step. Every Time. Every Day*". As described in the Performance Review (Reference B1, Attachment B, Section 3.1.3), the goal is to ensure everyone is committed to consistently following standards.

The initiative has focused on industrial safety as the first area for improvement. Since the launch in 2017, the project has implemented the following improvements:

- Improved hazard identification program, including job safety analysis and pre-job brief tools;
- New team-based observation and coaching program, to ensure key outage focus areas have increased leadership oversight; and,
- New leadership training program for our first line managers up to the executive level of the organization.

Although this initiative is still relatively new, initial results from the Unit 6 outage (beginning September 2017) were very positive, with a significant step change in industrial safety performance, and completion of the outage better than targets for lost time injuries, medically treated injuries, and first aid events.

Going forward, Bruce Power plans to simplify programs and processes that interfere with a worker's ability to adhere to standards, every time. First on the agenda are the maintenance and operations procedure quality and backlogs, performance improvement program burden, and the work authorization program.

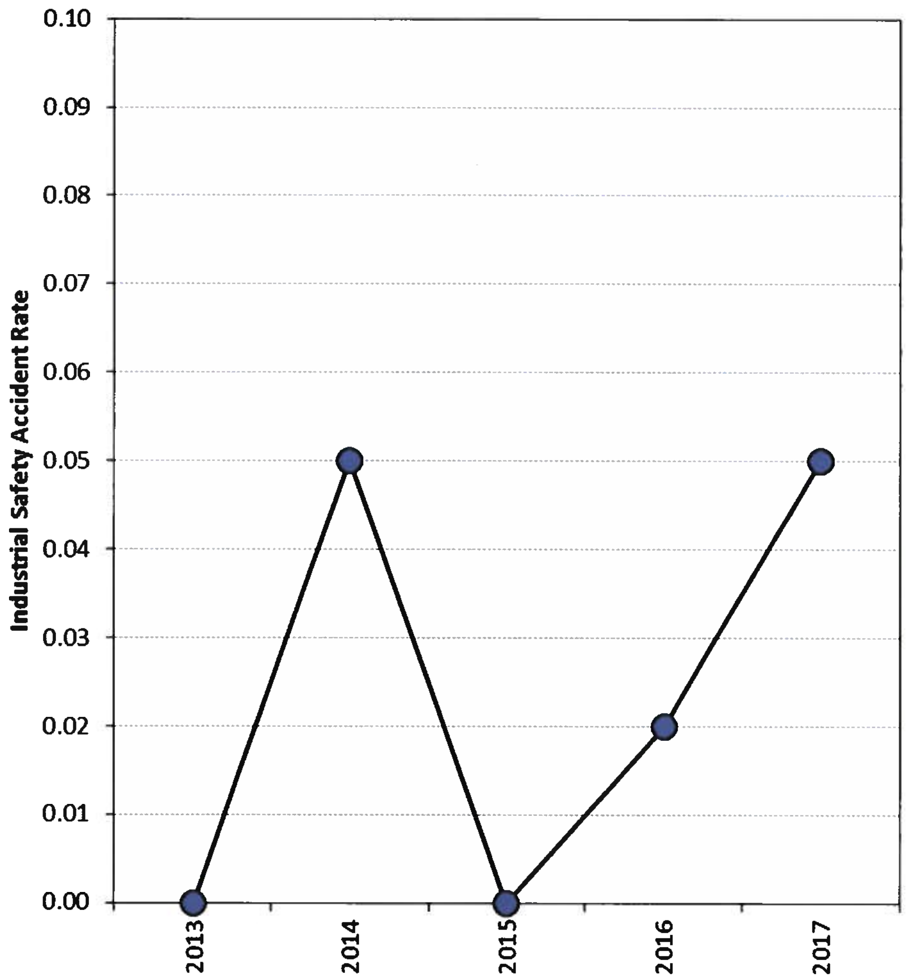


Figure 3. Industrial Safety Accident Rate (ISAR; 2013-2017)

9.0 ENVIRONMENTAL PROTECTION

9.1 Effluent and emissions control (releases)

Bruce Power maintains a suite of derived release limits and environmental action levels for airborne and waterborne radioactive emissions for each of Bruce A, Bruce B, and the Central Maintenance and Laundry Facility, as described in Reference B1, Attachment A, Section 2.6.

Annual emissions are reported to the CNSC and to the public through the Environmental Monitoring Program report (available in May of each year).

The radionuclide most associated with public dose is airborne tritium. Emissions are well below the derived release limit and are generally declining (see Figure 4), even when considering the restart of Units 1 and 2 in late 2012.

Airborne tritium emissions are shown in Figure 4. Data for 2017 are not yet available. For comparison, the Derived Release Limit for each of Bruce A, Bruce B, and the Central Maintenance Laundry Facility is more than 100x greater than the total annual emissions from all three facilities together.

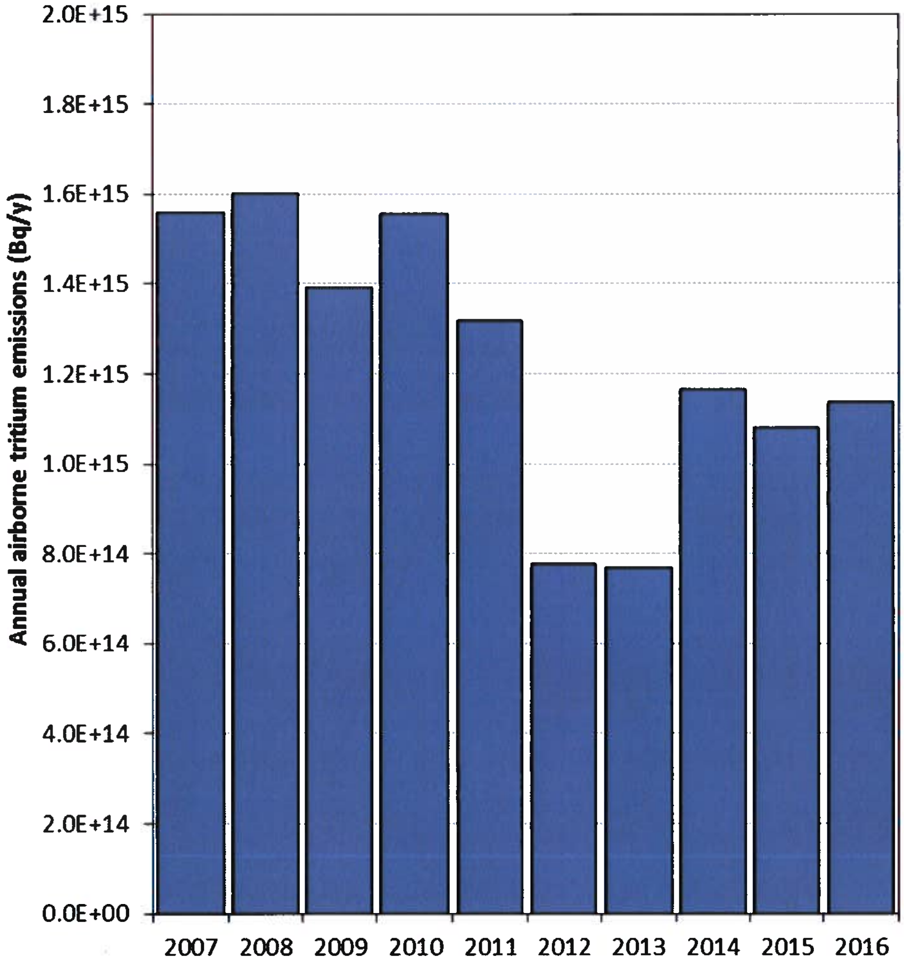


Figure 4. Annual airborne tritium emissions (Bq/y) for Bruce Power site facilities (2007-2016).

9.6 Update on the status of the Fisheries Act Authorization

As discussed in Reference B1, Bruce Power has been working with Fisheries and Oceans Canada and the CNSC with respect to a *Fisheries Act* authorization. As previously noted, Bruce Power submitted a draft application in 2015, an application in 2016, and a revised application in May 2017. The application process has involved multiple iterations, as appropriate methodologies were developed and as information and results were discussed by the various parties.

CNSC conducted a completeness review and requested additional information for the application. Bruce Power provided that additional information in October 2017, but discussion is continuing with respect to offset monitoring and calculations. Bruce Power plans to re-submit the final application in the latter part of 2018, pending outcomes of the continuing discussions with the CNSC.

10.0 EMERGENCY MANAGEMENT AND FIRE PROTECTION

10.2 Nuclear emergency preparedness and response

In Section 10.2.3 and 15.15.2, Bruce Power described plans to purchase a second mobile Emergency Management Centre (EMC). Based on a change to capital allocations, Bruce Power now plans to purchase the second mobile EMC in 2020.

Bruce Power has purchased mobile portal monitors and is developing a change plan to replace the manual contamination meters currently used to identify vehicular contamination at off-site municipal decontamination centres.

Additional information on emergency preparedness was provided in the supplemental material (Attachment A of this letter). This update discussed the changes to the Provincial Nuclear Emergency Response Plan (PNERP) as well as distribution of KI tablets.

11.0 WASTE MANAGEMENT

11.3 Waste management practices

As discussed in Reference B1, Section 11.2, Bruce Power continues to produce less low-level radioactive waste than planned through its internal programs to reduce and to minimize the volumes of waste required for long-term storage. Through these efforts, the company is consistently diverting 90% of its waste through this program.

Bruce Power also produces intermediate-level radioactive waste, which is primarily resin. The generation from resin from station operations is relatively fixed on an annual basis.

12.0 SECURITY

No update is provided.

13.0 SAFEGUARDS AND NON-PROLIFERATION

No update is provided.

14.0 PACKAGING AND TRANSPORT

No update is provided.

15.0 OTHER MATTERS OF REGULATORY INTEREST

15.12 Indigenous engagement

An update was provided in the supplemental material (this letter, Attachment A).

15.14 Physical modifications made as a response to Fukushima

The status of physical modifications made in response to the Fukushima incident was provided in the supplemental material submitted to the Commission (Attachment A of this letter). Briefly, Bruce Power continues to make progress with respect to the planned modifications.

15.15 Emergency communications systems

A detailed description of emergency communications was provided in Reference B1.

As discussed in Attachment A, Bruce Power is developing a system (DLAN) that can obtain and share plant data in the event of a beyond design basis accident. In 2017, Bruce Power continued to make progress with development and implementation of DLAN. Electronic forms (used within the DLAN application) were further developed. Draft emergency response procedures applicable to DLAN were developed. Training is in progress for applicable Emergency Response Organization positions. Updates to the DLAN application itself are being made based on lessons learned from the Bruce A and Bruce B corporate exercises that were conducted in 2017.

As discussed in Reference B1, Bruce Power and OPG developed enhanced plume dispersion modelling software. The new software application was tested and fully implemented in 2017.

Bruce Power demonstrated the use of mapping software during the 2017 corporate exercise. However, Bruce Power has selected an alternate software package to provide the capability to track on-site and off-site response equipment through real-time geolocation technology. Bruce Power continues to plan to make this package operable within the Emergency Management Centre through the DLA system, which is supported with backup power and communications to ensure continuity of operations.

15.16 Elements of the licence application package

As initially described in Reference B1, the licence renewal application package was structured as two primary documents: the licence renewal application and the performance review. These documents were supported with supplementary submissions:

- Integrated Implementation Plan (Reference B2),
- Unit 6 Return to Service Plan (Reference B3),
- Unit 6 Project Execution Plan (Reference B3),
- Environmental Risk Assessment (Reference B4) ,
- Final report for the U12 Environmental Assessment follow-up monitoring program (Reference B5),
- Summary report of whitefish research activities (Reference B6),
- Summary report of low-dose radiation and environmental research activities (Reference B7), and,
- Security program description (Reference B8).

Since that time, Bruce Power has submitted the following additional supplemental material to the Commission (technical material submitted to CNSC staff on request is not listed here):

- Fitness-for-service of pressure tubes (Reference B9),
- Updated Environmental Risk Assessment (Reference B10),
- Community interest reports (Reference B11)
- Supplemental application for consolidation of selected 13152 licences (Reference B12), and,
- Supplemental material and update to the performance review (this letter).

Integrated Implementation Plan: the Integrated Implementation Plan (IIP) is the final output of the Periodic Safety Review. Based on the PSR, Bruce Power has committed to implement 191 actions to implement practicable safety improvements. The IIP was submitted as part of the PROL renewal application in Reference B2 and accepted by CNSC staff in Reference B14.

Note that the overall conclusion of the Periodic Safety Review is that continued operation of Bruce A and Bruce B over the 10-year Periodic Safety Review period is acceptable.

- The review against modern codes and standards, as well as industry best practices, identified no safety concerns requiring immediate action.

- Operation of Bruce A and Bruce B is safe, with significant safety margins to deterministic safety analysis dose acceptance limits and probabilistic safety analysis safety goals. The IIP will further enhance the safety basis of the nuclear facilities in order to ensure that dose limits and risk goals are met over the designated period and beyond. As described in the Global Assessment Report, the Periodic Safety Review demonstrated adequacy of the design and defence-in-depth provisions, based on a review of the fundamental safety principles associated with all five levels of defence-in-depth.

- As described in the Safety Factor Reports, the Structures, Systems, and Components and programs that are in place are adequate to ensure safety for operation; and,

- As listed in the IIP, practicable improvement opportunities were identified in order to further enhance safe and reliable operation, as well as to align Bruce A and Bruce B design and operation with modern regulatory documents, codes, and standards applicable to new nuclear power plants.

Since the application in 2017, Bruce Power has fully completed nine IIP items and completed interim milestones for three additional IIP items. Going forward, Bruce Power will submit an annual IIP update to CNSC staff which will summarize the status of each item and address any appropriate changes to schedule or scope. Bruce Power is on track to complete 16 additional IIP items before the next annual update in 2019.

Environmental Risk Assessment: at the request of CNSC staff, an updated Environmental Risk Assessment was submitted (Reference B10). This update did not change any of the conclusions of the ERA submitted in Reference B4. The ERA demonstrates that the major component replacement activities and the operation of the Bruce nuclear facilities will have no significant adverse effect on the environment or human health.

Community interest reports: supplemental information was provided with respect to current and past engagement with Saugeen Ojibway Nation, Historic Saugeen Métis, and the Métis Nation of Ontario (Reference B11).

U12 Environmental Assessment follow-up monitoring program: the final report for the U12 Environmental Assessment follow-up monitoring program was submitted in 2016 (Reference B5). CNSC staff have agreed that the follow-up monitoring program is complete (Reference B13).

Application for consolidation of 13152 licences: as discussed in the Performance Review, Bruce Power plans to consolidate selected 13152 licences into the PROL, and plans to work with CNSC staff to consolidate any remaining 13152 licences in the future. A separate application for revocation of selected 13152 licences, with concurrent amendment to the PROL, was prepared and submitted to the Commission (Reference B12).

16.0 REFERENCES

B1. Letter, F. Saunders to M.A. Leblanc, "Application for the Renewal of the Power Reactor Operating Licence", June 30, 2017, NK21-CORR-05031-13493 / NK29-CORR-00531-14085 / NK37-CORR-00531-02768.

B2. Letter, F. Saunders to M. Leblanc, "Supplement to the Application for Renewal of the Power Reactor Operating Licence: Periodic Safety Review Reports", July 19, 2017, NK21-CORR-00531-13543 / NK29-CORR-00531-14165.

B3. Letter, F. Saunders to M. Leblanc, "Supplement to the Application for the Renewal of the Power Reactor Operating Licence: Major Component Replacement (MCR) Project Execution Plan and MCR Bruce B Unit 6 Return to Service Plan", June 30, 2017, NK29-CORR-00531-14175.

B4. Letter, F. Saunders to M. Leblanc, "Supplement to the Application for the Renewal of the Power Reactor Operating Licence: Updated Environmental Risk Assessment that includes Major Component Replacement", June 30, 2017, NK21-CORR-00531-13620 / NK29-CORR-00531-14261 / NK37-CORR-00531-02787.

B5. Letter, F. Saunders to K. Lafrenière, "Bruce A Environmental Assessment Follow-up Monitoring Report, 2015", November 21, 2016, NK21-CORR-00531-13142.

B6. Letter, F. Saunders to M. Leblanc, "Supplement to the Application for the Renewal of the Power Reactor Operating Licence: Whitefish Research Review", June 30, 2017, NK21-CORR-00531-13494 / NK29-CORR-00531-14088.

B7. Letter, F. Saunders to M. Leblanc, "Supplement to the Application for the Renewal of the Power Reactor Operating Licence: University Research Summary", June 30, 2017, NK21-CORR-00531-13587 / NK29-CORR-00531-14219.

B8. Letter, F. Saunders to M. Leblanc, "Supplement to the Application for the Renewal of the Power Reactor Operating Licence: Submission of Updated Security Program Description - Bruce Nuclear Generating Stations A and B", June 30, 2017, NK21-CORR-00531-13367 / NK29-CORR-00531-13917.

(This document contains prescribed information, pursuant to the *General Nuclear Safety and Control Regulations*, Section 21(c), and cannot be released to the public.)

B9. Letter, F. Saunders to M. Leblanc, "Supplement to the Application for the Renewal of the Power Reactor Operating Licence: Fitness-for-Service of Pressure Tubes", October 13, 2017, NK21-CORR-00531-13854 / NK29-CORR-00531-14517.

B10. Letter, F. Saunders to M. Leblanc, "Supplement to the Application for the Renewal of the Power Reactor Operating Licence: Updated Supplement to the 2017 Environmental Risk Assessment Data", December 7, 2017, NK21-CORR-00531-13937 / NK29-CORR-00531-14601 / NK37-CORR-00531-02876.

B11. Letter, F. Saunders to M. Leblanc, "Supplement to the Application for the Renewal of the Power Reactor Operating Licence: Bruce Power Indigenous Community Interests Reports for Saugeen Ojibway Nation, Historic Saugeen Metis, and Metis Nation of Ontario", January 24, 2018, NK21-CORR-00531-14156 / NK29-CORR-00531-14842 / NK37-CORR-00531-02912.

B12. Letter, F. Saunders to M. Leblanc, "Bruce Power Application for the Renewal of the Power Reactor Operating Licence: Supplemental Requests", February 1, 2018, NK21-CORR-00531-13890 / NK29-CORR-00531-14552 / NK37-CORR-00531-02865.

B13. Letter, S. Simic to F. Saunders, "Bruce NGS A: Environmental Assessment Follow-up Monitoring Report, 2015", November 1, 2017, e-Doc# 5377613, NK21-CORR-00531-13962.

B14. Letter, S. Simic to F. Saunders, "Acceptance for the Global Assessment Report and Integrated Implementation Plan", September 13, 2017, e-Doc#5333499, NK21-CORR-00531-13840 / NK29-CORR-00531-14502.

Enclosure 1

Performance Review of Bruce A and Bruce B

June 2017

(Attachment B of Letter, F. Saunders to M. Leblanc, "Application for the Renewal of the Power Reactor Operating Licence", June 30, 2017, NK21-CORR-00531-13493 / NK29-CORR-00531-14085 / NK37-CORR-00531-02768)

PERFORMANCE REVIEW OF BRUCE A AND BRUCE B

June 2017

Executive Summary

Bruce Power is applying to the Canadian Nuclear Safety Commission for a 10-year renewal of its licence to operate the Bruce A and B nuclear generating stations.

This application covers the period from 2018-2028 and incorporates the Integrated Implementation Plan (IIP) into the licensing basis. This multi-faceted plan emerged from a global assessment of all site activities and details specific commitments Bruce Power has made to ensure ongoing operations will remain safe.

Over the next 10 years, Bruce Power plans to complete life extension activities. This includes selected asset management activities during regular maintenance outages and Major Component Replacement (MCR) for Units 3 through 8 during more extended outages. Rather than completing all life extension activities during a traditional single, long refurbishment outage, this division of activities reduces project execution risks.

This document provides a high-level review of Bruce Power's business and performance as it relates to the Safety and Control Areas defined by the CNSC. The review of past performance primarily covers the time since the last licence application in 2015.

Table of Contents

0.0 INTRODUCTION

0.1 Background

Bruce Power is applying for a 10-year renewal of the Power Reactor Operating Licence for Bruce A and Bruce B, from September 1, 2018, to August 31, 2028.

0.1.1 Bruce Power

Bruce Power is Canada's only private-sector nuclear generator and the operator of one of the world's largest operating nuclear generating facilities.

The company is a partnership among TransCanada Corp., Borealis Infrastructure (a trust established by the Ontario Municipal Employees Retirement System), The Power Workers' Union, The Society of Energy Professionals, and the Employee Equity Trust. Bruce Power employs approximately 4,200 people, more than 90% of whom own a stake in the company through an internal investment program known as Ourshare.

The Bruce A and Bruce B nuclear generating stations produce electricity for sale primarily in Ontario and are the source of nearly one-third of the province's needs. Bruce Power has a commercial agreement with the Government of Ontario to operate all eights reactors until 2064.

As Canada's largest public-private partnership, Bruce Power leases the Bruce site from the Government of Ontario. This long-term arrangement sees Bruce Power: operate and invest private-sector funds in the long-term viability of these publicly-owned assets; make annual rent payments; fund waste management and future decommissioning.

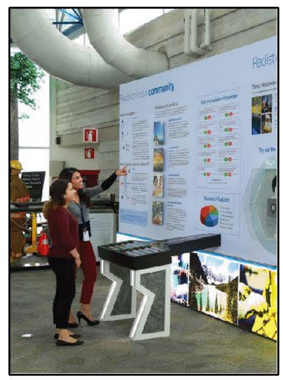
When Bruce Power assumed operation of the site in 2001, only four reactor units at Bruce B were in operation. During its first 11 years, Bruce Power and its private investors doubled the fleet of operating units; returning two laid-up reactors at Bruce A to service in 2003 and 2004 and entirely refurbishing the remaining two Bruce A units by 2012.

Today, Bruce A and Bruce B are critical parts of Ontario's electrical power infrastructure. This was underscored in 2012, when Hydro One successfully completed its 180-km, 500 kilovolt Bruce to Milton transmission line to improve grid capacity and stability.

In addition to electricity, Bruce Power also produces Cobalt-60, a radioactive isotope used in the medical industry for cancer treatment as well as sterilization of medical devices.

Bruce Power's agreement to supply Cobalt-60 to Ottawa-based Nordion also includes High Specific Activity (HSA) Cobalt, which is used in cancer treatments across the globe. This will help maintain the world's supply of HSA cobalt once the National Research Universal reactor in Chalk River, Ont., reaches its end-of-life in 2018. Cobalt-60 was also used to combat the Zika virus in impacted countries in 2016.

0.1.2 The Bruce site



Bruce Power operates from a 2,300-acre site that was chosen by the former Ontario Hydro more than 50 years ago because of its abundance of cooling water, naturally-low fish populations and solid bedrock in one of Ontario's most seismically-stable regions.

Situated on the shores of Lake Huron between the towns of Kincardine and Saugeen Shores, the Bruce site rests in the midst of woodland and wetlands approximately 250 km northwest of Toronto. It is home to more than 235 species of plants and more than 200 species of wildlife ranging from fish and reptiles to deer and 150 species of birds.

In many ways, the site is like a small, self-contained city. It boasts its own fire, security and emergency response teams as well as its own medical clinic and staff. It has a high-tech training centre, industrial laundry facilities, warehouses and a works department to maintain the more than 56 km of roads than line the property.

Bruce Power's corporate functions are housed on site in its modern Support Centre which also contains a large, multi-purpose auditorium. The Bruce Power Visitors' Centre, with a host of interactive, educational displays in its Exhibit Hall, overlooks the site and welcomes thousands of visitors a year to learn more about how nuclear electricity is generated.

A high-tech hub in a part of Ontario renowned for agriculture and tourism, Bruce Power works closely with the indigenous communities and municipalities in Bruce, Grey and Huron counties that surround and support its site. The company invests heavily in its local community through joint initiatives like physician recruitment programs and community sponsorships focused on health, wellness and youth development. Additional details are outlined later in this submission.

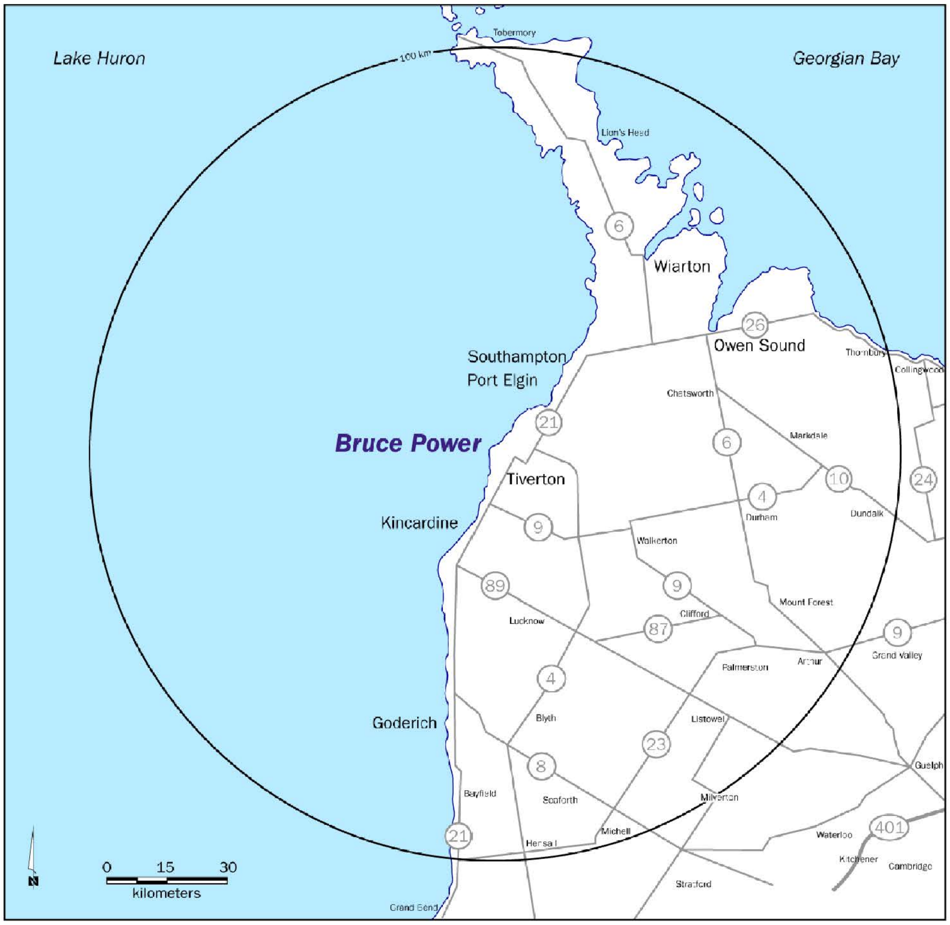


Figure 1. Bruce site location (NK21-SR-01320-00001 R005, Figure 1-2)

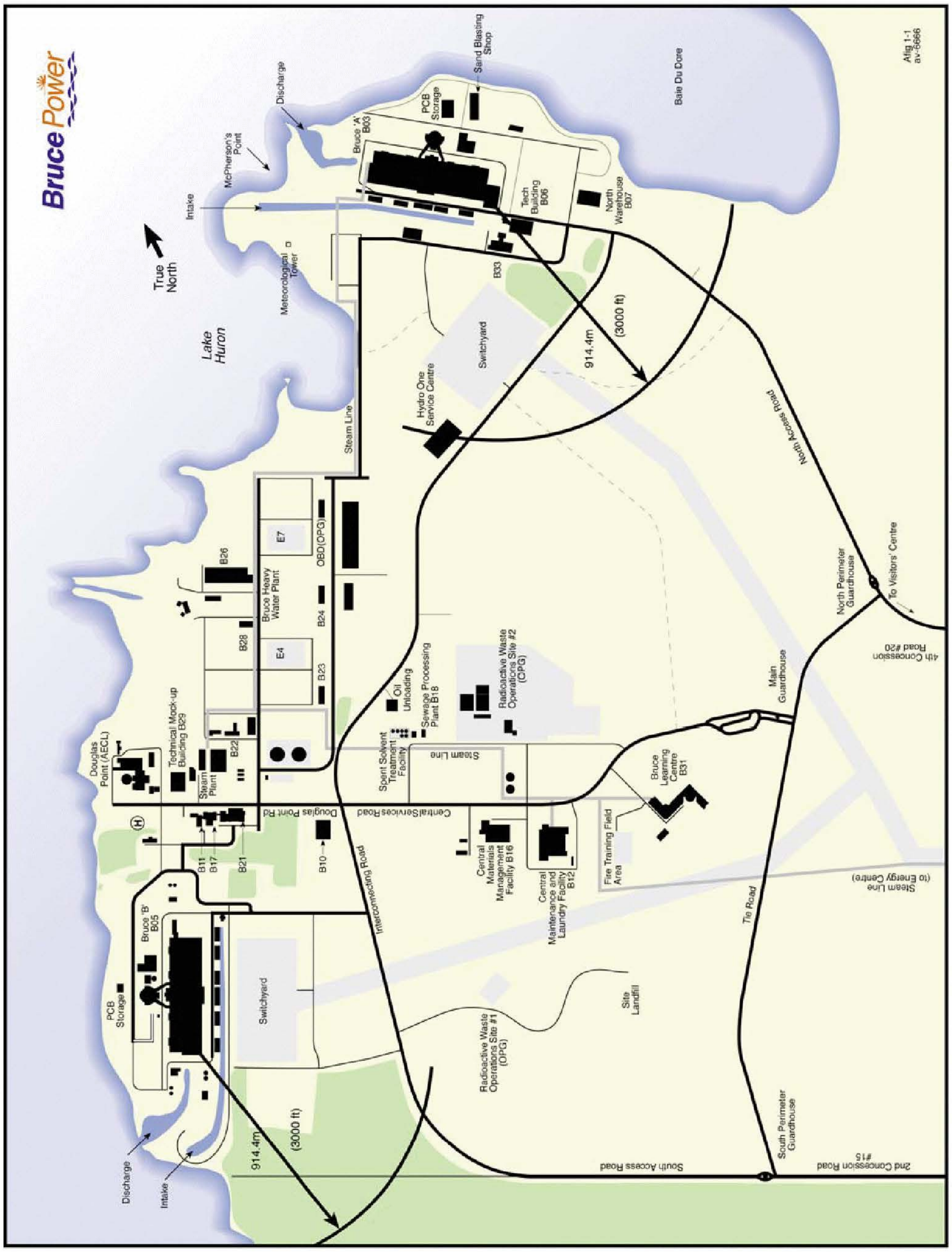


Figure 2. Bruce site layout (NK29-SR-01320-00001 R005, Figure 1-3)

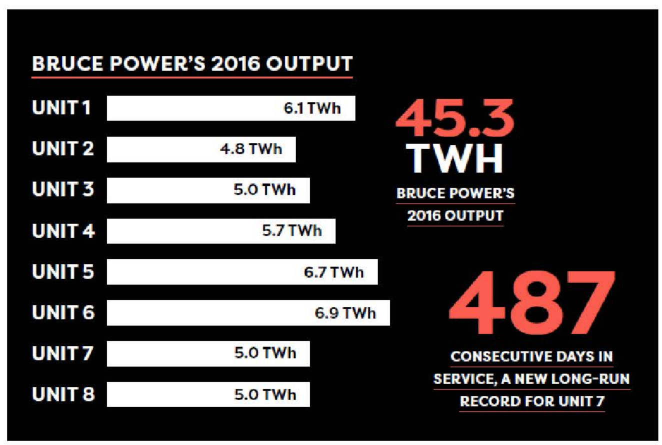
0.1.3 Environmental stewardship

Just like safety, environmental stewardship is central to Bruce Power's daily operations. It is committed to meeting or exceeding the standards of environmental performance set by its regulators and to continually assess the implications day-to-day actions have on the land, water and air that surround the site. During its 16-year history, Bruce Power has completed detailed reviews of its site under the *Canadian Environmental Assessment Act* for the restart of Units 3 and 4 and subsequently the refurbishment and continued operation of Units 1-4 at Bruce A. These environmental assessments confirmed that site operations do not have a significant adverse impact on the environment.

Bruce Power uses the International Organization for Standardization (ISO) 14001 Environmental Management System (EMS) as a tool to manage, control and assess environmental impacts. The ISO 14001-registered management system is designed to help improve environmental performance, ensure compliance with the law, improve efficiency and effectiveness to earn and retain regulatory and community trust. The management system is based on a PLAN-DO-CHECK-ACT cycle and helps integrate policy within people, processes, and procedures. Key policy commitments include regulatory compliance, pollution prevention and continuous improvement in environmental performance.

0.2 Highlights (2015-2017)

0.2.1 Performance



Bruce Power generated a record 45.74 TWh of electricity in 2015 and supplied the province with 2,400 MW of flexible generation. The company followed that up by producing 45.3 TWh in 2016, once again keeping its output in line with record years in 1991, 2013, 2014 and 2015. This sustained operational performance has been supported by an improving Equipment Reliability Index (ERI) through successful execution of maintenance activities and strong Human Performance practices.

In October of 2016, Bruce Power announced a new site peak output of 6,400 MW, an increase of 100 MW thanks to a range of enhancement made on the secondary side of the plants in recent years. Those enhancements equated to enough additional electricity to power a city the size of Sudbury.

Also in 2016, Unit 1 set a new post-refurbishment record run when it reached 151 days of consecutive operation. Unit 7 also celebrated a record run of 487 days before it was removed from service for a planned maintenance outage. High Specific Activity cobalt absorber rods were installed for the first time during that Unit 7 outage.

Bruce Power's performance has also been recognized nationally and internationally.

In 2015, an international review team conducted an Operational Safety and Review Team (OSART) mission to evaluate Bruce B operational safety performance compared to IAEA safety standards. Bruce B was very successful, and a number of good practices were identified that support our good performance. 19 items were identified as recommendations, suggestions, or self-identified areas for improvement.

The week of May 29-June 2, 2017, Bruce Power hosted four representatives from the IAEA to review progress since the 2015 OSART mission. For all of the 19 items, this team of international experts determined that the item was resolved or that Bruce Power is making satisfactory progress.

During the exit meeting, the OSART team noted a number of other positive findings from their short time on site. Bruce Power workers were recognized for openness, professionalism, and a strong commitment to the review process. The OSART team was also very impressed with Bruce Power's strategy to effectively drive improvements to adherence to the highest standards in a very personal way. The OSART team recognized Bruce Power's preparations for Major Component Replacement (MCR) in Unit 6 as very thorough and also noted improvements in the material condition and housekeeping standard at Bruce B.

The OSART team has provided a draft report to the Bruce Power leadership and to the CNSC. Both organizations will have the opportunity to provide comments before the final report is submitted to the Canadian government in late 2017.

In 2016, the World Association of Nuclear Operators (WANO) completed a successful peer review of Bruce A.

Both reviews helped Bruce Power identify areas for improvement as part of its journey to excellence and also let reviewers identify strengths at Bruce Power to share with others in the global nuclear community.

Nationally, Bruce Power received its strongest overall report card from the CNSC in 2016 (for the 2015 calendar year). The CNSC provides annual ratings of the effectiveness of each safety and control area, with "Satisfactory" and "Fully Satisfactory" comparable to an "A" and "A+", respectively. Both Bruce A and B received an integrated, overall rating of "Fully Satisfactory" and top ratings for Operating Performance, Conventional Health and Safety, Waste Management and Security. All other areas were rated "Satisfactory," as shown below.

Table 1. CNSC ratings for 2015 and 2016.
Satisfactory = safety and control measures are effective.
Fully Satisfactory = safety and control measures are highly effective.

	2015 Rating		2016 Rating (draft)	
Safety and Control Area	**Bruce A**	**Bruce B**	**Bruce A**	**Bruce B**
Management System	Satisfactory	Satisfactory	Satisfactory	Satisfactory
Human Performance Management	Satisfactory	Satisfactory	Satisfactory	Satisfactory
Operating Performance	Fully Satisfactory	Fully Satisfactory	Fully Satisfactory	Fully Satisfactory
Safety Analysis	Satisfactory	Satisfactory	Fully Satisfactory	Fully Satisfactory
Physical Design	Satisfactory	Satisfactory	Satisfactory	Satisfactory
Fitness for Service	Satisfactory	Satisfactory	Satisfactory	Satisfactory
Radiation Protection	Satisfactory	Satisfactory	Fully Satisfactory	Fully Satisfactory
Conventional Health and Safety	Fully Satisfactory	Fully Satisfactory	Fully Satisfactory	Satisfactory
Environmental Protection	Satisfactory	Satisfactory	Satisfactory	Satisfactory
Emergency Management and Fire Protection	Satisfactory	Satisfactory	Satisfactory	Satisfactory
Waste Management	Satisfactory	Satisfactory	Fully Satisfactory	Fully Satisfactory
Security	Fully Satisfactory	Fully Satisfactory	Satisfactory	Satisfactory
Safeguards and Non-Proliferation	Satisfactory	Satisfactory	Satisfactory	Satisfactory
Packaging and Transport	Satisfactory	Satisfactory	Satisfactory	Satisfactory
Integrated Plant Rating	**Fully Satisfactory**	**Fully Satisfactory**	**Fully Satisfactory**	**Satisfactory**

0.2.2 Safety

Bruce Power's Number 1 value of "Safety First" is fundamental to its success and essential to achieving its long-term business goals. Safety is the primary consideration guiding decisions and actions.

The company minimizes risk to the public, visitors, contractors and employees by integrating robust and effective hazard management into business planning and work activities. A healthy safety culture and healthy workplace environment are at the heart of everything Bruce Power does, which is reflected in the company's goal of incurring zero occupational injuries or illnesses. Its Occupational Health and Safety (OH&S) managed system provides a framework which regularly realigns safety objectives and programs to ensure continuous improvement.

Bruce Power strives for excellence beyond the minimum legal requirements and adopts proven, effective, best-in-class practices to provide enhanced safeguards vital to sustainable, top-quartile performance. In 2015, employees and contract staff worked than 12 million hours worked without a Lost Time Injury (LTI) and its Industrial Safety Accident Rate (ISAR) continued to be 0.00, placing Bruce Power in the top quartile of CANDU plants. In 2016, employees delivered sustained performance across all four safety pillars with a clear focus on reactivity management, environmental performance and with up to seven million hours worked without an a lost-time injury or a major or moderate environmental spill.

More recently, the company launched its "***You Can Count On Me***" campaign to reinforce the personal responsibility we all have for safety. Its central message -- that everyone at Bruce Power relies on one another to be safe every step, every time and every day – is at the very heart of the company's safety culture.

Or course, safety does not stop at the site boundaries. With respect to safety of the public, Bruce Power assesses the annual radiation dose to people living near the Bruce site. The maximum dose received by any member of the public is well below the legal dose limit, as discussed further in Section 7.5.

Over the past several years in particular, there has been a growing focus in the nuclear industry and with the Canadian Nuclear Safety Commission (CNSC) on emergency preparedness and emergency response following the event at the Fukushima Daiichi nuclear power plant in Japan. Bruce Power is regarded as an industry leader in this area.

In 2015, Bruce Power opened a $25 million, 23,000 square-foot fire training facility (bottom right), providing greater training opportunities for our Emergency and Protective Services department, as well as co-training opportunities with municipal fire departments.

Additionally, in 2015 Bruce Power participated in a joint exercise with Ontario Fire Marshal and Emergency Management (OFMEM) called Huron Resolve to test our collective capability to respond to these situations. Over 1,000 participants, including individuals from Bruce Power and over 30 municipal, provincial and federal agencies, collaborated on "Exercise Huron Resolve," a five-day, full-scale emergency situation. Emergency response organizations were tested in a wide-range of scenarios.

0.2.3 Fukushima Improvement Project update

Fukushima-related projects continue to demonstrate progress. During the Bruce A Station Containment Outage (SCO) in 2016, the Bruce A Containment Filtered Vent connections were installed.

In 2017, the preferred option for Passive Containment Filtered Venting System has been selected. Preparations are also progressing well for the Primary Heat Transport/Moderator Emergency Makeup system.

In response to new CNSC requirements, Bruce Power distributed potassium iodide (KI) tablets to households and businesses around its site in 2015. This initiative replaced the existing practice of having the tablets available in bulk at the Municipal Reception Evacuation Centre. Information packages were mailed out in April 2015 to approximately 1,500 residents and businesses within 10 km of the Bruce Power site outlining a number of options as to how to obtain these tablets for safe keeping in their home or business with direct follow-up to occur with those residents.

An updated information package was sent out during Emergency Preparedness Week that also highlights how to be prepared for all hazard risks. In addition, Bruce Power “Category A” workers on site have received portable radios from which they will receive provincial emergency notifications. Testing of these new portable radios has been incorporated into Bruce Power’s annual Emergency Response Organization drill and exercise schedule.

Above: ***Bruce Power’s Break The Silence campaign has raised awareness, and more than $84,000, for mental health initiatives.***

Below: ***The Plug N’ Drive exhibit at the Bruce Power Visitors’ Centre serves as an educational tool to promote environmental sustainability.***

0.2.4 Community

Throughout its 16-year history, Bruce Power has worked hard to be a responsible neighbour. Through open communications, active community outreach and an extensive Corporate Social Responsibility program, the company has forged strong community ties.

Bruce Power is committed to meaningful and effective engagement with Indigenous communities, including the Historic Saugeen Métis (HSM), the Métis Nation of Ontario (MNO), and the Saugeen Ojibway Nation (SON). Protocol agreements with all three groups enable active collaboration on matters pertaining to regulatory engagement and consultation, employment, training, education, community investment, business development and open communication.

In 2016, the company created a $1.2 million Aboriginal Community Investment Fund to strengthen educational, environmental, training and youth development initiatives until 2019. It also hosted an Aboriginal Employment and Business Forum in Owen Sound and launched an initiative to encourage its suppliers to become members of the Canadian Council for Aboriginal Businesses (CCAB) to strengthen links to Indigenous communities and businesses.

Bruce Power also enhanced its contracting process to include recognition for companies that are Aboriginally-owned, employ Aboriginal people, have an Aboriginal Policy and are active CCAB members.

In 2015, Bruce Power created its Environment and Sustainability Fund to invest $400,000 annually in restorative and rehabilitation projects and programs that involve waterways and habitats. The fund will also help manage invasive species, promote the growth and survival of native plants and species, support educational events and contribute to sustainable communities.

Tying innovation to environmental responsibility, Bruce Power also partnered with Plug ‘n Drive, Pollution Probe, local municipalities, conservation and educational institutions to Electric Vehicle charging stations in Kincardine, Port Elgin, Saugeen First Nation, Southampton, Walkerton, Wroxeter, the University of Waterloo and Humber College in downtown Toronto.

Bruce Power understands the need to invest today in tomorrow’s leaders. In 2017, its new scholarship program provided 10 post-secondary students with $2,000 each for their studies. The company also announced plans to provide $5 million in funding to the Northern Ontario School of Medicine to conduct health research in Northern Ontario, specifically in relation to radiation and the environment. To meet growing demand and help educate the public on how nuclear energy is generated, Bruce Power also expanded its bus tour program to two site tours a day from Monday to Saturday throughout the peak summer period.

As the largest employer in its region, Bruce Power understands how vital health care is to its employees, their families and communities. For years, the company has actively recruited new physicians and invested in facilities and equipment throughout the region. Since 2016, Bruce Power has also led a social media awareness campaign during Mental Health Awareness Week and donated $1 for every use of the hashtag #BreakTheSilence. In 2017, Bruce Power proudly donated $84,000 to local mental health initiatives as part of the campaign.

These community efforts have drawn external recognition for Bruce Power, which was honoured with the 2016 Sustainability Award as part of the Ontario Business Achievement Awards by the Ontario Chamber of Commerce. The award goes to a business that has demonstrated that being a leader in sustainability makes good business sense. For the fifth straight year, Bruce Power was also named one of Canada’s 2016 Top Employers for Young People, which recognizes the nation’s best employers when it comes to attracting and retaining younger workers. The company was also awarded the 2015 Platts Global Energy Award for Industry Leadership in the power sector at an event in New York City. The award highlights corporate and individual innovation, leadership and superior performance in 17 categories that span the entire energy complex.

0.3 Summary of the Application

Bruce Power is applying to renew the CNSC licence to operate the Bruce A and Bruce B nuclear generating stations at the Bruce site. The current licence, PROL 18.00/2020, is valid from 2015 to 2020.

Bruce Power is applying for a 10-year renewal period, from September 1, 2018, to August 31, 2028. An "early" renewal and a longer licence period are requested to support the planned Major Component Replacement at the Bruce A and Bruce B stations.

Specifically, the current operating licence does not encompass the full scope of the Major Component Replacement projects (for more details, see Section 0.4). Our application therefore includes the Periodic Safety Review, which is a major, multi-year assessment of Bruce Power operations against a broad suite of modern international codes and standards. The output of the Periodic Safety Review is referred to as the Integrated Implementation Plan (IIP) and describes specific commitments that will be taken to address differences between Bruce Power operations and the requirements of the modern codes and standards.

Although codes and standards have evolved since the plants were designed and built 40 years ago, the commitments from the IIP ensure that deviations from those codes and standards are addressed. Deviations that have relevance to safety are addressed in a manner that leads to an equivalent level of safety. The IIP is Bruce Power's guarantee that its operations are as safe as would be required by modern codes and standards.

The renewal application is intended to incorporate the IIP commitments in the IIP into the licensing basis for the next renewal period. This will ensure that the scope of the Major Component Replacement is well defined in advance of the appropriate milestones, which will support on-time, on-budget execution of these projects.

A longer licence renewal period is warranted based on past performance and is requested to ensure continued investor support. The Major Component Replacement projects represent an $8 billion private-sector investment in public assets, to support a long-term contract with the Government of Ontario. In order ensure availability of private-sector funding, Bruce Power must minimize the risk that major changes in project scope imposed by the regulator could have on project cost and schedule.

A longer licensing period—with a licensing basis that includes the Major Component Replacement projects as well as the IIP—will ensure continued investor support as regulatory requirements will not change substantively during the initial phases of the MCR project. Therefore, Bruce Power requests a 10-year period of validity for the renewed operating licence. The commitments in the IIP ensure that safety will be assured over the licensing period.

The documents submitted by Bruce Power to the Commission that form the elements of the licence application are described in Section 15.16.

This document—the Performance Review—describes, at a high level, the Bruce Power programs which address each CNSC Safety and Control Area. The entirety of Bruce Power's business is governed by the collection of programs that fall within the Bruce Power management system.

Note: The term *program* is generally used in this document to refer to the second level of the Bruce Power management system; each program is a suite of related procedures and processes that are managed collectively. However, the programs required by the operating licence may be implemented through multiple Bruce Power business programs.

The definition, as given by the CNSC, of each Safety and Control Area is provided. For each Safety and Control Area, the CNSC lists Specific Areas that fall within the overall Safety and Control Area. For each Specific Area, this review addresses the following, in accordance with GD-379, Guide for Applicants and Intervenors Writing CNSC Commission Member Documents:

- Relevance and management: the relevance of the Specific Area to the licensed activities, and the overall approach by which Bruce Power manages that specific area;
- Past performance: performance over the last licensing period (2015 onwards), at minimum. Because this review was compiled in Q2 of 2017 with information available as of Q1 of 2017, the review primarily covers performance from 2015 to 2016;
- Future plans: specific future plans with respect to that specific area, if known. General statements of planned improvement have not been made, as continuous improvement is expected for all areas of Bruce Power's management system. If changes or improvement plans are relevant for MCR, these have been noted. (Note that the MCR project will use existing Bruce Power governance, so changes may not be required for all programs.)
- Challenges: as with any organization, Bruce Power sometimes experiences challenges with managing people, processes, or projects. This performance review is intended to provide a frank self-evaluation of significant challenges with respect to the Specific Area. Where challenges have been identified, this review provides the planned approach to addressing those challenges. This section is intended to reflect high-level challenges, with the understanding that minor or routine challenges are continuously managed through the management system.
- Requests: this section lists any requests made by Bruce Power to the Commission with respect to the renewed licence and the conditions of the renewed licence.

Bruce Power maintains a suite of licences from the CNSC, all of which support the business authorized by the power reactor operating licence which is the subject of this review. In addition to the operating licence for the nuclear generating stations, Bruce Power has the following licences:

- A Nuclear Substance and Radiation Devices licence, issued for the possession and use of nuclear substances for a wide variety of support activities and equipment;
- A Class II Nuclear Facilities licence, issued for operation of an irradiator facility (instrument calibration) at the Bruce B generating station, as well as a supporting storage facility on the Bruce site;
- A Nuclear Substance and Radiation Devices licence, issued for the conduct of industrial radiography;
- A Dosimetry Services licence;
- A Waste Nuclear Substances Licence, issued for support activities, including radiological laundry, machine shop, and instrument calibration. Revocation of this licence has been requested, as the authorization of the power reactor operating licence extends to these support activities (Reference B1);

- Various licences to import or export controlled nuclear information. This typically refers to technical data submitted to potential vendors competing for service contracts. Although the number of import or export licences varies regularly, at the end of Q1 2017, Bruce Power held 19 additional import and/or export licences.

Going forward, Bruce Power plans to work with the CNSC to consolidate some of these licences.

0.4 Business plan

"Safety First" is Bruce Power's number one value. Bruce Power ensures that a healthy safety culture and a healthy work environment are at the heart of decision making.

Bruce Power is a key supplier of reliable baseload electricity, in support of Ontario's Long-Term Energy Plan. Bruce Power has secured a long-term agreement with the Independent Electricity System Operator (IESO) to provide up to 6400 MW of electricity from the Bruce site. In return, Bruce Power must operate Bruce A and Bruce B with the highest level of predictability and reliability, complete investment projects on time and on budget, and execute asset management and life extension activities.

The Bruce site life-extension project took effect on January 1, 2016, with the commencement of a long-term agreement to provide Ontario with reliable baseload electricity to 2064. This agreement with the Independent Electricity System Operator (IESO) requires Bruce Power to demonstrate operational excellence as well as project excellence—simultaneously operating one of the world's largest nuclear facilities while growing into one of the largest construction companies in Ontario.

The scope of the life extension activities includes Major Component Replacement (MCR) and Asset Management Work (AMW). This mutually exclusive categorization will reduce execution risk by reducing the number of simultaneous projects while maximizing operational output.

In order to extend the life of the reactor units to 2064, Major Component Replacement is required for units 3 and 4 at Bruce A and units 5 through 8 at Bruce B. (Units 1 and 2 at Bruce A were refurbished as part of an earlier project completed in 2012.) For each of units 3 through 8, the Major Component Replacement projects will include (1) steam generator replacement, (2) feeder replacement, (3) pressure tube and calandria tube replacement, (4) installation and removal of unit isolation bulkheads, and (5) additional enabling work including defueling/dewatering and refueling.

The MCR projects will be completed in Life Extension Outages that will begin in 2020 with Unit 6. The planned schedule, shown in Figure 3, reflects coordination between Bruce Power, the IESO, the Ministry of Energy, and the broader nuclear industry. This schedule is subject to change.

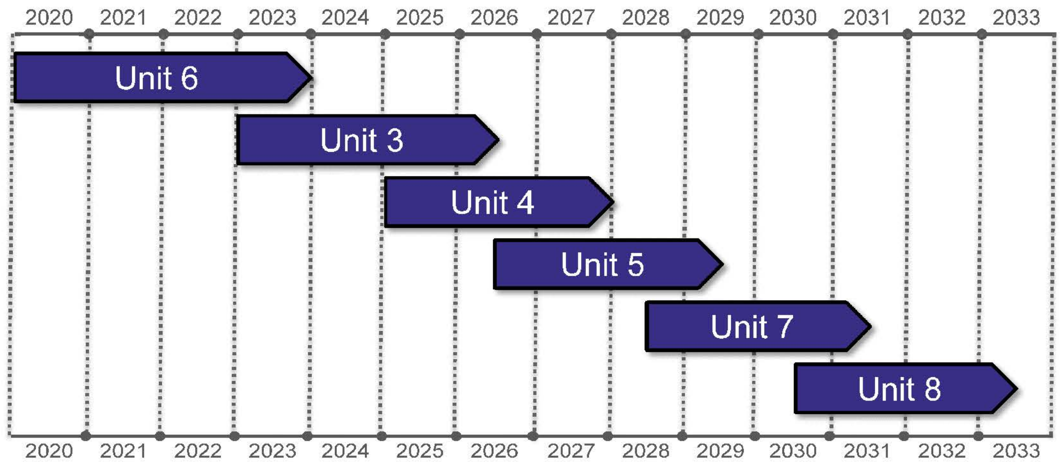


Figure 3. Planned schedule for Life Extension Outages (may be subject to change)

The scope of the Asset Management Work includes replacement and/or refurbishment of components from many key plant equipment groups (valves, motors, electrical equipment, fuelling machines, etc.). A core activity for the AMW project is the ongoing evaluation of operational health of plant equipment. This will allow Bruce Power to schedule the AMW activities prior to degradation or failures that could impact safe, reliable operation. At the same time, this evaluation will allow Bruce Power to optimize the schedule and cost by not replacing components sooner than necessary.

Bruce Power estimates that the Major Component Replacement project (units 3-8) will cost $8 billion (2014 dollars), while Asset Management Work will cost an additional $5 billion through 2053. Between 2016 and 2020, Bruce Power will invest $2.3 billion in both MCR and AMW activities.

Going forward, Bruce Power plans to:

- Invest in site infrastructure, Fukushima response, security, and fire protection to prepare the site for increased construction activities;
- Focus on continuous improvement, with initiatives directed to maximize equipment reliability, to sustain industry top quartile operating performance, and to safely complete outages on budget and schedule;
- Implement enhancements that deliver improved project management, to safely deliver projects with high quality, on time and on budget;
- Monitor the health of critical positions and manage resource pipelines through robust succession planning and leadership development programs;
- Foster strong support from the region around the site, including Indigenous communities, through a range of programs in place related to Corporate Social Responsibility, Economic Development and Community Outreach/Communications;
- Promote innovation and collaboration with the community, suppliers, unions, and industry partners to find new ways to improve operations and to deliver activities safely, with no consequential human performance errors; and,

- Work in partnership with Ontario Power Generation, allowing both organizations the opportunity to leverage experience in operations, refurbishment, and advocacy.

1.0 MANAGEMENT SYSTEM

Covers the framework that establishes the processes and programs required to ensure an organization achieves its safety objectives, continuously monitors its performance against those objectives, and fosters a healthy safety culture.

1.1 Management system

1.1.1 Relevance and management

The Bruce Power Management System (BPMS) describes the structure of Bruce Power, key processes, and expectations. It defines how all aspects of the business fit together in an integrated manner and drives Bruce Power towards excellence. The BPMS supports the enhancement and improvement of safety culture, excellence in worker performance, and the achievement of nuclear safety, security, and, business results.

The BPMS is designed to support the Bruce Power leadership team in consistently delivering expected results and in satisfying stakeholders such as the regulators, the public, shareholders, and employees. It provides the mechanisms, structure, and processes that ensure Bruce Power complies with its operating license and other legal and business requirements.

The objective of the Bruce Power Management System (BPMS) is to coordinate the business framework needed to satisfy corporate governance and regulatory requirements with a commitment to nuclear safety (reactor safety, radiological safety, industrial safety, and environmental safety) and security as a paramount consideration guiding decisions and actions. The BPMS is Bruce Power's quality assurance program and conforms to the requirements of CSA N286-05, *Management System Requirements for Nuclear Power Plants*.

The BPMS is documented in a Management System Manual (BP-MSM-1) and a suite of implementing programs. The governance provided by the BPMS controls changes to the interdependent processes, organizational structure, and document structures that are essential to managing business.

By design, the BPMS contributes to the establishment of a healthy culture for nuclear safety and a healthy culture for security. The BPMS assures the “Four Pillars” of nuclear safety (reactor, environmental, industrial, and, radiological safety), and security during normal operations as well as during extreme events, in support of N286-05 requirements.

No single element of the BPMS operates independently, as all parts of the management system are interconnected and interdependent.

A graded approach is used throughout the management system. The degree to which management system requirements are applied reflects the importance of the activity to safety, health, environmental, security, quality, economic, or other business requirements. Where a graded approach is adopted, the grading process is documented, with safety being the paramount consideration for guiding decisions and actions.

1.1.2 Past performance

Bruce Power is transitioning to full compliance with CSA N286-12. When the transition is complete, Bruce Power programs will use a PLAN-DO-CHECK-ACT approach to ensure the CSA N286-12 principles are embedded in governance. This approach will demonstrate the cycle of continuous improvement, which includes establishing requirements and performance metrics, monitoring performance, performing assessments, and implementing changes to the management system.

To support the transition, a Focus Area Self-Assessment was completed by each Corporate Functional Area Manager (CFAM) for their programs. A transition plan developed and accepted by CNSC staff. Governance supporting the development of program level documents and general procedures was revised to support the transition. All Bruce Power program-level documents will be revised by mid-2017 to reflect the new standard.

1.1.3 Future plans

Bruce Power will continue to integrate the BPMS and to consolidate processes and documents. This will support the ability to manage an increasing regulatory footprint, without necessarily adding complexity to the management system.

Bruce Power will seek to provide improved support for CFAMs in establishing the requirements for each program suite and to fully understanding the CFAM role.

Bruce Power plans to make improvements in governance with respect to defining the authorities and responsibilities associated with quality and other unique needs associated with project-related activities. These improvements will assist in preparation for life extension activities.

Bruce Power is undertaking a review of all programs to ensure the capabilities and resources needed for the MCR projects are in place.

1.1.4 Challenges

For some programs there have been indications of inadequate governance and inadequate definition of program requirements. In response, changes were introduced to the BPMS in order to more effectively identify how regulatory requirements are implemented within the management system. Additional changes were made to support CFAMs in their understanding of their role, and the requirements associated with the relevant program(s). This effort is ongoing.

Some areas, such as Pressure Boundary Quality Assurance, continue to operate as a small managed system within the larger managed system. This creates duplication of effort and increases the likelihood of misalignment between processes.

The oversight of work processes to ensure alignment with program requirements requires additional strengthening.

1.1.5 Requests

None.

1.2 Organization

1.2.1 Relevance and management

The clear definition of roles, authorities, and responsibilities is critical to achieving excellence in nuclear safety and to achieving Bruce Power's business goals.

BP-MSM-1 SHT0002, MSM-Approved Reference Chart Authorities and Responsibilities - Sheet 0002, and BP-PROC-00031, Organization Authority Register, define the authorities and responsibilities unique to each leadership position at the section manager level and above. An Approved Reference Chart of the organization structure is maintained. The Approved Reference Chart derives from information in the WorkDay application (the official system of record) and defines the organizational names, position/role titles, and reporting structure at the section manager level and above.

Controlled documents—including programs, plans, and procedures—further define responsibilities specific to workers associated with the scope of the document.

1.2.2 Past performance

During the licensing period, all organization manuals were superseded to a single document, BP-MSM-1 SHT0002, MSM-Approved Reference Chart Authorities and Responsibilities - Sheet 0002, which defines the authorities of positions at section manager level and above. This consolidated over 100 separate controlled documents into a single document. This consolidation improves the process for managing organizational structure change and provides improved overall configuration control for organizational structure changes.

A new enterprise system, WorkDay, was introduced. The new system provides improvements in the ability to execute changes to the organizational structure.

Bruce Power's previous Chief Executive Officer (CEO) retired in April 2016. A rigorous selection process was initiated, which included a broad international talent scan against a predetermined set of executive criteria and competencies relevant to Bruce Power and the CEO's role, including responsibility for safety. Three search firms (Canada, United States, and United Kingdom) executed the global search with regular guidance and direction from the Board of Directors. The new CEO commenced work in August 2016.

Bruce Power has re-organized to address the life extension activities. The improved structure will help Bruce Power safely and successfully execute the life extension activities. New positions include:

- Executive Vice President, Projects and Field Services,
- Vice President, Projects,
- Vice President, Life Extension, and
- Deputy Chief Nuclear Officer.

1.2.3 Future plans

The process for organizational change management will continue to be strengthened and streamlined as the integrated management system continues to mature.

1.2.4 Challenges

Configuration control of the management system is challenging due to a lack of integration between Bruce Power's enterprise systems. Following organization structure changes, updates to governance are not always timely. More efficient and timely alignment of changes are expected as a result of implementing a new enterprise-wide information system.

1.2.5 Requests

None.

1.3 Performance assessment, improvement and management review

1.3.1 Relevance and management

Bruce Power uses an "oversight defence-in-depth" approach, with multiple layers of performance assessment coupled with a strong corrective action process to assure continuous improvement.

Line management undertakes continuous in-process performance assessment through day-to-day activities such as observations of work, use and sharing of operating experience, lessons learned in project activities, monitoring of metrics, and supervisory oversight of workers.

Additionally, the management system includes a Corrective Action program. This program is used to identify and to eliminate or mitigate adverse conditions that resulted in, or could result in, undesirable impacts on nuclear safety (reactor, industrial, radiological, and environmental safety), business loss, or corporate reputation. The main elements of the Corrective Action program include:

- All adverse conditions are promptly identified, documented, and reported;
- For significant events and significant conditions adverse to quality, causes are determined, and corrective actions are taken to correct and/or prevent recurrence;
- Corrective actions are tracked to completion;
- Effectiveness is verified where appropriate; and,
- Periodic trend analysis is performed to identify adverse trends. If appropriate, corrective actions are taken to address adverse trends.

Planned and trend-informed oversight of the programs is performed regularly by process owners, including Corporate Functional Area Managers (CFAMs) who are responsible for the establishment and effectiveness of governance.

A major tool for performance assessment is the Focus Area Self-Assessment (FASA) process, which includes both comprehensive FASAs as well as Quick Hit FASAs. The FASA process is used to assess adequacy and effective implementation of a functional area (one or more programs), including a comparison with legal requirements, industry standards for excellence, and business needs. FASAs are also used to identify internal strengths and best practices, to identify performance and/or programmatic gaps, identify adverse conditions and opportunities for improvement, and to identify the specific corrective actions required to close identified gaps.

Other self-assessment tools used by CFAMs include self-evaluation team reviews, surveys, root cause investigations, apparent cause evaluations, self-checking, peer-checking, and training needs analyses. The use of the FASA and other self-assessment tools results in improved performance, innovation, quality, and productivity.

Planned quality control activities associated with contracts for services and source surveillances assure that work performed by third parties receives the oversight appropriate to its significance.

Internal audits are conducted by an independent nuclear oversight group.

Independent oversight consists of surveillances, planned audits, performance-based assessments, and regular Board of Directors oversight. Senior management receives information from oversight activities and acts on it if required in order to promote continuous learning. Senior management evaluates and escalates the results of oversight activities, if required.

The Executive Team participates in regular performance monitoring, project review meetings, and the periodic Business Assessment process to review performance, identified gaps, the health of nuclear safety culture, and the effectiveness of the management system.

The Nuclear Safety Review Board (NSRB), a subcommittee of the Bruce Power Board of Directors, has responsibility for monitoring the effectiveness of the management oversight process as it relates to nuclear safety. NSRB positions are filled with independent experts from the nuclear industry. The NSRB ensures that issues are identified and corrected. The NSRB reports independently to the Board.

Performance is assessed by the World Association of Nuclear Operators (WANO) as well as the International Atomic Energy Agency (IAEA) Operational Safety and Review Team (OSART). Good practices, as well as potential improvements and corrective actions, are identified through these external assessments.

1.3.2 Past performance

Bruce Power is transitioning to full compliance with CSA N286-12, *Management System Requirements for Nuclear Facilities*. When the transition is complete, Bruce Power programs will use a PLAN-DO-CHECK-ACT approach to ensure the CSA N286-12 principles are embedded in governance. This approach will demonstrate the cycle of continuous improvement, which includes establishing requirements and performance metrics, monitoring performance, performing assessments, and implementing changes to the management system. A graded approach is defined for many of these activities.

To support the transition, a Focus Area Self-Assessment was completed by each Corporate Functional Area Manager (CFAM) for their programs. A transition plan developed and accepted by CNSC staff. Governance supporting the development of program level documents and general procedures was revised to support the transition. All Bruce Power programs will be revised by mid-2017 to reflect the new standard.

1.3.3 Future plans

Bruce Power plans to better integrate the results of self-assessment and independent assessment activities. A more immediate and more holistic perspective on performance trends and oversight findings will improve self-criticality and proactive problem resolution.

Life extension activities will increase the amount of work activities performed at the Bruce site, as well as the utilization of contractors. Ensuring quality will require progressive enhancements to verification and oversight of work and to monitoring performance. Collaborating with vendors to ensure excellence in worker performance, a healthy nuclear safety culture, and the provision of quality materials and services will be a focus throughout the next licence period.

1.3.4 Challenges

For some programs there have been indications of inadequate governance and inadequate definition of program requirements. In response, changes were introduced to the management system in order to more effectively identify how regulatory requirements are implemented within the management system. Additional changes were made to support CFAMs in their understanding of their role, and the requirements associated with the relevant program(s). This effort is ongoing.

1.3.5 Requests

None.

1.4 Operating experience (OPEX)

1.4.1 Relevance and management

Bruce Power's Operating Experience Program defines processes to identify and capture lessons learned from sources within Bruce Power and from the international nuclear industry.

By systematically identifying, evaluating, and applying operating external experience, Bruce Power ensures that safety is the primary consideration guiding decisions and actions. The use of operating experience improves plant safety, equipment reliability, and commercial performance through improvements to processes, procedures, training, and design.

The main interface for gathering external operating experience is the CANDU Owner's Group (COG), which maintains a database of event information from all over the world. Operating experience provided by COG is screened by Bruce Power staff for significance and relevance and is shared with managers and subject matter experts to ensure due consideration. If appropriate, follow-on actions are created and tracked to ensure the operating experience is internalized.

All employees have access to internal and external operating experience when planning and performing their tasks.

1.4.2 Past performance

In recent years, Bruce Power has made several improvements to the process by which internal and external operating experience is used, including:

- "On This Day" OPEX is now available electronically on the OPEX website, which provides an opportunity for all workgroups to discuss OPEX events and lessons learned;
- Process improvements to Significant Operating Experience Reports (SOER) and other external OPEX reviews. The improvements were based on industry benchmarking and self-assessments performed in each year of the current licensing period; and,
- Development of a process to create and deliver interactive case studies for leadership development. On a periodic basis, leaders reflect upon past internal and external OPEX as a method to find and implement ways to continuously improve the organization.

Bruce Power was recognized by industry-expert peers for its performance in leveraging Significant Operating Experience Reports (SOERs). This is validated by the success that Bruce A and B have had in WANO Peer Evaluations in recent years.

In December 2015, Bruce Power hosted an IAEA OSART Mission, which provided positive feedback on the OPEX program.

Bruce Power has been recognized by its industry-expert peers and those in the CANDU fleet for leading CANDU plants in sharing useful lessons learned from its events and doing so in a timely manner.

1.4.3 Future plans

Bruce Power is committed to continued performance review and process improvement for all areas of the organization, including the OPEX program. This includes increased management oversight to ensure OPEX is considered and appropriately dispositioned, with relevant items communicated so that risks and lessons learned are fully understood. Specific future initiatives include:

- Vendor technical briefings, bulletins, and alerts are now acknowledged in the OPEX program but are evaluated under BP-PROG-10.01, Plant Design Basis;
- Improvements to knowledge management, including capturing, transferring, and accessing knowledge.
- Development of an "all-In-One" OPEX search capability to simplify the identification of relevant OPEX from site databases in a world where the growth of information continues to increase.

1.4.4 Challenges

The growth of available information continues to increase, which poses challenges for efficiently identifying and using relevant OPEX. As noted above, Bruce Power plans to develop simplified search capability to manage this increasing quantity of information.

1.4.5 Requests

None.

1.5 Change management

1.5.1 Relevance and management

BP-PROG-01.02, BPMS Management Program, establishes the framework for change management. Change is controlled to ensure that safety and regulation implications are considered and to ensure that changes reflect Bruce Power's number one value of "Safety First."

In accordance with BP-PROG-01.02, changes to the organization, processes, designs, systems, equipment, materials, and documents must be identified, justified, reviewed by stakeholders, approved, and implemented. Each program within the management system defines how changes are controlled with respect to the program's scope of activities. Some programs have defined implementing procedures specifically for management of change.

1.5.2 Past performance

During the last licensing period, Bruce Power made improvements to the processes used to manage changes to the governance hierarchy and to processes. These changes support the ongoing transition to full compliance with CSA N286-12, *Management System Requirements for Nuclear Facilities*.

The process tool used for assessment of proposed process changes has been improved in order to more effectively determine whether change management activities are required in association with the proposed process change.

1.5.3 Future plans

The process for management of changes to processes will continue to be strengthened and streamlined as the integrated management system further matures.

1.5.4 Challenges

The number, complexity, and interdependency of changes will increase with execution of life extension activities. This will increase the importance of effective and integrated change management over the future licensing period. Proper use of the change management processes will assure that any impact on safety is properly considered and mitigated, and that the benefits anticipated from implementing changes will be realized.

Bruce Power has observed that the impacts of proposed changes have not always been fully identified or managed. A continuing area of focus is to ensure accurate verification of initial change proposals, to ensure the proposals capture significant impacts prior to approval and implementation of the change.

1.5.5 Requests

None.

1.6 Safety culture

1.6.1 Relevance and management

Ensuring a healthy nuclear safety culture is essential to maintain safe operations and to operate efficiently. A healthy nuclear safety culture supports Bruce Power's number one value of "Safety First."

Bruce Power monitors the nuclear safety culture regularly, and periodically performs a nuclear safety culture assessment using an industry-recognized framework.

1.6.2 Past performance

The most recent nuclear safety and security culture assessment was a comprehensive, site-wide self-assessment completed in 2016. The Assessment used the INPO/WANO Traits of a Healthy Nuclear Safety Culture Framework and drew upon draft IAEA guidance for conducting assessments of culture for security. This was the first assessment, conducted at a Canadian power reactor licensee, of safety culture that also integrated an assessment of security culture.

The 2016 assessment included a survey, interviews, and focus groups. In addition, the 2016 assessment included contractor workers for the first time. The results showed improvements in all areas of the assessment repeated from the previous assessment in 2013. The overall results from the assessment are being considered. The corrective action program will be used to address findings.

1.6.3 Future plans

While the process for assessing culture for safety is mature, new opportunities are emerging to assess culture for security. Bruce Power intends to continue to lead in this area.

1.6.4 Challenges

Nuclear safety culture is difficult to measure. It relies of the ability of leaders or nuclear safety culture experts to draw insights from data collected, primarily, as part of nuclear safety culture assessments. In the past Bruce Power has relied on external support to identify underlying issues and to develop insights into its nuclear safety culture. In the future, Bruce Power needs to enhance its internal capability for nuclear safety culture assessment.

Bruce Power is currently considering how to most effectively monitor and assess culture for safety and security together, within the context of a project-based organization, in contrast to an operations-based organization. Bruce Power intends to explore good practices and to innovate in this area.

1.6.5 Requests

The CNSC has requested feedback on REGDOC-2.1.2, *Safety Culture*. Bruce Power notes that the field of safety culture assessment has evolved considerably since the early 2000s, and this evolution is expected to continue at least through the next licence period. Any regulatory document must recognize the rapid evolution of the field and therefore not act to stymie the development of new and innovative tools and methodology. Bruce Power requests that the CNSC include sufficient flexibility in REGDOC-2.1.2 such that licensees may adopt new and developing methodologies.

1.7 Configuration management

Configuration management is addressed in Section 5.0.

1.8 Records management

1.8.1 Relevance and management

Bruce Power's document management program defines the processes associated with the management of controlled documents and records. The program is required to satisfy statutory, regulatory, and licensing requirements for management of records.

As defined by the document management program, Bruce Power identifies records, retains them according to appropriate document retention requirements, and manages the storage and access to records to ensure integrity and protection against damage, deterioration, or loss.

1.8.2 Past Performance

The document management program is a mature program, with clearly defined processes and expectations. As with all of Bruce Power's programs, Bruce Power monitors for compliance with respect to the document management program. If gaps are identified, those gaps are addressed through the corrective action program.

1.8.3 Future plans

Bruce Power will continue to improve the document management program through streamlining and automating processes where feasible.

1.8.4 Challenges

None.

1.8.5 Requests

None.

1.9 Management of contractors

1.9.1 Relevance and management

Bruce Power's contractor management program defines the requirements and processes for management of workers under contract to complete work on behalf of Bruce Power. The contractor management program ensures that work is executed and managed as per the contractual agreement and in accordance with safety regulations, applicable Bruce Power procedures, budget, schedule, and appropriate quality standards. This program includes oversight processes and defines the roles and responsibilities of Bruce Power and its contractors.

1.9.2 Past performance

During the past licence period, Bruce Power completed an internal audit of the program. Additionally, CNSC staff completed a Type II inspection of the program. These assessments have provided insights for improving the program in 2017.

Strengths that were identified during these evaluations include:

- Information exchange with contractors through OPEX, Lessons Learned, and Pre-Job Briefs is done, and SCRs from previous jobs are included in the field packages.
- Bruce Power successfully monitors operating performance through the Station Condition Record (SCR) process. Through this process, issues are identified and corrective actions are put in place. The expectation is the same for contractors as Bruce Power Employees.
- Bruce Power’s human performance tools are communicated and clearly understood by contractors. Human performance is monitored through observation and coaching.
- Job Analyses identify the tasks or job functions that requiring initial training and those that require continuing training. Training content is created based on established training objectives. Procedures are applied to verify qualifications of contractors.

Areas for improvement that were identified during these evaluations include:

- Opportunity to improve documentation to be more explicit with expectations of contractor deliverables and subsequently the verification of those deliverables;
- Consistency in the application of forms; and,
- Linking of workers under contract to qualifications within the Training Information Management System is hindered by the status of the qualification.

In 2017, Bruce Power launched the “You Can Count On Me” initiative to ensure everyone is committed to consistently following standards (see Section 3.1.3). “You Can Count On Me” has a strategic focus on contractor performance and their commitment to high standards. Vendor performance scorecards have been implemented for our strategic partners and preferred suppliers. This increased focus on safety and quality has resulted in improved human performance (see Section 2.1.2). Vendor performance scorecards are reviewed frequently with oversight committees to help identify opportunities and to track action plans.

1.9.3 Future plans

The findings of the audit and inspection above will be addressed through the corrective action program.

The contractor management program is undergoing a major revision to incorporate these findings as well as to incorporate the PLAN-DO-CHECK-ACT cycle. Alignment with, and implementation of, Bruce Power’s pressure boundary program will also be assessed as part of the revision. New governance has been drafted with respect to managed task contracts, in order to provide enhanced focus on suppliers’ quality assurance programs and processes.

A comprehensive review of the governance has taken place to identify areas that can be enhanced to better address the requirement of the life extension activities.

As a result of the cross-functional CNSC inspection, there has been an increased collaboration with, and understanding of processes in Supply Chain, Training and Engineering. Opportunities to better integrate exist as each area deals with a separate part of the overall process of contractor management.

"You Can Count On Me" includes the active engagement of our strategic partners and preferred suppliers. Our partners will be assessed with respect to leadership fundamentals, standards, and worker engagement and will identify actions to achieve excellence in safety and quality.

1.9.4 Challenges

A number of stakeholder areas and processes are necessary to hire, onboard, oversee and off-board supplemental employees.

Contractor relationships are complex, with a number of due diligence requirements to address for each relationship. Additionally, contracts are becoming more specialized in relation to the type of work to be done. Bruce Power will continue to review the contractor management program to ensure that tools and techniques are available to manage the variety of contracted work.

An area of focus is the development of methods for verification of supplier qualifications, work processes, and oversight plans. A clear delineation is required between work executed under Bruce Power's management system and under a supplier quality program. This delineation assists the development and implementation of supplier oversight plans.

1.9.5 Requests

None.

1.10 Business continuity

1.10.1 Relevance and management

Bruce Power's business continuity management process identifies risks, threats, and vulnerabilities that could impact Bruce Power's continuity of operations. It provides a framework for building organizational resilience and provides the capability to recover if the business is interrupted.

The business continuity process is managed as part of Bruce Power's emergency management program. The process framework is based on the PLAN-DO-CHECK-ACT cycle, described briefly as follows:

- PLAN: identification of business functions which are critical to the existence of Bruce Power, and determination of the time at which those functions must be operational following an abnormal event;
- DO: implementation of business continuity controls, processes, strategies, and plans;

- CHECK: validation, monitoring, and review of performance with reporting to the business continuity governance committee; and,
- ACT: improvement of the process through preventative and corrective actions, based on the results of the reviews.

As part of the business continuity management process, Bruce Power has defined a business continuity and recovery plan. The purpose of this plan is to guide the recovery director in developing a recovery plan following an incident. The plan assists the Emergency Response Organization (ERO) Commander and Crisis Management Team to determining when to activate the Recovery Phase. The plan includes a set of activities to guide the Recovery Director in formulating the incident-specific recovery plan to continue or recover critical functions with the goal of minimizing loss or harm to Bruce Power.

Most functional areas (one or more programs) have a defined business continuity plan as well. The functional area business continuity plans document all activities to continue or recover the critical functions and the resources (tools, material, staff, and information) required to operate the critical function at a minimally acceptable level, within a specific recovery time that ranges from 0 hours to 7 days. The plans are written in a manner that enables repeatable recovery performance, by any Emergency Response Organization member assigned to lead or perform the recovery activities.

1.10.2 Past performance

Bruce Power's business continuity management process has evolved considerably throughout the past licensing period.

In 2015, a governance and oversight body was established to provide strategic direction and executive oversight.

In 2016, Bruce Power comprehensively re-assessed the critical functions across all functional areas. A series of executive challenge sessions were conducted to ensure organizational alignment through application of consistent methodology and assessment criteria. During a corporate exercise scenario, Bruce Power exercised the critical functions with a recovery time of 0-48 hours. This exercise (and associated awareness and documentation) was used to improve the integration of the crisis management team, the ERO Commander, and the recovery team.

1.10.3 Future plans

As with all Bruce Power programs and processes, Bruce Power will continue to improve the business continuity process. In 2017, Bruce Power plans to:

- Enhance the integration between the emergency response and business recovery organizations;
- Improve the business continuity plan template to enhance guidance for preparation of business continuity plans;
- Develop business continuity training for Corporate Functional Area Managers (CFAMs), business continuity coordinators, and business continuity leads; and,

- Conduct a third-party audit of the business continuity process.

In 2018 and in future years, the focus will be ensuring continuous improvement through the CHECK and ACT elements of the process, applying lessons learned, and through implementing operating experience.

1.10.4 Challenges

None.

1.10.5 Requests

None.

2.0 HUMAN PERFORMANCE MANAGEMENT

Covers 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.

2.1 Human performance program

2.1.1 Relevance and management

Bruce Power's human performance (HU) program defines how Bruce Power plans, implements, detects, and corrects human performance-related activities. The program takes into account human factors and applies defence-in-depth measures to ensure continuous safety to personnel, the plant, and the environment through error-free performance. The program provides support to all workers—including contractors—in ensuring that safety is the paramount consideration guiding decisions and actions.

The objectives of the human performance program include: sustaining a high level of plant worker safety, promoting high levels of safety culture, sustaining high levels of plant performance, sustaining event-free operations, avoiding unplanned and long-duration shutdowns, managing and understanding safety, design, and operating margins, sustaining a highly-skilled, knowledgeable, and collaborative workforce, and maintaining readiness to responsd effectively to an emergency situation.

2.1.2 Past performance

Improvements in the past few years have allowed Bruce Power to make significant progress in strengthening the monitoring of human performance and reducing human performance-related events and errors.

Some of the improvements include:

1. Improvements to work planning: enhancements to pre-job briefing forms have resulted in improvements to risk assessment, assignment of worker roles expectations, and verification of worker qualifications. Additionally, Bruce Power has improved the

definition of clock reset criteria and improved observation and coaching checklists to support safety requirements and procedural adherence.

2. Improvements to work execution: enhancements to human performance tools, such as the “Core 4” human performance tool, and more widespread training delivered to workers, team leaders, and contractors.

3. Improvements to oversight and performance monitoring: improved oversight and verification of workers in the field, by management and supervisors, to ensure proper adherence to specified worker behaviours and task requirements as outlined in the pre-job briefs.

4. Improvements to Systems and Work processes: strengthened corrective action development and completion in support of performance improvement and the prevention of event reoccurence, and strengthened human performance training through department-specific observation and coaching checklists and dynamic learning activities tailored to specific work and anticipated errors.

High levels of observation and coaching has also led to high levels of adherence to human performance behaviours and to task-specific requirements (see Figure 4). This, in turn, has led to a reduced number of human performance-related events (see Figure 5).

The human performance event rate and human performance error rate are shown in Figure 6 and Figure 7, respectively. (These figures exclude discretionary station level clock resets, which are included in Figure 5.)

Observation and coaching of workers proactively identifies gaps in performance that require additional focus to ensure error-free performance. Observation and coaching is also used in response to any minor adverse nuclear safety events to ensure the right worker performance and task requirements are being adhered to across all similar systems and work activities being performed. This supports the principle of continuous performance improvement and prevents repeat events.

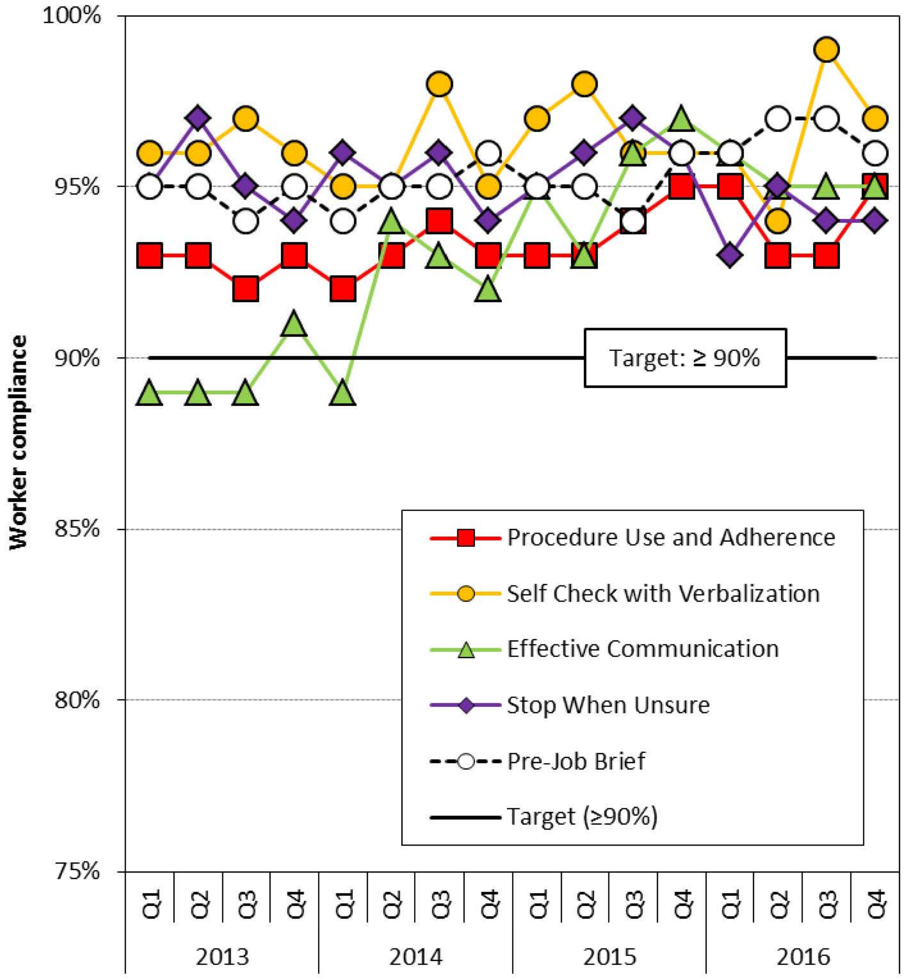


Figure 4. Worker compliance to human performance tool behaviour expectations

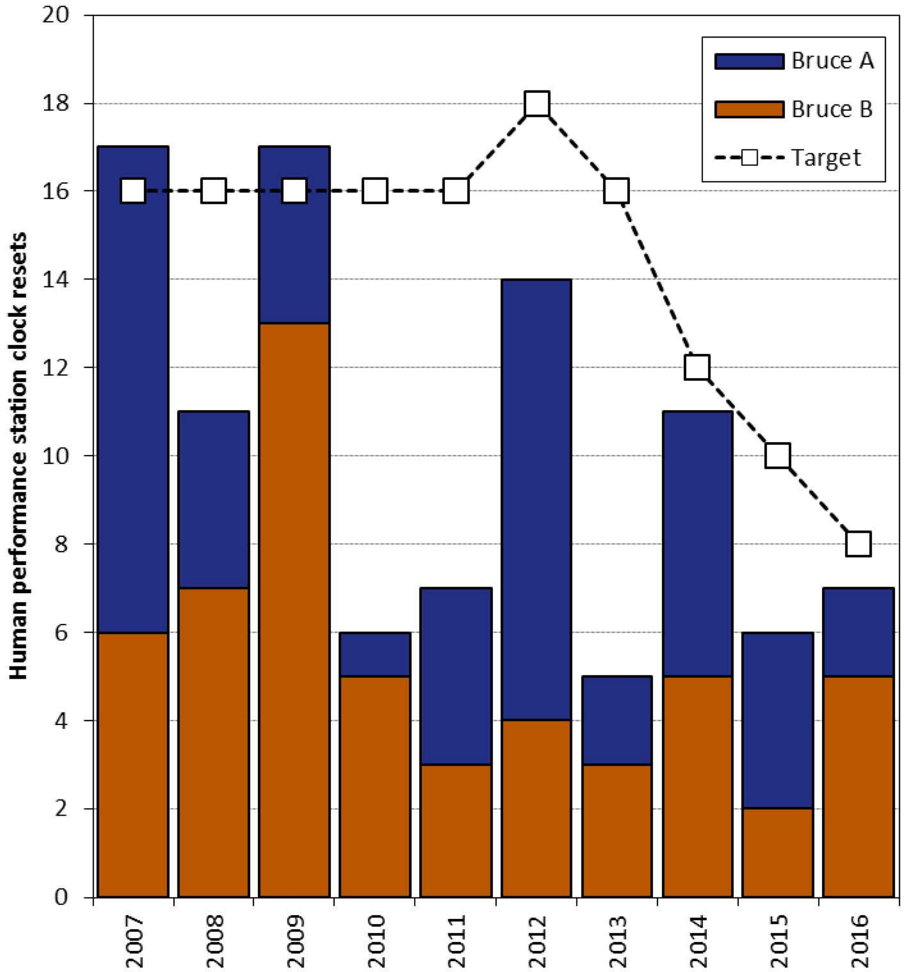


Figure 5. Human performance station level clock resets

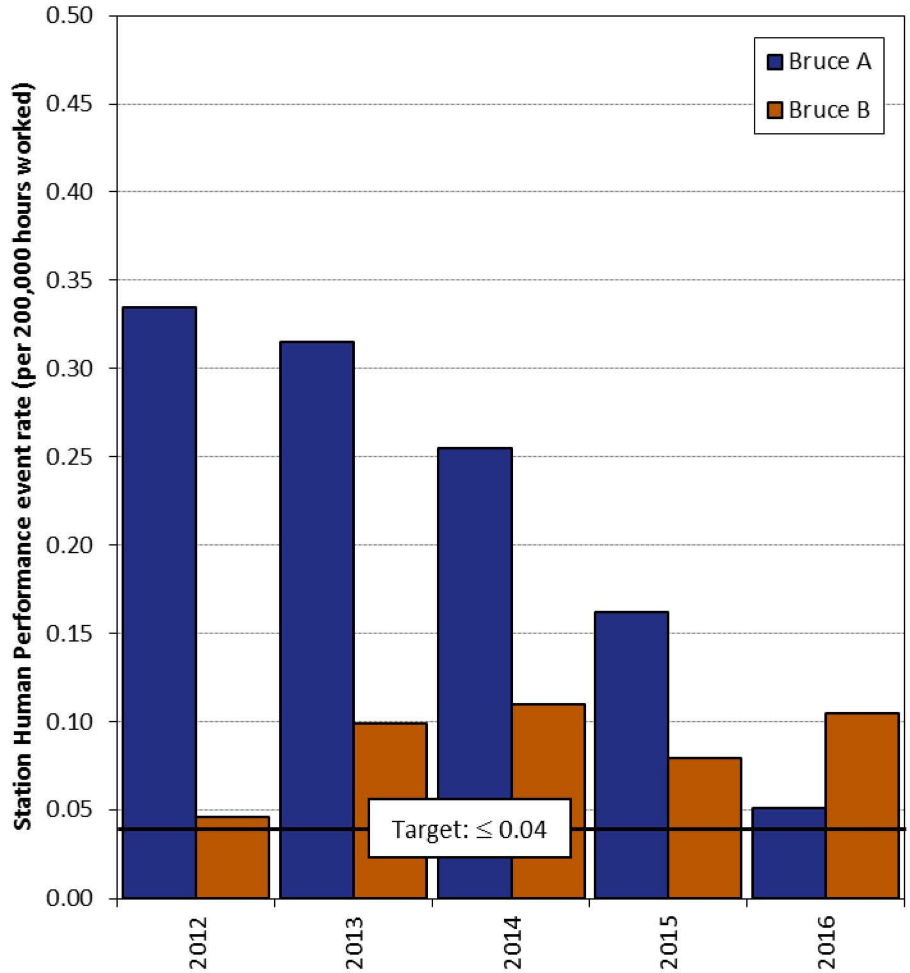


Figure 6. Human performance event rate (events meeting station clock reset criteria in the past 18 months, normalized to 200,000 hours)

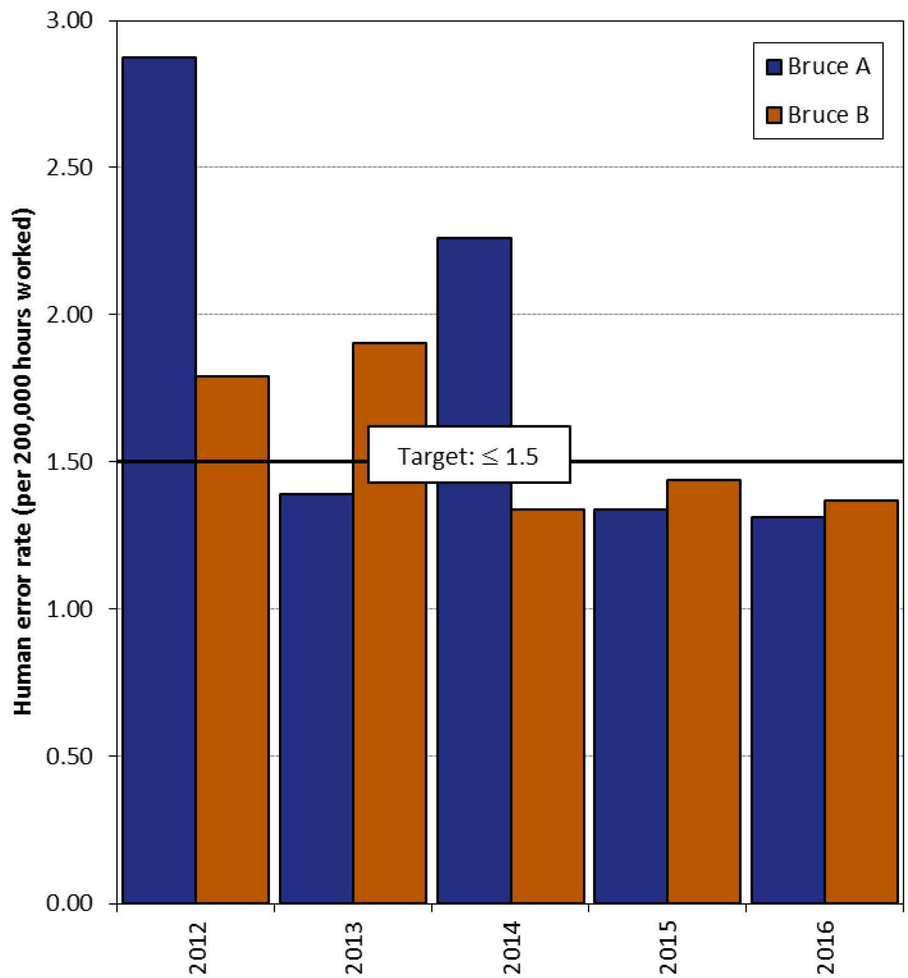


Figure 7. Human performance error rate (events meeting department or station clock reset criteria in the past 3 months, normalized to 200,000 hours worked)

Over the past licensing period, Bruce Power has also recognized the need to strengthen worker and vendor adherence to the “Core 4” set of human performance tools (Table 2) through consistent communication and reinforcement at all levels in the company. Vendor human performance programs, including human performance training, are being evaluated to ensure compliance with Bruce Power’s overall human performance program.

Table 2. Core 4 human performance tools.

1	Procedure Use & Adherence (Step-by-step)
2	Self Check with Verbalization (Stop – Think – Act – Review)
3	Effective Communication (3-way)
4	Stop When Unsure (Contact your supervisor)

The “Core 4” human performance tools are considered as fundamental to human performance worker competency and the achievement of error-free performance. Additionally, Bruce Power uses pre-job briefings as a tool to plan for error-free work. The “Core 4” tools and pre-job briefings together prevent the reoccurrence of approximately 95% of similar past events.

Additional human performance initiatives, such as the implementation of human performance days (“HU days”) in the stations, have also led to performance improvement. Station “HU days” provide an emphasis on key learnings from past performance results with a focus on correct human performance standards of excellence in the field. These exercises, along with supervisory observation and coaching to reinforce the standards and expectations, have resulted in reduced human error rates and improved defensive barriers. This in turn has led to a reduction in consequential human performance-related events.

Observation and coaching exercises have been rolled out to strengthen the engagement of supervisors (including senior management) with front line staff to ensure workers are performing work to set expectations and behavioral standards.

Two additional human performance managers were hired within the past licensing period. As a result, a dedicated human performance manager has been integrated into each of the five main work areas at the Bruce Power site (Bruce A, Bruce B, Outage and Maintenance Services, Project Management & Construction, and Centre of Site). The integration of dedicated human performance managers into key divisions has improved human performance monitoring, reporting, and coordination of improvement activities.

In addition, human performance Dynamic Learning Activities (DLAs) are now being developed by individual station department areas under the oversight of the human performance managers and human performance advocates. The human performance advocates are assigned within each of the station departments, are trained to high levels of adherence to human performance tools, and support human performance planning, monitoring, and verifying department work results. Moreover, the human performance advocates assist in the development and rollout of two DLAs per year to all station workers—including vendor staff—and help to ensure human performance training is tailored to specific work activities performed by department staff.

In 2017, Bruce Power launched the “You Can Count On Me” initiative to ensure everyone is committed to consistently following standards. This included implementation of vendor performance scorecards to improve human performance. The vendor performance scorecards were implemented in January 2017, and preliminary results show improved human performance in 2017 with respect to 2016 (Table 3).

Table 3. Department and station-level human performance clock resets for vendors (2015-2017)

Year	Department	Station
2015	7	0
2016	12	1
2017[1]	2	0

Note 1: through April 2017

2.1.3 Future plans

In 2017, Bruce Power launched the "You Can Count On Me" initiative to ensure everyone is committed to consistently following standards. A focus area for 2017 is the rejuvenation of the hazard identification, observation, and coaching processes in order to increase worker and supervisor engagement.

2.1.4 Challenges

None.

2.1.5 Requests

None.

2.2 Personnel training

2.2.1 Relevance and management

Personnel training is managed through the worker learning and qualification program, which enables personnel to competently and safely operate, maintain, and improve the performance of the Bruce nuclear generating stations. Learning includes both the training elements for worker qualifications that grant working rights as well as the training elements that support general professional development.

Bruce Power recognizes the substantial role played by training in ensuring staff have the required competence to perform assigned work. Providing high quality initial training to qualify newly hired or newly assigned staff and then maintaining and improving their knowledge and skills via continuing training is a key element in the Bruce Power strategy to ensure quality in operations.

Approximately 2800 individuals (of nearly 4100 employees) are in positions deemed to require a rigorous, systematic approach to determining the competence required to safely perform the role. These workers hold "Key Qualifications". The Bruce Power Key Qualifications equate closely with the "Accredited Positions" regulated by the United States Nuclear Regulatory Commission (US NRC), although the Bruce Power list is larger than the US NRC list.

These workers are the individuals who directly operate and maintain the plant, and therefore the position qualifications form an important part of "defence-in-depth" with respect to safety. Therefore, Bruce Power rigorously trains and tests these workers to ensure that they have and that they maintain the knowledge and skills required for the job.

Workers who do not directly operate the plant are qualified for their roles through a combination of education, experience, and knowledge requirements (ensured through the hiring process) as well as additional training and qualification requirements.

Professional development enables staff to add knowledge and skills beyond that required for qualifications associated with their current role. The intent is to foster an environment of continuous learning, to add breadth and depth to a workers' current knowledge and skills base, to improve performance, and to prepare for a future role. Professional development includes financial support for attendance at a professional development course, or participation in a program which results in a degree or recognized diploma or professional certification not required by Bruce Power.

Bruce Power is committed to the development of its leaders. Leadership development programs are offered to all leaders at all levels across the organization. This includes (but is not limited to) front line leader workshops, senior leader workshops, leadership essentials, high potential leadership program, emerging leader program, leadership continuing training, and project management development.

A Learning Governance & Oversight Committee has been established to implement the Governance & Oversight functions within the Governance-Oversight-Support-Perform (GOSP) model of accountabilities prescribed in the Bruce Power Management System Manual. The Learning Governance & Oversight Committee is responsible for the governance of the worker learning functional area, including the ongoing assurance that programs and processes are "leading practices" compliant with government regulations, aligned with Bruce Power Policy, and that they are implemented consistently throughout Bruce Power. The Learning Governance Committee is chaired by the Chief Nuclear Officer.

Reporting to this committee are the Cross Functional Qualifications Oversight Committee and the Key Qualifications Oversight Committee. These committees are established under a Vice President, as appointed by the Learning Governance Committee.

Training program owners, who report to the oversight committees, maintain documentation of assigned programs within a Training Qualification Description (TQD).

The Bruce Power Training Information and Management System (TIMS) is the system of record to show that staff hold the qualifications required by the TQD, as associated with their work assignment.

2.2.2 Past performance

Bruce Power carefully tracks the qualifications that we must have available at all times in the Bruce nuclear generating stations. These are known as minimum complement qualifications. This tracking ensures qualified workers are available to fill the required roles and also ensures sufficient workers are onsite at all times.

Bruce Power also carefully tracks the qualifications that we deem important to efficiently and safely operate Bruce A and Bruce B. This subset is known as business capability qualifications.

For all qualifications Bruce Power maintains a rigorous program containing several checks and balances to ensure staff that have not completed qualifications or that hold expired qualifications are not assigned to perform associated work independently.

2.2.3 Future plans

Bruce Power has active improvement plans in the training functional area as part of continuous improvement, including:

- Training Developer Training: two major courses have been updated to improve the curriculum associated with training analysis, design, development, implementation and evaluation. In addition, a new process document has been created to outline the standards for training program, qualification, and program element design.

- Professional development: Bruce Power has consolidated listings of professional development activities into an interactive on-line catalogue for the purpose of staff professional development and engagement improvement.

- Supplemental worker Task Performance Evaluations (TPE): Bruce Power has adopted the Electrical Power Research Institute (EPRI) TPE program for supplemental workers. This program augments our other methods to ensure journeypersons arriving as supplemental workers have the specific knowledge and skills required for their assignments. The TPE program uses knowledge and skills testing, designed to an exacting EPRI standard, to ensure competence.

- Project Training Team: this team has been formed to provide oversight on the training impacts associated with the life extension scope of work and to perform high quality training needs analysis for each training delivery unit. Oversight activities include tracking of project training implementation to completion, in support of available-for-service requirements.

- Simulator fidelity: full-scope simulators are being upgraded with improved technology to model most thermalhydraulic and nucleonic processes. These upgrades will improve the fidelity of abnormal condition responses.

- Systematic Approach to Training (SAT) software implementation: Bruce Power is actively updating its learning management system software. This includes new standards and tools for test item and test development; re-performing job analysis associated with all key qualifications (and many others) to a higher standard; and building more reliable processes to revise the SAT basis documents upon changes to control documents.

- Bruce B Unit 7/0 simulator construction: Bruce Power will build a second Bruce B full scope simulator which will include Units 7 and 0. This will allow training to occur on modifications associated with life extension activities, as well as training on the unmodified units. This will ensure that control room workers will maintain proficiency in all unit configurations. Construction will begin in 2017.

2.2.4 Challenges

The challenges associated with personnel training are demographics. Bruce Power plans to establish and maintain succession plans in which key positions are identified for risk of vacancy and succession is tracked and managed appropriately.

2.2.5 Requests

None.

2.3 Personnel certification

2.3.1 Relevance and management

Bruce Power manages control room personnel certification as an element of the Worker Learning and Qualification program. The Worker Learning and Qualification program enables personnel to competently and safely operate, maintain, and improve the performance of the Bruce A and Bruce B stations.

Bruce Power has a team of five managers and staff assigned to personnel certification, with a portfolio that covers initial certification training for nuclear operators, initial certification training for control room supervisors, refresher training and re-certification, and certification test development. Together, this team oversees roughly 50 certification candidates for each station at any one time.

The training and certification of these workers is supported by full scale simulators of Bruce A Unit 0, Unit 2, and Unit 3 and by full scale simulators for Bruce B Unit 0 and Unit 6.

The certification programs begin each year in the fall and take from two to three years to complete, depending on the certified position. All candidates have at least two years working in the station prior to seeking certification.

2.3.2 Past performance

Bruce Power currently has over 180 certified operations workers. During the current licence period, 65 certifications have been granted to Bruce Power workers.

During the current licence period, all requests for re-certification of operations staff have been approved by the CNSC. This demonstrates that Bruce Power has a robust process for personnel certification training.

2.3.3 Future plans

Over the next licence period, the program elements associated with initial certification examination and requalification tests will systematically improve, as described in Section 2.4.3.

2.3.4 Challenges

The challenges associated with personnel certification are demographic in nature. Bruce Power expects to maintain and to grow the numbers of certified workers, even while many workers retire. This is achievable through a healthy operator pipeline and appropriate pipeline oversight.

It is essential to ensure certified workers demonstrate proficiency on reactor units that have been upgraded through life extension activities, while ensuring those workers also remain proficient on the unmodified reactor units. Bruce Power is currently constructing a second Bruce B full-scope simulator that will include Units 7 and 0. This will allow training to occur on modifications associated with life extension activities, as well as training on the unmodified units. This will ensure control room workers maintain proficiency in all unit configurations.

2.3.5 Requests

None.

2.4 Initial certification examination and requalification tests

2.4.1 Relevance and management

Bruce Power manages initial certification examinations and requalification tests as a subset of the Worker Learning and Qualification program. This program enables personnel to competently and safely operate, maintain, and improve the performance of Bruce A and Bruce B.

Bruce Power has a team of thirteen current or former certified workers, reporting to a manager of certification test development. This team designs, prepares, administers, grades, and processes all certification exams. The categories of certification examinations include written knowledge exams for initial certification or re-certification, and performance exams (simulator) for initial certification or re-certification.

2.4.2 Past performance

Since January 1, 2014 to the time of preparation, Bruce Power conducted 556 certification examinations (Table 4). All examination results were accepted by the CNSC.

Table 4. Number and pass rate for certification examinations (2014-current)

Examination	Number delivered	Pass rate
Initial certification written knowledge	196	95.9%
Initial certification performance	62	89.9%
Re-certification written knowledge	65	94.3%
Re-certification performance	233	91.2%

Candidates who are not successful on an initial certification examination are either removed from the certification program or repeat appropriate training and sit for a new examination. Candidates who are not successful on a re-certification examination are removed from the certified role until the candidate completes a formal remediation training plan and passes a new examination.

2.4.3 Future plans

Over the next licence period, the program elements associated with initial certification examination and requalification tests will systematically improve the following:

- Testing methodology: Bruce Power will finalize a move from a short answer / essay examination (for certain written examinations) to a rigorous multiple-choice examination methodology. This change will allow for a more valid examination process, with sampling of four times as many items and removal of any subjectivity from the grading process.

- Simulator fidelity: the full-scope simulators will be upgraded with improved technology to model most thermalhydraulic and nucleonic processes. These upgrades will improve the fidelity of abnormal condition responses.

These improvements will further enhance our current methods to ensure workers have the required competence to perform assigned work.

2.4.4 Challenges

None.

2.4.5 Requests

None.

2.5 Work organization and job design

2.5.1 Relevance and management

Bruce Power manages the workforce through the workforce planning process, which is reviewed annually. The workforce planning process uses internal and external benchmarks and current business needs to plan future staffing level activities. An attrition model is used to forecast future retirements and internal movement. An appropriate lead time has been identified for all critical positions, including certified workers. Senior managers also review the status of Bruce Power’s staffing activities on a monthly basis.

During yearly business planning sessions, executives and senior managers reconcile current work program requirements and Bruce Power's long-term workforce model, to develop the appropriate staffing levels across site for each year of the planning horizon. Consequently, Bruce Power has pipelines and plans in place to ensure that current programs are managed, while implementing improvement strategies to reach Bruce Power's future workforce model and staffing levels.

This ensures that Bruce Power maintains an adequate level of workers to safely manage the Bruce A and Bruce B stations.

Minimum complement is discussed in Section 2.6.2 and Section 3.7.1.

2.5.2 Past performance

Past staffing levels, including voluntary/involuntary terminations and retirements, are shown in Table 5.

Table 5. Annual head count (2013-2016; 2017 projected)

Year	Beginning of year	New hires	Exits	End of year
2013	4,069	270	227	4,112
2014	4,112	163	186	4,089
2015	4,089	173	191	4,071
2016	4,071	204	163	4,112
2017*	4,112	41	46	4,107

The recruitment process includes posting, screening, interviewing, selection, and offer.

- Posting: the job posting is created based on an approved job profile. The position may be posted internally or may be posted externally if the particular position requires a skill set for which an external posting is appropriate.

- Screening: the recruiter screens applicants based on education, experience, and certification requirements in the approved job document. Shortlists are confirmed with the hiring manager. Potential candidates are assessed through a pre-screen interview to confirm skills and knowledge and may be additionally assessed for aptitude and skills including technical writing, administration, math and science, and leadership.

- Interviewing: candidates receive a panel interview with the hiring manager and a human resources representative, as well as subject matter experts if required. The questions are determined prior to the interview based on the essential competencies for the role. The panel interview includes both technical and behavioural-based questions and are assessed using the Behaviourally Anchored Rating Scale for each competency.

- Selection: the most suitable candidate is selected based on data collected and relevant collective agreements. Reference checks, verification of education and previous employment, and security clearances are processed.

- Offer: a recommendation to hire is submitted to the hiring manager and the line vice president. On approval, human resources creates the offer of employment and notifies the successful candidate.

Work force planning includes consideration of talent pipelines, which include projected retirements and new hires. An example of the operations workforce planning report is provided in Table 6. Although in some areas, Bruce Power is under target, current staffing levels are well above minimum complement requirements. Targets are set to fill minimum complement positions, as well as support organizations such as training. Planned staffing levels take into consideration development pipelines, external hiring, and conservative predictions with respect to retirements. Bruce Power hires approximately 20-50 Nuclear Operators in Training each year to ensure a healthy pipeline for certified positions.

Table 6. 2017 recruitment targets for certified positions.

	Min. complement	Target	Current	Year target met
Bruce A				
Shift Manager / Control Room Shift Supervisor	10	25	19	2019
Authorized Nuclear Operator	30	61	46	2021
Unit 0 Control Room Operator	10	21	18	2020
Fuel Handling Control Room Operator	5	32	29	2019
Bruce B				
Shift Manager / Control Room Shift Supervisor	10	25	18	2019
Authorized Nuclear Operator	30	61	58	2017
Unit 0 Control Room Operator	10	19	25	Now
Fuel Handling Control Room Operator	5	32	36	Now

2.5.3 Future plans

There are several process and plans which directly support retention efforts. Examples include succession planning, leadership development, management bonuses, and other job-specific incentive plans.

The succession planning process is designed to pro-actively identify high potential employees within the organization and develop strategies for ensuring appropriate career progression for these individuals and replacement for key positions. There is also a list of mission-critical roles reviewed annually.

2.5.4 Challenges

If an area of concern is identified with respect to retention, Bruce Power will perform assessments and will implement a retention plan. The assessment may include salary design, job evaluation assessment, incentive plan design review, or retention/project completion bonus consideration.

2.5.5 Requests

None.

2.6 Fitness for Duty

2.6.1 Relevance and management

Fitness for duty is a vital component of worker safety.

The fitness for duty process is an important part of the work done by managers, with support and oversight from Employee Wellness. The fitness for duty process encompasses all aspects of a worker’s fitness to perform work, including fatigue, physical health, and mental health.

Ensuring workers are fit for duty is a safety concern in all roles at the Bruce site. It is an important part of nuclear safety with respect to individuals in certified roles within the station but is an equally important part of conventional (non-nuclear) safety.

All employees are required to self-report if they are not fit for work. However, the manager has the primary role in assessing whether an employee is fit for duty—during the regular work day, but, in particular, also when fitness for duty may be more of a concern (such as performance of safety-sensitive work, times when a worker is facing work or personal challenges, or times when a worker is required to work past the normal work hours).

Managers are provided with training on the Fitness for Duty procedure via a Computer Based Training course and a classroom module as part of the required manager training. In 2016, all managers were provided with training specifically for dealing with Fitness for Duty issues arising as a result of mental health.

The primary tools for assessing fitness for duty are two checklists, including a fatigue assessment. The fatigue assessment form must be used when certified staff are required to work extended shifts beyond 16 hours (and may be used in other situations). Training has been provided to all managers in Shift Operations on the use of this form.

Each year, fitness for duty information is provided to all operations staff during the “Conduct of Operations” meetings. Bruce Power provides the *Shiftworker* newsletter every two months to all shift workers on site. This newsletter covers strategies to overcome challenges associated with shiftwork. Fatigue and other concerns resulting from shift work are discussed by the Shift Issues Team, a group that meets quarterly and includes representatives from unions, security, Employee Wellness, and Labour Relations.

As per Bruce Power procedure, reporting to work fit for duty is everyone's responsibility. From time-to-time, personal health and life events may impact on the fitness for duty of workers either prior to work, or while on the job. The worker may or may not be aware of these impacts. Early identification and appropriate intervention can speed resolution and recovery. Bruce Power is committed to assisting workers achieve optimum functioning by providing support and resources.

Bruce Power recognizes that anyone working past 13 hours is potentially fatigued, both physically and mentally. As such, Bruce Power has implemented GRP-OPS-00055, Fitness for Duty Considerations for Shift Complement Staff Held Over for More Than 13 Hours. The procedure provides detailed rest period requirements for individual workers and crews held over for varying durations including completion of an assessment for fitness for duty.

2.6.2 Past performance

In the current licensing period, there have been no incidents in which fatigue played a role. This demonstrates that managers are engaged in ensuring their employees are fit for duty and not fatigued when extended hours of work are required.

Bruce Power maintains sufficient numbers of qualified staff to meet minimum complement requirements. However, issues such as short-notice absences or severe weather present challenges to the maintaining the minimum complement. If a replacement worker cannot be located in a timely manner, Bruce Power will hold over qualified staff. While this may result in an hours-of-work non-compliance, it is clearly the right decision from a safety perspective.

Since the last licence application submission, the following improvements have been made:

- The process for fatigue assessments was clarified;
- Sleep facility improvements were made to allow improved resting and nap periods. The sleep facility is used, for example, when personnel are held over due to severe weather that prevents travel to or from the Bruce site.
- The fitness for duty checklist has been modified to improve fatigue monitoring.
- Bruce A has significantly increased the number of Authorized Nuclear Operators, which has resulted in fewer hours-of-work violations and fewer occurrences of holding staff over 13 hours.
- The staffing plan for Licensed Operator positions continues to show commitment to maintaining and increasing the number of certified workers.

Since 2014, Bruce Power has increased the focus on mental health, with the goal of increasing discussion, reducing stigma regarding mental health, and increasing self-reporting of mental health issues. Bruce Power celebrates Mental Health Week each May with communications to all staff on the wellness benefits and resources that are available to support them. Additionally, Bruce Power has implemented the "Not Myself Today" program from the Mental Health Commission of Canada. The "Not Myself Today" program is intended to increase awareness that everyone experiences highs and lows and that is acceptable to self-report when this is a concern.

2.6.3 Future plans

The relevant fitness for duty process will be reviewed and potentially revised based on the usual three-year review cycle for procedures. The fitness for duty training is also reviewed and potentially revised every three years to ensure that the most up-to-date information is provided to managers.

CNSC staff have requested that Bruce Power provide an implementation plan for meeting the requirements of REGDOC-2.2.4, *Fitness for Duty: Managing Worker Fatigue*. Bruce Power plans to review this request and provide an appropriate response by September 2017.

Bruce Power plans to make revisions to GRP-OPS-00055 and the fitness-for-duty checklist to take into account recommendations made by CNSC staff as a result of inspections in 2017 with respect to fatigue management processes.

2.6.4 Challenges

As with any employer, Bruce Power cannot control a worker's actions during off-work hours, which may impact that worker's ability to arrive well-rested for work. This emphasizes the importance of fitness for duty observations by supervisors.

Severe weather also poses challenges. In some cases, longer shifts are required for minimum complement staff, if the next shift is unable to travel to the Bruce site.

2.6.5 Requests

None.

3.0 OPERATING PERFORMANCE

Includes an overall review of the conduct of the licensed activities and the activities that enable effective performance.

3.1 Conduct of licensed activities

3.1.1 Relevance and management

Bruce Power conducts licensed activities in a manner that complies with legal requirements and ensures the protection of workers, the public, and the environment. As Bruce Power's business is integrated within the overall management system (Section 1.1), this entire document is relevant to the conduct of licensed activities and the overall Operating Performance SCA.

With respect to the operation of Bruce A and Bruce B specifically (i.e., not considering supporting activities or areas addressed elsewhere in this review), Bruce Power manages the conduct of licensed activities through maintenance of Operating Policies & Principles and the Conduct of Operations program.

Operating Policies and Principles

Bruce Power maintains Operating Policies and Principles (OP&Ps) for Bruce A and Bruce B. The OP&Ps are policy-level documents within the management system and define operating requirements and parameters, which are consistent with relevant safety analyses and licensing requirements. The OP&Ps clearly outline the operating boundaries, within which the station is safely operated, maintained, and modified. The OP&Ps also specify the authorities of station staff—in particular the Senior Operation Authority, the Shift Manager, and the Chief Engineer—to make decisions within defined boundaries. The OP&Ps identify actions for which discretion may be applied and for which appropriate jurisdictional authorization is required.

The Operating Policies and Principles (OP&Ps) are a combination of principle statements and policies, as well as operating limits and conditions which reflect the Safe Operating Envelope (SOE). The principles provide context for the more detailed requirements, while the policies provide direction for establishing, maintaining, and restoring safe operation. The limits and conditions define the specific requirements which must be met in order to determine if a station is in an accepted safe state. The OP&Ps further establish the boundaries which are implemented in the operating documentation used by workers.

Within the boundaries of the OP&Ps, detailed operating procedures are written to clearly define operating requirements for normal, abnormal, and emergency conditions. As operating experience accumulates, these detailed procedures are occasionally revised to improve the quality, simplicity, and efficiency of station operation.

Conduct of Operations

The Conduct of Plant Operations program defines the requirements and responsibilities of operations workers. The overall objective of the program is to put in place the governance to safely and reliably operate the station systems within the design basis for which the stations are licensed. Operations conducted in accordance with the standards and expectations defined in this program provide strong support for the four pillars of nuclear safety: reactor safety, industrial safety, radiation safety, and environmental safety.

The Conduct of Operations program is implemented by governing procedures and system operating documents/procedures.

Operations workers operate the Bruce A and Bruce B stations using operating documents, which are described in Section 3.2.1.

Nuclear Safety Review Board (NSRB)

The NSRB is a subcommittee of the Bruce Power Board of Directors and reports to the Board of Directors on the extent to which Bruce Power conducts its business in a manner that promotes safety. The NSRB emphasizes the long-term effort required to make permanent improvements in safety culture, including changing management behaviours and demonstrating leadership.

At least three appointed members of the NSRB are required to be an expert in matters of nuclear operations and safety. Each of the members is independent of Bruce Power and is required to be experienced in matters of operational safety including: industrial safety and/or nuclear safety and/or environmental compliance. The NSRB also includes up to 10 *ex officio*, non-voting members, including the President and CEO, Chief Nuclear Officer, and Vice President, Nuclear Oversight and Regulatory Affairs.

The NSRB reports directly to the Board of Directors on safety issues, performance, and culture. At meetings the NSRB will review management safety reports, CNSC inspection reports, and internal audit reports, receive briefings from staff and management, review significant events, review industry reports, and conduct plant tours, observations, and investigations.

3.1.2 Past performance

Bruce Power received its best-ever “report card” from the CNSC in 2016 (for 2015): both Bruce A and Bruce B received an overall “Fully Satisfactory” mark for the CNSC’s Integrated Plant Ratings. Operating Performance was rated “fully satisfactory” as well.

WANO evaluations for both Bruce A and B have been completed recently (2016 and 2017, respectively). These peer reviews identify areas of strength that can be shared with other operators around the world, and areas where we can learn from others to improve our own performance.

In 2015, an international review team conducted an Operational Safety and Review Team (OSART) mission to evaluate Bruce B operational safety performance compared to IAEA safety standards. Bruce B was very successful, and a number of good practices were identified that support our good performance. 19 items were identified as recommendations, suggestions, or self-identified areas for improvement.

The week of May 29-June 2, 2017, Bruce Power hosted four representatives from the IAEA to review progress since the 2015 OSART mission. For all of the 19 items, this team of international experts determined that the item was resolved or that Bruce Power is making satisfactory progress.

During the exit meeting, the OSART team noted a number of other positive findings from their short time on site. Bruce Power workers were recognized for openness, professionalism, and a strong commitment to the review process. The OSART team was also very impressed with Bruce Power's strategy to effectively drive improvements to adherence to the highest standards in a very personal way. The OSART team recognized Bruce Power's preparations for Major Component Replacement (MCR) in Unit 6 as very thorough and also noted improvements in the material condition and housekeeping standard at Bruce B.

The OSART team has provided a draft report to the Bruce Power leadership and to the CNSC. Both organizations will have the opportunity to provide comments before the final report is submitted to the Canadian government in late 2017.

3.1.3 Future plans

To further improve operations, Bruce Power will continue to use continuous improvement processes such as the corrective action program, internal assessments, and documentation improvement processes.

Additionally, capital projects, outage maintenance, and online work management processes continue to improve the overall health of Bruce A and Bruce B station equipment.

Major initiatives such as the life extension activities and the new Maximo asset suite software are in-progress and will support continued event-free operation.

In 2017, Bruce Power launched "You Can Count On Me–Every Step. Every Time. Every Day." "You Can Count On Me" is a long-term initiative that will align the entire site (including vendors) around a common message. The goal is to ensure everyone is committed to consistently following standards. The focus areas for 2017 include:

- Development of a robust branding and communication strategy that anchors nuclear safety communications to "You Can Count On Me";
- Rejuvenation of hazard identification, observation, and coaching processes in order to increase worker and supervisor engagement;
- Improvements with respect to maintenance procedure backlogs and quality; and,
- Implementation of vendor performance scorecards to improve human performance.

3.1.4 Challenges

None.

3.1.5 Requests

None.

3.2 Procedures

3.2.1 Relevance and management

Operating procedures establish safe, uniform, and efficient operating practices under all routine and non-routine operating conditions. The operating procedures ensure that legal requirements are met, the requirements of the OP&Ps are implemented, and the limits of the SOE are maintained.

Operations workers operate the Bruce A and Bruce B stations using the following types of operating documents, governed by the Conduct of Plant Operations program, which provide a defense-in-depth approach to ensure safe operations:

- Operating flowsheets: drawings that reflect the actual operational configuration of the field equipment. Operating flowsheets contain additional information beyond that which would be shown on design drawings to aid in the operation of the plant and equipment.
- Operating manuals: operating manuals provide operations with specific direction to keep the operating unit within normal parameters.
- Operating memos: these are “temporary” operating procedures used by operations workers to address a specific unit condition that is not otherwise addressed by operating manuals (i.e., temporary equipment configurations). These are not intended for long-term issues, but instead address or provide mitigating strategies.
- Safety system tests: these processes are used by operations staff to test important systems to ensure they respond as per design.
- Alarm response manual: this manual provides direction to operations worker when the main control room receives an alarm.
- Abnormal incident manuals: these manuals provide responses or direction to address unit upsets within the design basis. The use of the abnormal incident manuals will prevent any OP&P limits from being exceeded.
- Common technical procedures: these procedures coordinate multiple workgroups in cases for which hand-off between separate procedures would contribute to an increased likelihood of error or miscommunication.
- Emergency mitigating equipment: these procedures provide operations staff with direction for events that are beyond the design basis.
- Severe accident management: these procedures provide a framework for identifying appropriate mitigating actions for events that fall into the severe accident category.

3.2.2 Past performance

Bruce Power operating procedures are developed, used, and controlled in compliance with management system. The operating procedures support safe plant operation.

3.2.3 Future plans

Bruce Power will make continuous improvements to the operating documentation to support safe plant operation.

3.2.4 Challenges

None.

3.2.5 Requests

None.

3.3 Reporting and trending

3.3.1 Relevance and management

Reporting and trending is conducted as part of the Corrective Action program as well as the CNSC Interface Management program.

The purpose of the Corrective Action program is to identify and eliminate or mitigate adverse conditions that have resulted in, or could result in, loss. The corrective action program fosters a healthy nuclear safety culture by establishing a process to identify, document, evaluate, and trend adverse conditions, and to develop and implement appropriate actions to fix those adverse conditions.

The purpose of the CNSC Interface Management program is to ensure that notifications and reports are made pursuant to the *Nuclear Safety and Control Act* and associated CNSC licences. Pursuant to the Power Reactor Operating Licence 18.00/2020, Bruce Power makes notifications and reports to the CNSC in accordance with REGDOC-3.1.1, *Reporting Requirements: Nuclear Power Plants*.

3.3.2 Past performance

Overdue Corrective Actions continue to stay minimal. In 2016, there were 2 overdue corrective actions. The number of overdue Corrective Actions continues to decrease year over year (see Figure 8).

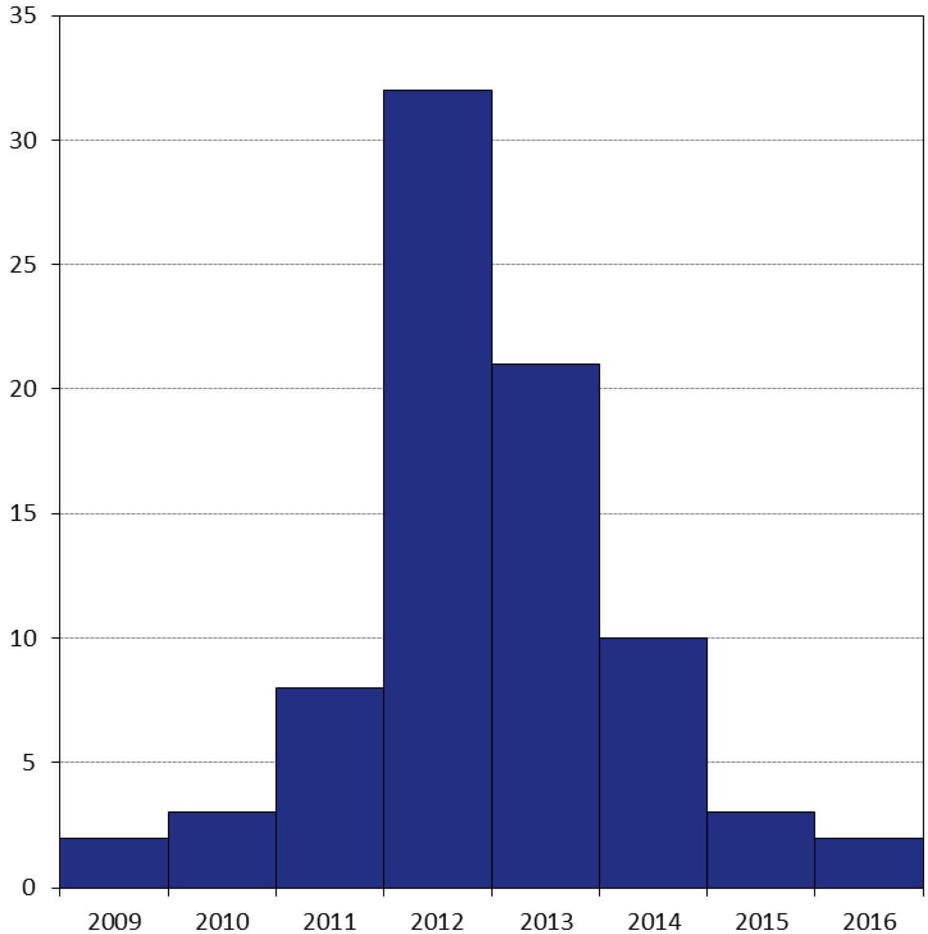


Figure 8. Overdue corrective actions (C/M/L types)

Since the previous licence submission, a number of improvements have been implemented to strengthen the corrective action program:

- To right-size problem solving, Bruce Power introduced A3 Problem Solving Evaluations, which is used in conjunction with a causal analysis technique. The A3 process is more flexible and less rigorous than an Apparent Cause Evaluation. Initially piloted at Bruce B in 2013, the process was integrated site-wide in 2014. Oversight of A3s can be through the Corrective Action Review Board, Management Review Meeting or by the line organization. The A3 Problem Solving Evaluation has been well adopted, as illustrated in the graph which illustrates the number of A3s performed at Bruce A and Bruce B since inception:

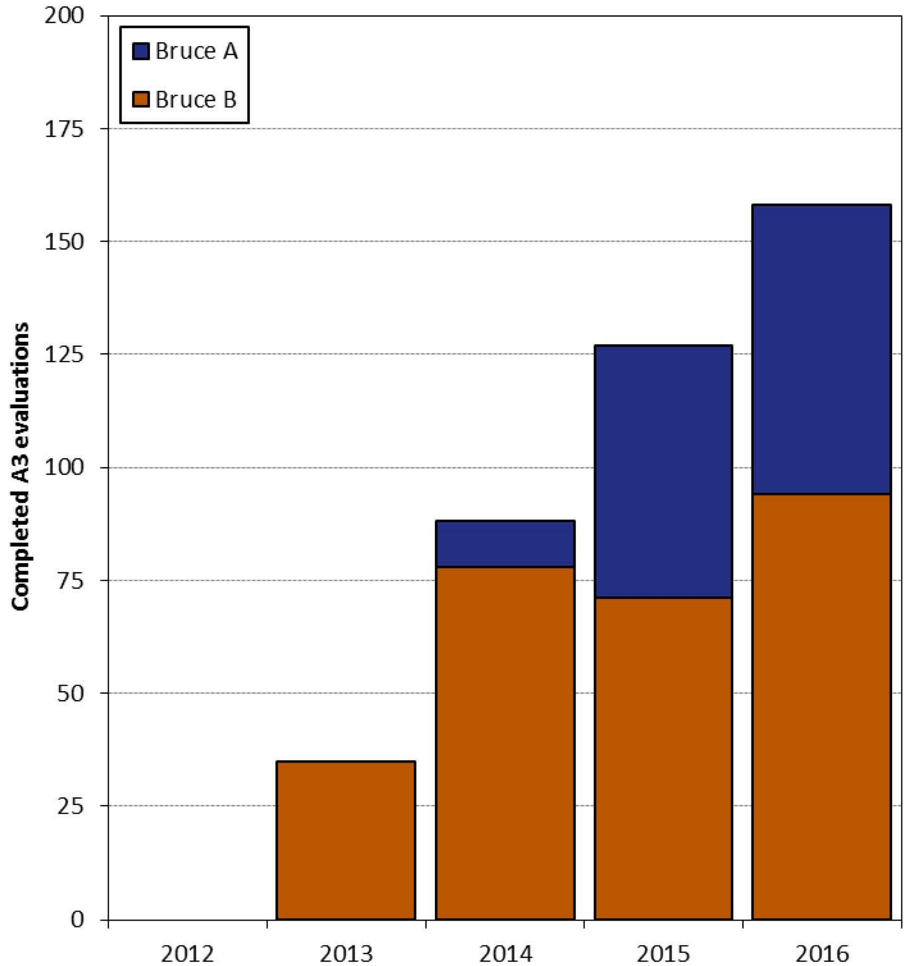


Figure 9. Completed A3 problem solving evaluations.

- The Apparent Cause Evaluation (ACE) training qualification was changed in January 2014. Computer-based training was replaced by instructor-led classroom sessions. Bruce Power currently has more than 460 workers who have received the instructor-led training; several more ACE classroom sessions planned throughout 2017.

- A new trending process was implemented in late 2015 as a result of an assessment against "best in class" trending processes and a review of INPO Guideline 07-007, "Performance Assessment and Trending." Each month, data is gathered from the population of SCRs initiated over the previous 24 months and is used to determine SCR trends over time. The results are used to facilitate the Bruce A and Bruce B Quarterly Assessment Reports, as well as monthly, department level reports.

3.3.3 Future plans

Several improvement initiatives are underway for the corrective action program to continue to encourage the right behaviours and to ensure alignment with best practices. These include:

- Bruce Power intends to explore additional approaches to streamline and right-size the types of investigations available within the corrective action program;

- The CAP Index, in place since 2012, was revised in 2015 and again in 2016. Further refinements are planned to ensure the CAP Index provides the right information on the overall health of the Program; and,

- SCR data will be used to better monitor trends by simplifying trend codes and alerting line organizations when trends emerge.

The CNSC Interface Management program is being streamlined and will be renamed the Nuclear Regulatory Affairs program. No substantive changes to reporting will be made.

3.3.4 Challenges

Bruce Power is migrating to new enterprise software for managing nuclear assets. This transition will provide many opportunities to improve corrective action processes, including problem reporting, action tracking, and document storage. However, during the transition, there will be challenges in:

- Providing the same or improved software functionality to both search for and find items in the existing corrective action program databases;

- Providing information to staff regarding Maximo functionality as it pertains to the corrective action program; and,

- Completing administrative updates with respect to the governance suite.

These challenges will be managed through routine business processes as part of the project for implementing the new software.

3.3.5 Requests

None.

3.4 Outage management performance

3.4.1 Relevance and management

Successful operation of the nuclear reactor units at the Bruce A and Bruce B station includes outages in which a specific reactor unit is shut down in a controlled manner to permit maintenance and inspections.

Bruce Power manages outages through the Outage Work Management program, which provides the controls associated with planning, implementing, assessing, and continuously improving work performed on a reactor unit when the unit is shutdown. The Outage Work Management program ensures that work activities are identified and that the requirements for the work are understood. Additionally, the program ensures that the work is sequenced, scheduled, and controlled in a manner that maximizes nuclear safety in accordance with the importance of the station, systems, and components. The program includes selecting and controlling the scope of work, planning, scheduling, coordinating work execution, and closing out the outage.

The goal is to establish the optimum conditions for safe and efficient planning and execution of outage activities.

Shutdown safety is a key outage success factor and an outage goal. Performance indicators have been established for events resulting from a loss of decay heat removal, challenges to shutdown safety function, and events that result in unplanned increased risk conditions. These indicators are monitored throughout the outage, with a particular focus on control, cool, contain, and off-site power availability. Policies and procedures are in place to address conservative decision making to maintain sufficient safety margins.

For information with respect to Life Extension Outages, see Section 15.13.

3.4.2 Past performance

In 2015, Bruce A had three planned outages, and Bruce B had five planned outages, including a vacuum building outage. All planned outages were delivered on or ahead of plan. Additionally, Bruce Power experienced 17 forced outages across the 8 operating units.

In 2016, Bruce A had three planned outages, including a station containment outage, and Bruce B had three planned outages. Of the planned outages, only two outages were delivered slightly over the planned duration. Bruce Power experienced 14 forced outages across the 8 operating units as a result of equipment issues.

Safety is the number one value during outage windows. Recent events have resulted in Bruce Power increasing oversight in this area through “You Can Count on Me”. This initiative is intended to arrest a declining trend in performance through site-wide communication reinforcing commitment to safety, a simplified and updated pre-job briefing form, and a new “Tools of the Trade” card to ensure workers think about workplace hazards prior to the pre-job briefing.

3.4.3 Future plans

Bruce Power will continue to focus on outage milestone improvements through the Outage Health Initiative, which will improve the overall outage process and outage scheduling. This includes:

- Generating preventative maintenance work orders for three outage cycles per unit (approximately 10 years in advance). Early scope definition will allow the organization to see the work demand and execute accordingly;
- Implementation of model work orders, which will improve the efficiency of assessing the planned work; and,
- Improving the outage preparation milestones to deliver predictable, repeatable scoping and execution of outages.

Additionally, Bruce Power is increasing the focus on vendor human performance.

The Life Extension Division has been formed to support the MCR organization with effectively implementing the MCR projects. This new division will provide oversight to ensure that operational requirements are met, including adherence to regulatory commitments, standards, and Bruce Power processes.

3.4.4 Challenges

None.

3.4.5 Requests

None.

3.5 Safe operating envelope

3.5.1 Relevance and management

The Safe Operating Envelope (SOE) is the set of limits and conditions—associated with safety analysis—that ensures safe operation of the nuclear generating station.

Bruce Power manages the SOE through the Design Basis Management program as well as the Engineering Change Control program, in accordance with CSA N290.15-10, *Requirements for the Safe Operating Envelope for Nuclear Power Plants*. This standard provides requirements for the definition, implementation, and maintenance of the SOE.

The nuclear generating stations must be designed, analyzed, operated, and maintained within the defined SOE.

The safe operating limits, conditions, and surveillance requirements, as well as their bases with respect to the current safety analyses, are documented in station- and system-specific Operational Safety Requirements (OSRs), along with any associated instrumentation uncertainty calculations.

Operations and maintenance procedures, processes, and tests, are required to comply with the Operational Safety Requirements, including any corrective or mitigating actions and action times. Changes to station design, maintenance, or operation require that compliance is maintained.

3.5.2 Past performance

Compliance to CSA N290.15-10 was verified in 2015 through an internal audit. All resulting required actions have been implemented or dispositioned; recommended actions are in progress.

A review was performed of all safety analysis completed after issuance of the initial OSR documents. This review was intended to verify that safety analysis impacts were appropriately identified. Although the review validated the adequacy of the processes for safety analysis implementation, engineering change control processes were revised to include implementation of new or revised safety analysis limits. This will ensure that, when changes are implemented, the associated SOE requirements are identified, and impacted station operation and maintenance compliance documentation is flagged.

A review of all actions identified during the implementation of the initial baseline OSRs as part of the SOE project has been performed to verify that the required actions are complete. This includes actions that were raised to update compliance documents, such as Safety System Tests and alarm limits. Closure of any outstanding actions is being addressed, and metrics for tracking these actions to completion are being developed as part of Bruce Power's management reviews.

The compliance tables, which document station compliance to each of the requirements specified in the OSRs, are being reviewed and updated as the OSRs are revised. The updated compliance tables are being issued as controlled documents, with a clear link to the appropriate OSR. This will ensure widespread access to the compliance table documents and will enhance their use in ensuring sustainability of station compliance to SOE requirements.

3.5.3 Future plans

As discussed above.

3.5.4 Challenges

None.

3.5.5 Requests

None.

3.6 Severe accident management and recovery

3.6.1 Relevance and management

Severe accident response and recovery is managed as part of the Conduct of Plant Operations program. Additionally, severe accident management at Bruce Power utilizes the existing concepts, structures, roles, and processes defined in Bruce Power’s Nuclear Emergency Response Plan to execute the mitigating measures necessary during a severe accident.

In the event of a severe accident, the severe accident management process establishes the actions to be taken to:

- Terminate core damage progression;
- Maintain the capability of containment;
- Minimize on site and off site releases; and,
- Achieve a safe, stable state of the reactor and plant over the long term.

To the maximum extent practicable, Bruce Power has adopted the COG Industry recommendations for Severe Accident Management Guidelines (SAMG). These recommendations are summarized in a technical support group user`s guide. The user's guide is a field-level reference and training document that describes the overall structure of SAMG, the rules of SAMG usage, and additional practical aspects associated with Technical Support Group (TSG) performance of evaluations and development of recommended mitigating strategies and recovery actions. It is intended to support TSG member training by providing a concise high-level summary of the key points associated with use of the SAMG package.

Training for the use of Severe Accident Management Guidelines are documented in the training qualifications for the emergency response organization, control room shift supervisor and shift managers, and certified staff continuing/re-certification training.

SAMG drills and exercises are prepared in accordance with emergency management drill and exercise plans. Specifically, all time-critical SAMG actions will be practiced within a drill or exercise at least once every 3 years.

3.6.2 Past performance

As a result of the incident Fukushima Daiichi Nuclear Power Plant, the CANDU Owners' Group (COG) established an industry joint project to review SAMG in use at Canadian nuclear power plants. The COG review identified several gaps in the pre-Fukushima SAMG, including:

- Lack of guidance to address shutdown units or low-power operation;
- Lack of guidance for multi-unit events;
- Lack of guidance for Irradiated Fuel Bay severe accidents;
- A need to develop a methodology for evaluating instrumentation and equipment survivability during a severe accident; and,
- A need to develop a process to determine plant habitability during a severe accident.

As a result of this review, the Bruce Power SAMG Technical Basis Document (TBD) was revised to address these gaps, along with revision of station-specific guidelines.

3.6.3 Future plans

Bruce Power plans to validate the revised SAMGs in 2017. Bruce Power will create new SAMG-enabling instructions for new toolkits that have been installed in the stations for temporary water makeup connections to the Primary Heat Transport System and to the Moderator System. The revised enabling instructions will be created and validated by the end of 2017.

3.6.4 Challenges

None.

3.6.5 Requests

None.

3.7 Accident management and recovery

3.7.1 Relevance and management

The Bruce Power operations program establishes safe, uniform, and efficient practices under all operating conditions (routine and non-routine), ensuring that legal requirements are met and the requirements of the OP&Ps are implemented. Operating limits are established in accordance with a Safe Operating Envelope.

Measures in place to support this SCA:

- Abnormal Incident Manuals (AIMs): these manuals provide responses or direction to address unit upsets within the design basis. While the use of AIMs is rare, their use prevents any OP&P limits from being exceeded;
- Emergency Field Operation procedures (EFOs);
- Severe Accident Management procedures: these procedures provide a framework for identifying appropriate mitigating actions for events that fall into the severe accident category;
- Sufficient number of qualified staff during accidents: at all times, Bruce Power staffs Bruce A and Bruce B with the required number of workers who are qualified to fill minimum complement positions; and,
- Emergency Response Organization: Bruce Power's Emergency Management Program outlines the five elements: prevention and mitigation, preparedness, response, and transition to recovery. See Section 9.6 for additional information.

3.7.2 Past performance

On an annual frequency, each nuclear operator and authorized nuclear operator who holds a minimum complement position receives training for EFOs and AIMs. For additional information on training, see Section 2.2.

In the past licensing period, Bruce Power safely and successfully utilized AIM procedures in two separate events. For example, on August 24, 2016, Unit 6 experienced a loss of high pressure service water. AIMs and procedures were used to address the event and to successfully shut down the reactor unit.

Bruce Power's "all hazards" approach to emergency management has been tested and assessed through quarterly drills and annual corporate-level exercises. The drills and exercises are used to verify that the integrated emergency response processes, command structure, equipment, systems, and personnel are capable of responding to and mitigating the effects of design basis accidents.

Additional information regarding past performance is provided in Section 10.2.2.

3.7.3 Future plans

See Section 10.2.3.

3.7.4 Challenges

None.

3.7.5 Requests

Bruce Power requests that the CNSC does not implement version 2 of REGDOC-2.2.3, *Accident Management*. In its current form, this regulatory document cannot be implemented. This document interchanges requirements for Design Basis Accidents and Severe Accidents, which are managed by Bruce Power and the rest of the nuclear industry using totally different methodologies. Accordingly, the management of these two accident sets must be properly separated in REGDOC-2.2.3, in order to match current industry best practices.

4.0 SAFETY ANALYSIS

Covers 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.

4.1 Deterministic Safety Analysis

4.1.1 Relevance and management

Bruce Power has a dedicated organization as well as programs and processes to ensure that safety analysis issues are understood, prioritized and addressed, in order to safely operate and maintain the facilities.

The Plant Design Basis Management program governs the processes used to define, document, and control changes to the design basis. This program ensures the design basis meets regulatory requirements and remains within approved safety margins. Additionally, this program includes safety analysis.

This program is supported by the environmental qualification process, which establishes an integrated and comprehensive set of requirements to provide assurance that credited essential equipment and components can perform their safety-related functions if exposed to harsh environmental conditions resulting from design basis accidents.

Safety analysis is performed for the following reasons:

- To verify that regulatory requirements (such as dose limits) are met,
- To assist in defining the safe operating envelope, and,
- To verify that special safety systems and safety-related systems can perform their mitigating role for design basis accidents.

In other words, safety analysis ensures that plant operation conforms to the design basis and licensing assumptions, and remains within the bounds of analyzed conditions and the Safe Operating Envelope (SOE).

Deterministic Safety Analysis is an analysis of nuclear power plant responses to an event, performed using predetermined rules and assumptions (e.g., those concerning the initial operational state, availability and performance of the systems and operator actions).

Bruce Power uses the safety report update process to update the Safety Reports. One output of this process is the Safety Report Basis (SRB), which is used as the basis for the next scheduled update of the Safety Report and is provided to the CNSC in accordance with REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*. The SRB is a listing of Analysis of Record items and auxiliary documents since the last Safety Report revision.

Meetings with CNSC Ottawa staff are held on a regular basis to discuss the status of various safety analysis work programs.

4.1.2 Past performance

Starting with latest updates of Part 3 of the Bruce A and Bruce B Safety Reports, Bruce Power is providing a more comprehensive description of the revision history in the Safety Report.

4.1.3 Future plans

A 3-year Safety Report Improvement project is currently in progress to upgrade the Bruce A and B Safety Reports. In order to achieve material compliance with REGDOC-2.4.1, *Deterministic Safety Analysis*, Bruce Power prioritized the outstanding safety analysis activities in order to achieve the greatest safety benefit. Bruce Power is working closely with the CNSC to ensure that the updated Bruce A and Bruce B Safety Reports result in an equivalent level of safety as that required by REGDOC-2.4.1. Bruce Power plans to have this update issued by December 2017.

Bruce Power has updated the Bruce Power deterministic safety analysis processes and procedures to ensure consistency with REGDOC-2.4.1.

The Safety Report improvement project will update Part 3, Accident Analysis, of the Bruce A and Bruce B Safety Report. Additionally, a new Safety Report appendix on common mode failures will be introduced into both Safety Reports. This update is planned to be completed by December 2017.

4.1.4 Challenges

None.

4.1.5 Requests

None.

4.2 Hazard analysis

4.2.1 Relevance and management

The CSA N289 series of standards includes general requirements for seismic hazard evaluation, seismic design and qualification, and testing and monitoring, as applicable for the seismic qualification of those nuclear power plant structures, systems, and components necessary for safe shutdown, fuel cooling, the containment of potential releases of radioactive material, and the monitoring and control of essential safety-related functions in the event of an earthquake.

With some exceptions, Bruce A was not qualified to a design basis earthquake. For the restart of Bruce A in the 2000s, Bruce Power applied the seismic margin assessment methodology for all Bruce A units in lieu of the CSA N289 series (an approach that was accepted by the CNSC). The seismic margin assessment methodology applies a review level earthquake, which is stronger than the design basis earthquake.

For Bruce A, modifications to pressure-retaining components implement the requirements of CSA N289.3, *Design Procedures for Seismic Qualification of Nuclear Power Plants*, using the dual qualification requirements of the Bruce B design basis earthquake and the Bruce A review level earthquake. This dual criterion ensures robustness of new modifications to the design basis earthquake as well as the review level earthquake (which is the basis for the seismic qualification of the rest of the Bruce A station).

Bruce B was originally designed with a design basis earthquake. Modifications to Bruce B are qualified to the Bruce B design basis earthquake.

Note: The plant design basis earthquake is conservative in magnitude when compared to relevant local and international earthquake data. The plant design basis earthquake is applicable for the Bruce site. These robust seismic qualification requirements have been validated to adequately protect the plant in the event of an earthquake.

The fire protection assessment—including code compliance review, fire hazard analysis, and fire safe shutdown analysis—is completed and updated in accordance with CSA N293. Changes to the facility (engineering changes) are assessed to determine whether the change adversely affects assumptions in the fire protection assessment.

4.2.2 Past performance

The Bruce A seismic design guide has been updated to incorporate new regulatory approvals in association with the use of newer versions of CSA N289 series.

The more stringent Bruce A dual qualification criteria have been applied to Fukushima-related modifications at Bruce B with respect to beyond design basis assessments and analysis.

In order to incorporate the requirements of CSA N289.4, *Testing Procedures for Seismic Qualification of Nuclear Power Plant Structures, Systems, and Components*, Bruce Power has developed a list of seismic specifications which outline the requirements for testing of equipment and components requiring seismic qualification at Bruce A and Bruce B.

4.2.3 Future plans

The suite of reviews and analysis that make up the fire protection assessment are updated on a five-year cycle. Bruce Power plans to complete this update for both Bruce A and Bruce B by Q1 of 2018.

Life extension activities will introduce additional storage locations in the stations. However, the fire protection assessment (specifically, fire hazard analysis and fire safe shutdown analysis) identifies areas that are not suitable for storage. Accordingly, storage related to major component replacement will not impact the fire protection design basis. Additionally, modifications due to the major component replacement project will be assessed as per existing processes.

4.2.4 Challenges

None.

4.2.5 Requests

None.

4.3 Probabilistic safety analysis

4.3.1 Relevance and management

Bruce Power integrates deterministic safety analysis and probabilistic safety assessment (also known as probabilistic risk assessment) to ensure nuclear safety requirements are defined for issues that may impact the station's design basis or safety analysis basis.

Safety analysis is performed, in accordance with REGDOC-2.4.1, *Deterministic Safety Analysis*, and REGDOC-2.4.2, Prob*abilistic Safety Assessment (PSA) for Nuclear Power Plants*, to verify that regulatory requirements (such as dose limits), are met, to assist in defining the safe operating envelope, and to verify that special safety systems and safety-related systems can perform their mitigating role for design basis accidents.

Bruce Power also has a well-organized system which provides risk oversight by senior managers and governance by both station and independent committees. Risks are reported and reviewed by these committees via technical reporting or business risk log summaries.

Station-specific PSAs have been developed and maintained for each station and the results are assessed against the goals defined in the governing procedures (DIV-ENG-00010 and its implementing procedures). The PSAs are used to demonstrate safe design and operation of the plants, and as a tool to assist in risk-informed decision making for design or operational changes. The PSA includes the assessment of the adequacy of protection of the nuclear power plant against internal and external hazards.

Bruce Power chairs the CANDU Owners Group risk and reliability task team and ensures that the PSA process and outputs are consistent with best industry practice.

4.3.2 Past performance

As of last licence application, Bruce Power has updated the Bruce A and Bruce B PSA to comply with S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*, including internal events affecting a unit at-power, internal events affecting a unit in planned shutdown, internal fire affecting a unit at-power, internal flooding affecting a unit at-power, an earthquake affecting a unit at-power; and high winds affecting a unit at-power.

In addition, a list for all other external events to which Bruce A and Bruce B could be subjected (lightning, snow, forest fire, transportation accidents, external flooding, excessive rainfall, low lake level, etc.), was generated based on operating experience, a review of meteorological and historical records, and a review of international guidance, consistent with the Bruce Power external hazards methodology. These events were screened to determine credibility.

For those events for which a PSA was performed, the results were compared with the Bruce Power safety goals for severe core damage frequency ($1.0x10^{-4}$ occurrences per unit-year; the severe core damage frequency represents the likelihood of releasing radioactive material from the nuclear fuel into the containment structure), and large release frequency ($1.0x10^{-5}$ per unit-year; the large release frequency represents the release of radioactive material out of containment into the environment). The Bruce Power goals were met for each of the Bruce A and Bruce B PSAs (Table 7).

Table 7. PSA results for internal and external hazards

	Severe Core Damage Frequency[1]			**Large Release Frequency[1]**		
Event	**Safety goal**	**Bruce A**	**Bruce B**	**Safety goal**	**Bruce A**	**Bruce B**
Internal						
At power[2]	1.0×10^{-4}	3.8×10^{-6}	5.2×10^{-6}	1.0×10^{-5}	1.5×10^{-6}	6.9×10^{-7}
During shutdown	1.0×10^{-4}	1.3×10^{-5}	8.3×10^{-6}	1.0×10^{-5}	-	-
Internal flood[2]	1.0×10^{-4}	5.5×10^{-7}	4.6×10^{-7}	1.0×10^{-5}	-	-
Internal fire[2]	1.0×10^{-4}	8.7×10^{-6}	4.1×10^{-6}	1.0×10^{-5}	7.3×10^{-6}	8.7×10^{-7}
External						
Seismic[2,3]	$1.0 x10^{-4}$	$1.7 x10^{-6}$	7.2×10^{-7}	1.0×10^{-5}	1.7×10^{-6}	7.2×10^{-7}
High winds[2,3]	$1.0 x10^{-4}$	$4.8 x10^{-6}$	6.2×10^{-6}	1.0×10^{-5}	4.8×10^{-6}	6.2×10^{-6}

Note 1: per reactor per year.
Note 2: includes credit for Emergency Mitigating Equipment
Note 3: up to a 1-in-10,000-year event

The potential for an initiating event and for additional failures to affect more than one reactor unit is explicitly accounted for in the PSA. Therefore, the PSAs performed for multi-unit nuclear power plants in Canada are, in effect, what are referred to as Multi-Unit PSAs (MUPSAs). Although PSA results are expressed on a per-reactor basis, the results of the PSA explicitly account for multi-unit effects, interactions, and phenomena that contribute to the SCDF and LRF.

In addition to the inter-unit considerations already in the PSA methodology, Bruce Power has worked closely with industry and international organizations over the last two years to consider how to aggregate PSA results across a four-unit station in a meaningful manner.

The single-unit and station aggregation results for Bruce A and Bruce B At-Power Internal Events, Fire, Seismic and High Winds PSAs, shown in Figure 10 and Table 8, continue to show margin to the LRF safety goal of $1.0x10^{-5}$ occurrences per reactor-year (traditionally used to consider risk from a single unit only). The estimated parametric, modeling, and completeness uncertainties in each of the PSAs are provided, and the overall results show that the individual hazards meet the safety goal, and the sum of unit aggregation for internal events (At-Power Internal Events and Fire PSA) also meet the safety goal. The results for the external events (Seismic and High Winds PSA) are small in comparison to the internal events. Defence-in-depth improvements that were identified in areas such as fire protection are identified, and safety margins for the internal and external events have been assessed to demonstrate margins to any cliff-edge effects. The results indicate that the risk is dominated by Fire PSA results; however, no risk-dominant sequences were identified for mitigation.

The results of the LRF aggregation include estimates for planned improvements due to the following:

- Credit for installation of EME at both Bruce A and Bruce B (installation in progress),
- Automatic isolation of the Shield Tank on containment button-up at Bruce A (installation in progress),
- Improvements to containment response (e.g., Containment Filtered Venting System or CFVS) for multi-unit events at Bruce A and Bruce B (planned),
- Improvements to Group 2 reliability at Bruce B (installation in progress),
- Improved modeling of containment bypass events in PSA for Bruce A (modelling improvements in progress), and,
- Upgrades to Very Early Smoke Detection Apparatus at Bruce A and Bruce B (installation in progress).

Installation of CFVS is predicted to have significant beneficial impact on the limiting multi-unit scenarios by precluding containment failure in these scenarios. Currently containment is assumed to fail in any four-unit scenario. However, CFVS will maintain containment pressure below the containment failure pressure and will filter radioactive releases. Reduction factors for radioactive releases are anticipated to be on the order of 10,000 times. The CFVS may reduce accident releases below the large release threshold, but the final analysis will not be completed until the final design is installed and tested.

A preliminary assessment of the impacts of installing Shield Tank Overpressure Protection (all units), Shield Tank cooling relief line isolation valves (Units 2, 3, and 4), and CFVS (Bruce A and Bruce B) showed that these changes will reduce the LRF for at-power events by 45-60% for Bruce A and by 35-90% for Bruce B, when compared to the values shown in Table 6.

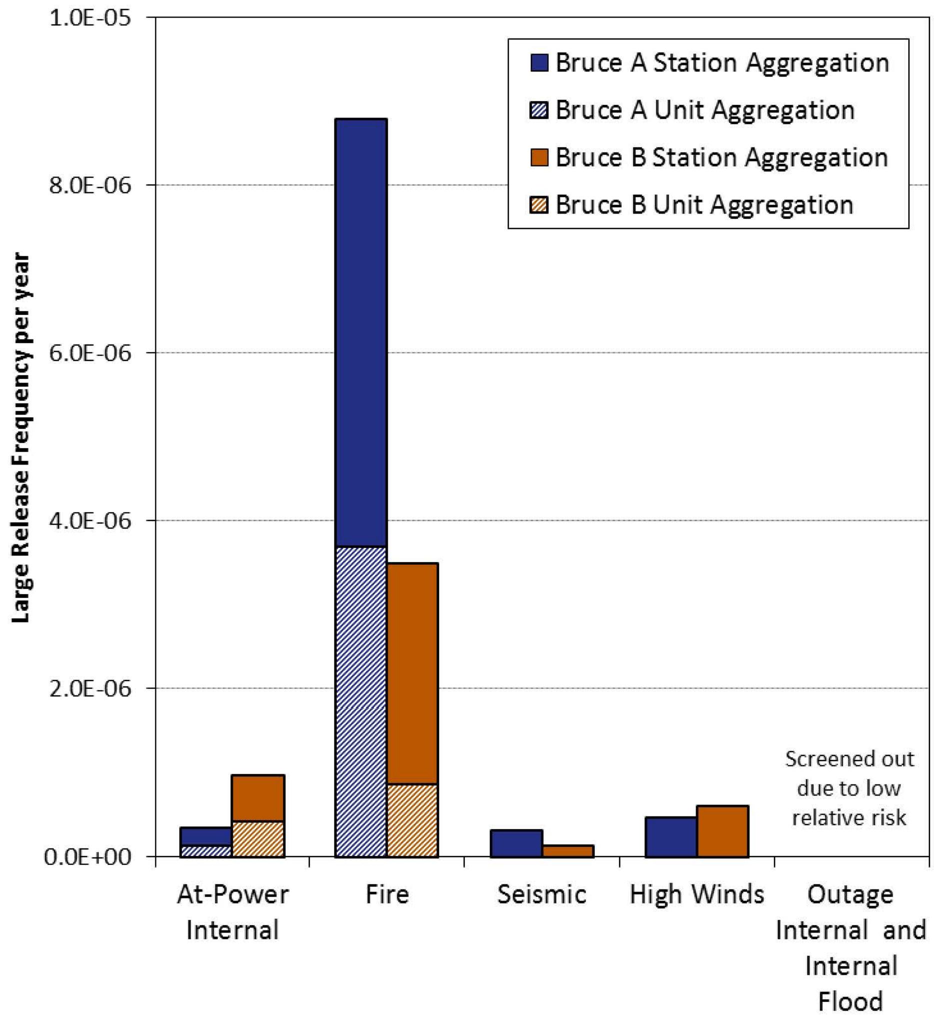


Figure 10. Bruce A and Bruce B PSA results for Large Release Frequency. Modeling is realistic for At-Power Internal and conservative for Fire, Seismic, and High Winds. Uncertainty is low for At-Power Internal and Moderate for Fire, Seismic, and High Winds.

Table 8. Multi-unit aggregation of PSA Large Release Frequency results

Purpose

The purpose is to summarize the safety assessment based on the Large Release Frequency for each of Bruce A and Bruce B, defined as the frequency of accidents causing a release to the environment greater than 10^{14} Bq of Cesium-137.

Parametric uncertainty	Modeling uncertainty	Completeness uncertainty
• Mean values represented in results	• Low uncertainty for internal failures at power and during outage • Conservative assumptions for fire initiating events • Conservative modeling for external hazards seismic and high winds	• Comprehensive scope/screening of internal and external reactor hazards. PSA performed for hazards not screened out. • External hazards cutoff frequency 1×10^{-4} per year. Margins assessed for lower frequency events. • Spent fuel events addressed deterministically and in the process of being screened for PSA.

Overall results characterization

- Individual hazard category results meet the LRF PSA goal of 1×10^{-5} per reactor per year
- Sum of internal events LRF = 3.8×10^{-6} per reactor per year for Bruce A and 1.3×10^{-6} per reactor per year for Bruce B. Both meet LRF PSA goal of 1×10^{-5} per reactor per year.
- LRFs for seismic and high winds are small in comparison to aggregated internal events LRF.

Multi-unit considerations

- Fire hazard category dominates both single unit and multi-unit results at both stations

Defence-in-depth characterization

- Defence-in-depth improvements implemented or in progress based on Fukushima lessons learned, including fire protection improvements such as early smoke detection

Safety margin characterization

- No vulnerabilities identified. No risk dominant sequences identified in Fire PSA.
- Seismic results do not increase significantly until severity exceeds that associated with 1 in about 40,000 year frequency.
- High wind SCDF doubles for event frequencies as low as 1 in 140,000 years.

Performance monitoring

- Bruce Power governance ensures potential design or operational changes are evaluated for impact on PSA results
- Bruce Power governance requires review if average or instantaneous PSA goals are exceeded
- PSAs are updated every 5 years or sooner if major changes occur

Integrated decision-making inputs

PSA goal met?	*Defence-in-depth*	*Safety margins*	*Multi-unit implications*	*Performance monitoring*
Yes	Confirmed	Dominated by fire hazard category	Fire still the dominant hazard category. No additional insights.	Annual average and instantaneous LRF monitoring

Conclusions

- Individual hazard categories and the sum of results for internal hazards meet the LRF goal
- Large margins for external hazards with frequencies 1 in 10,000 years or greater
- Fire dominates LRF. Results credit EME and improvements in fire detection equipment. There are no risk-dominant sequences.

4.3.3 Future plans

Bruce Power plans to be compliant with REGDOC-2.4.2 by the end of 2018.

As there have been no major changes in methodology, Bruce Power will not make major revisions to the current PSA that complies with S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*. The existing S-294 PSAs, along with seismically-induced fire and flood and irradiated fuel bay analyses, initiated as part of Bruce Power's response to the Fukushima event, will be used to meet REGDOC-2.4.2 requirements.

The PSAs will be updated to credit enhancements identified as part of S-294 work, including emergency mitigating equipment installed for Fukushima response.

Bruce Power will meet regularly with CNSC staff to discuss PSA update progress and schedule.

Going forward, the station-specific PSAs will be updated on a 5-year cycle.

4.3.4 Challenges

Bruce Power is working with its industry partners, through the CANDU Owners Group, and other industry experts to further characterize whole-site PSA. The appropriate methodology and results are planned to be in place as part of REGDOC-2.4.2 compliance.

4.3.5 Requests

None.

4.4 Criticality safety

4.4.1 Relevance and management

Bruce Power has a process to manage nuclear criticality safety practices, which are consistent with international standards and with RD-327, *Nuclear Criticality Safety*. Bruce Power always prevents the possibility for enriched reactor fuel to form a critical configuration outside the reactor core.

Any active nuclear criticality safety project would be subject to the requirements of the process for management of nuclear criticality safety practices. However, Bruce Power has no active nuclear criticality safety projects.

Nuclear criticality safety requirements are also integrated into the Bruce Power processes for controlling changes, for implementing new design and operating requirements, and for ensuring workers are qualified. As such, the requirements for nuclear criticality safety also apply to the storage of booster fuel assemblies and storage of low void reactivity fuel bundles.

4.4.2 Past performance

Bruce A: the booster fuel assemblies have been in long-term dry storage in the Booster Storage Facility since the late 1990s. The booster fuel assemblies are stored, handled, and managed in a manner that ensures their physical security and prevention of criticality. There were no criticality safety incidents involving the booster fuel assemblies or the Booster Storage Facility over the past licensing period.

Bruce B: the Low Void Reactivity Fuel (LVRF) demonstration irradiation was completed in 2008. No new LVRF bundles have been brought onto the Bruce site since that time. Currently 22 irradiated LVRF bundles are stored in the irradiated fuel bays. There were no criticality safety incidents involving irradiated LVRF bundles over the licensing period.

4.4.3 Future plans

There are no plans for developing an active nuclear criticality safety project.

There are no plans for changes to the storage of the legacy boosters and LVRF fuel bundles.

4.4.4 Challenges

None.

4.4.5 Requests

None.

4.5 Severe accident analysis

4.5.1 Relevance and management

As described in Section 4.3, Bruce Power has a robust process for probabilistic safety assessments, in order to evaluate the safe operation of the stations against defined safety goals. Probabilistic safety assessments (PSAs) include assessments of severe accidents as part of the Level 2 PSA, in accordance with REGDOC-2.4.2, *Probabilistic Safety Analysis (PSA) for Nuclear Power Plants.*

4.5.2 Past performance

As discussed in Section 4.3.2, Bruce Power updated the Bruce A and Bruce B PSAs to comply with S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*. This included an expansion of the scope of the PSAs, including the analysis of severe accidents (unmitigated loss of heat sinks on one or more units). The updated PSAs included updated Level 2 PSA methodology and a full treatment of severe accidents using an industry standard tool (MAAP4-CANDU).

Bruce Power continues to support industry R&D programs in this area, as well as the ongoing improvement of analytical tools for severe accident analysis (i.e., MAAP5-CANDU).

4.5.3 Future plans

Bruce Power plans to update the Bruce A and Bruce B Level 2 PSAs to comply with REGDOC-2.4.2, as discussed in Section 4.3.3. This includes an assessment of the impact of emergency mitigating equipment (improvements which were installed as part of the response to the Fukushima event) on the Level 2 PSA results.

4.5.4 Challenges

None.

4.5.5 Requests

None.

4.6 Management of safety issues (including R&D Programs)

4.6.1 Relevance and management

In collaboration with the broader nuclear industry, Bruce Power has made significant progress towards the resolution of Generic Action Items. All of the outstanding Generic Action Items have now been closed with follow-up actions, or have been re-categorized and tracked as CANDU Safety Issues (CSIs).

In 2007, the CNSC staff initiated a project to address the outstanding CSIs related to design and analysis.

4.6.2 Past performance

The following four CSIs related to Large Break Loss of Coolant Accident (LBLOCA) are managed and reported separately to the CNSC.

- AA 9, analysis for void reactivity coefficient,
- PF 9, fuel behaviour in high temperature transients,
- PF 10, fuel behaviour in power pulse transients, and,
- PF 12, channel voiding during a Large LOCA.

These CSIs were assessed as part of a Candu Owners Group (COG) joint project. PF 12 has been reclassified to a Category 2 CSI.

Bruce Power has been developing a path forward for reclassification of AA 9, PF 9 and PF 10 by implementation of the LBLOCA Composite Analytical Approach (CAA). The CAA methodology involves systematic reclassification of LBLOCA events to the beyond design basis accident category based on the extreme low frequency of the limiting initiating events. The CAA methodology, including the use of more realistic assumptions for safety analysis for beyond design basis accidents, provides significant improvement in safety margins compared to traditional safety analysis methods, further substantiating the confidence in safety analysis conclusions and robustness of the Bruce reactor design.

In support of the request for reclassification, Bruce Power has submitted additional information, including a plan and schedule for LBLOCA CAA licensing analysis and leak-before-break (LBB) assessment of the Primary Heat Transport System large diameter piping.

4.6.3 Future plans

Bruce Power continues to work with the industry and the CNSC to implement CAA in order to re-classify the remaining Category 3 issues.

4.6.4 Challenges

The CNSC has some remaining questions with the request by Bruce Power to re-classify the three remaining LBLOCA Category 3 issues. Bruce Power will work to address outstanding issues and obtain CNSC concurrence with the proposed path-forward to perform licensing analysis and LBB assessment over the next two years.

4.6.5 Requests

None.

5.0 PHYSICAL DESIGN

Relates to 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.

This Safety and Control area includes the following specific areas:

- Design governance,
- Physical design,
- Site characterization,
- Facility design,
- Structure design,
- System design, and,
- Component design.

Bruce Power has integrated all the relevant design activities through a suite of related programs. Accordingly, the discussion provided in Section 5 addresses all specific areas together.

5.1 Design governance, physical design, site characterization, facility design, and SSC design

5.1.1 Relevance and management

The physical design of the Bruce site facilities is managed through the Plant Design Basis Management, Engineering Change Control, and Configuration Management programs. These programs provide a disciplined approach to the control of the physical configuration, design requirements, and facility configuration information such that that structures, systems, and components are fully functional and support safe, reliable plant operation.

The overall objective of the program suite is to ensure that structures, systems, components, and tools (SSCT) meet design basis requirements and enable the plant to operate safely, reliably, and efficiently for the duration of its operating life. The program suite includes processes that ensure:

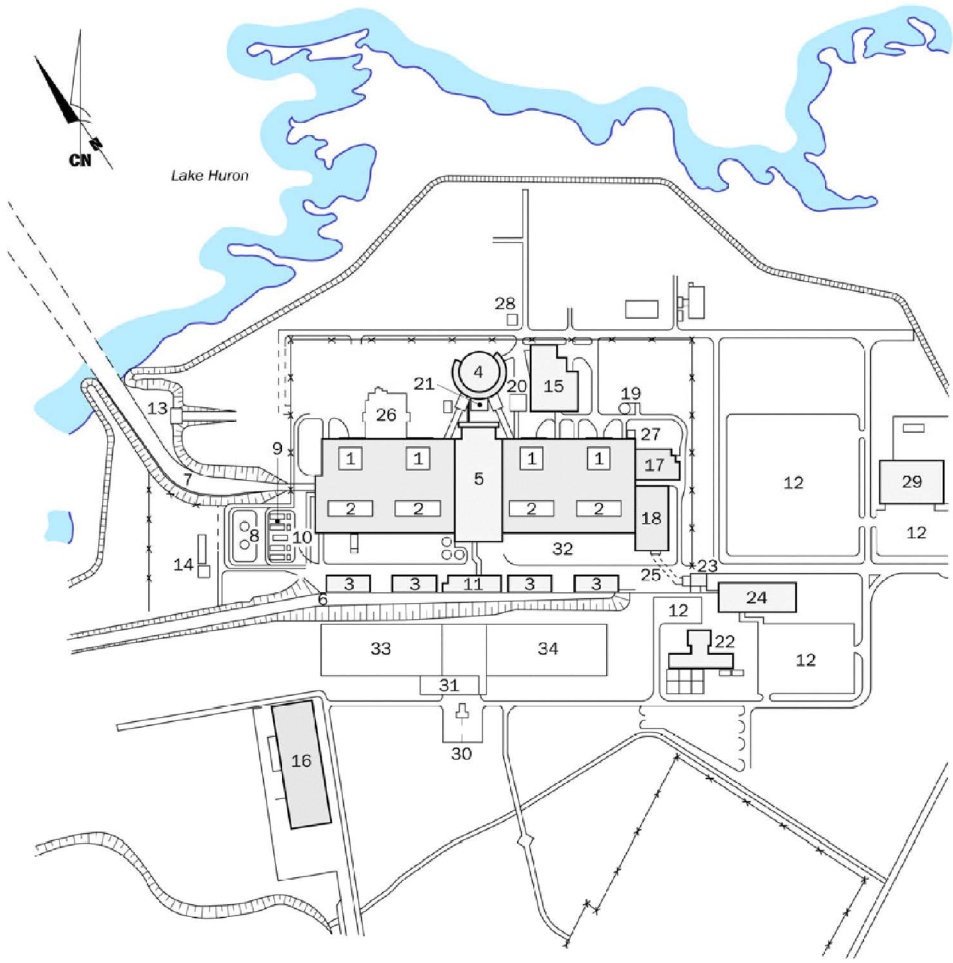
- Design requirements are defined and documented;

- Changes are correct, documented, controlled, and approved; and,

- Operations, maintenance, and training documents are up to date and are consistent with the plant design.

Organizational responsibilities and change approval authority are assigned to promote proficiency through standard processes and activities while ensuring commitment to the four pillars of nuclear safety (reactor, radiological, environmental, and industrial safety) is maintained.

The Bruce Power site is located on the eastern shore of Lake Huron in the Municipality of Kincardine, Bruce County, Ontario. The site hosts two nuclear generating stations, Bruce A and Bruce B. Bruce Power's location in relation to neighbouring communities is shown in the illustration below.



1. Reactor Building
2. Turbine Generator
3. Pump House
4. Vacuum Building
5. Service Building
6. Forebay and Open Channel
7. Discharge Channel
8. Fuel Oil Tanks
9. Standby Generators
10. Fuel Oil Pump Houses
11. (Old) Water Treatment Building
12. Parking Areas
13. Dock Area
14. Recirculating
15. Ancillary Service Building
16. (Old) Steam Transformer Plant "A" (Removed spring 2006)
17. East Service Bay
18. Amenities Building
19. HPECI Grade Level Storage Tank (TK6)
20. Accumulator Building
21. EFADS/Parms Building
22. Project Office
23. Main Security Building
24. Technical Building
25. Station Access Tunnel
26. Retube Building
27. Fuel Handling/Slar Trailer
28. Boiler Hem/Clean Liquid Waste Transfer
29. North Warehouse
30. Sludge Pond
31. (New) Water Treatment Building
32. Main and Service Transformer Area
33. 230 kV Switching Area
34. 500 kV Switching Area

Afig 1-3
BV-6666

Figure 11.
Bruce A: general station layout
(NK21-SR-01320-00001 R005, Figure 1-3)

All eight pressurized heavy water reactors at the Bruce site were originally designed by Atomic Energy of Canada Limited and Ontario Hydro.

The Bruce A nuclear generating station is comprised of four nuclear reactors, four turbine generators and associated equipment, services, and facilities as shown in Figure 11. Following an intensive campaign of investment in Bruce A, Bruce Power returned two of these units to service in 2012.

Notable building and structures at Bruce A include:

- Four reactor buildings,
- Four reactor auxiliary bays,
- A powerhouse including the turbine hall and turbine auxiliary bay,
- A central service area,
- A vacuum building,
- An ancillary services building,
- Four pump houses,
- The old water treatment building (which includes the Qualified Power Supply system),
- The new water treatment building,
- Four standby generator enclosures,
- An emergency filtered air discharge system building, and,
- Emergency coolant injection (accumulator, recovery pump, and storage tank).

The Bruce B nuclear generating station is similar.

Major plant systems at both Bruce A and Bruce B include the reactor, the reactivity control system, heat transport system, special safety systems, steam system, feed water system, turbine generator systems, electrical power systems, and process and service air and water systems.

Figure 12 provides a schematic of major plant systems for each generating unit.

Each reactor consists of a horizontal, cylindrical tank (the calandria). The calandria is penetrated by 480 through-tubes and contains heavy water which moderates the nuclear reaction. Nested in each through-tube is an additional tube known as a fuel channel. It is in this channel that fuel bundles are placed during operation. The reactor is surrounded by a tank containing light water in order to shield nearby structures and equipment from radioactivity during operation.

The reactors at Bruce A and Bruce B use natural uranium fuel. Each fuel bundle, as shown in Figure 13, is made up of 37 fuel pencils arranged in concentric circles. At Bruce A, each of the 480 channels in 2 reactors contains 13 bundles; each of the channels in the other 2 units contains 12 bundles. At Bruce B, each of the channels contains 12 bundles in all reactors.

Control of the nuclear reaction is measured using instruments which provide input to a pair of fully redundant control computers. Output from the computers allows operators to continuously monitor the reactor and its supporting systems.

Heat is generated as the nuclear reaction occurs. Generated heat is removed by the Heat Transport System. This system uses four very large pumps to circulate heavy water through all 480 channels and past each fuel bundle. This system forms a closed loop and transfers the heat to regular water by circulating through thousands of small tubes in each steam generator. Each reactor unit has eight steam generators, four on each side of the reactor.

During normal operation, two boiler feedwater pumps operate to supply demineralized water to the steam generators. As heat is transferred from the heavy water on the steam generator primary side, the regular water on the steam generator secondary side heats up and turns to steam. This steam travels through insulated piping to the turbines. The motion of the steam, entering the turbines, causes them to turn.

The turbines are directly connected rotating portion of the electrical generator known as the rotor. T he generator has a second part: the stator. The stator is stationary and fits around the rotor. As the rotor turns, electricity is generated and flows to the power distribution system.

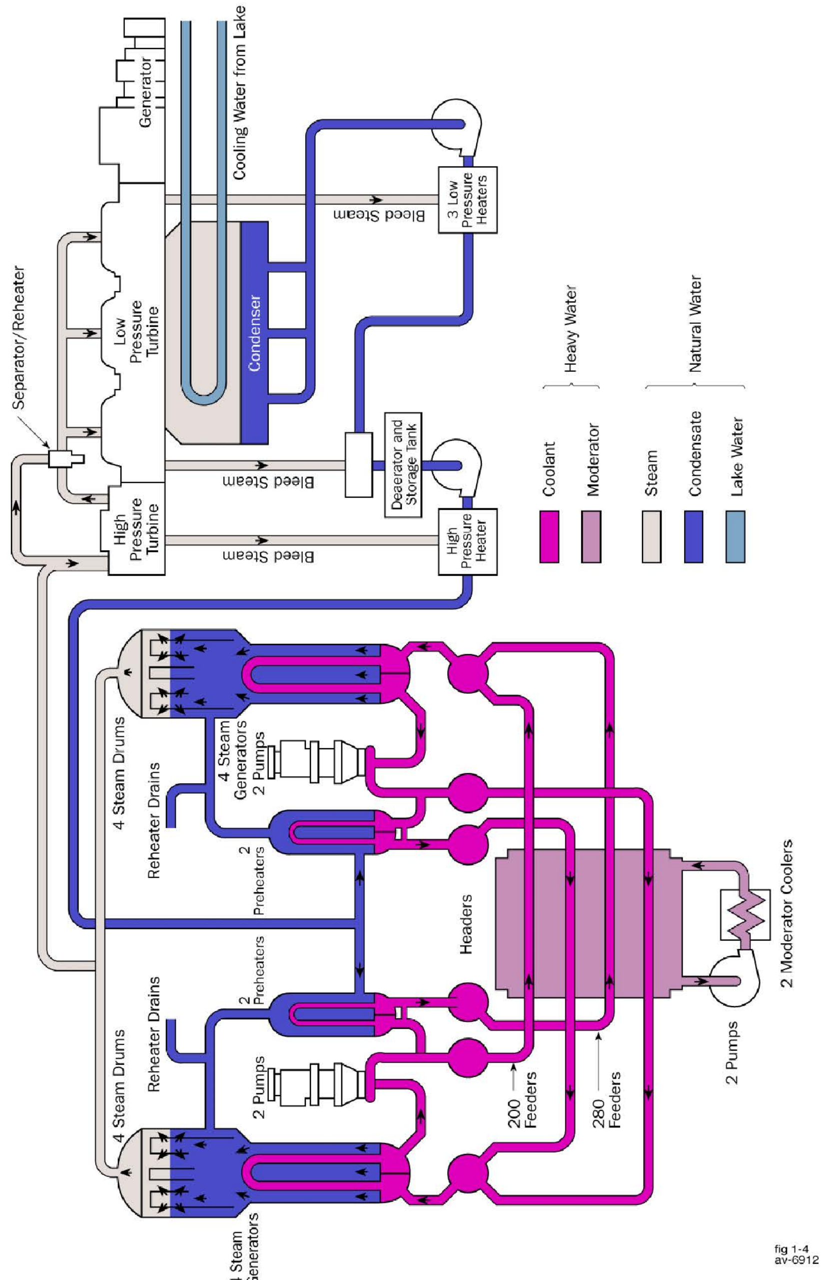


Figure 12. Simplified unit flow design (NK29-SR-01320-00001, Figure 1-4)

Figure 13. Modified 37-element fuel bundle

5.1.2 Past performance

Over past licence period, focus has been on continuous improvement. With requirements met, the vision has shifted to one that includes innovation and excellence in design management. Management continues to focus on this area through the use of product challenge boards and rigorous use of project controls to ensure good scope control and sustained cost and schedule performance.

Bruce Power installs approximately 300-400 modifications at Bruce A and Bruce B per year.

Examples of major modifications for reactor tooling, common to Bruce A and Bruce B, include:

- Bruce Reactor Inspection and Maintenance Systems (BRIMS),
- Modal Detection and Repositioning (MODAR) Tool Head, and,
- Circumferential Wet Scrape Tool (CWEST) Upgrades.

Examples of major modifications completed at Bruce A include:

- Instrument air compressor replacements,
- Enhanced cooling capability for beyond design basis conditions,
- Analog controller obsolescence replacements,
- Fuel handling inverters,
- U3,4 Shutdown System 1 NOP amplifier replacements,
- Heat Transport System pump motor replacements,
- Main output transformer replacement,
- Replacement of Units 1 and 2 switchyard synchronization breakers,
- Ongoing replacement of safety system monitoring computers, and,
- Generator output capacity increases.

Examples of major modifications completed at Bruce B include:

- Emergency Power Generator Controls Upgrades,
- Enhanced cooling capability for beyond design basis conditions,
- BB PARs Installation,
- Standby Generator Fuel Line Replacements ,
- Installation of a new Demineralized Water Plant and associated piping header,
- Gaseous Fission Product Monitor Upgrades ,
- Analog Controller Obsolescence Replacements,
- Ongoing Liquid Zone Level Control Valve Positioner Replacements,
- Ongoing Replacement of Safety System Monitoring Computers, and,
- D2O and H2O Monitor for Service Water Replacement.

Key contributors to good performance have included continued use of planning tools, use of human performance tools (such as procedure use and adherence, technical pre-job briefs, and turnover), and management oversight and reinforcement of high standards.

An area of particular attention has been modification quality. Continued improvements to the conceptual engineering process, early stakeholder involvement, use of requirements traceability matrices, failure modes and effects analyses, pre-engineered change process (for cost-effective component replacements), and digital design improvements have assured that high quality and effective solutions are developed to solve identified station challenges

5.1.3 Future plans

Effective use of stakeholder involvement and the corrective action program continue to drive further improvements in design engineering governance.

As part of a continual exercise, Bruce Power plans to benchmark the broader nuclear industry to optimize safety and performance during design and implementation of modifications.

5.1.4 Challenges

Historically, design registrations to pressure retaining systems were not updated as changes were made to Bruce A and Bruce B. The changes met safety standards at the time, but some administrative requirements were not completed.

In support of the focus on world-class nuclear operations, historical installations are being reconciled, and registrations are being updated. Bruce A is complete, and Bruce B is on track for completion in 2017. Completion of this project will ensure full compliance with all system registration requirements.

5.1.5 Requests

None.

6.0 FITNESS FOR SERVICE

Covers 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.

6.1 Equipment fitness for service / equipment performance

6.1.1 Relevance and management

The Equipment Reliability program is intended to ensure that Systems, Structures, and Components (SSCs) perform in a safe, reliable, and cost-effective manner. Bruce Power's integrated and coordinated Equipment Reliability program is based on the INPO Equipment Reliability Advanced Process Description (AP-913), with appropriate enhancements to address the regulatory and business requirements applicable to Bruce Power.

A broad range of activities are integrated in this program, including:

- Scoping and identification of SSCs important to maintain safe, reliable operation (critical SSCs);
- Development and optimization of the preventive maintenance technical basis and tasks to support documented preventive maintenance processes;
- Implementation of preventive maintenance, including periodic, predictive, and planned maintenance, to support continuous improvement of equipment reliability;
- Performance monitoring, with established performance criteria and monitoring parameters for important SSCs. This ensures that important SSCs will perform their functions under all design basis conditions. Monitoring includes the use of operator rounds, collection of reliability data, safety system tests, engineering walkdowns, and assessment of maintenance results (as-found conditions, post-maintenance testing, and work completion reports);
- Corrective actions to follow when a critical SSC experiences an unplanned failure or degraded performance. If degraded performance is observed, system health improvement plants are developed and implemented;
- Long-term planning and life cycle management for developing and implementing formal plans that ensure reliable asset performance until planned replacement or refurbishment.

Bruce Power addresses aging management for critical components in accordance with REGDOC-2.6.3, *Aging Management*, and the recommendations of INPO AP-913, *Equipment Reliability*. Aging management activities include preparation of a technical basis assessment to provide baselines for the maintenance and aging management strategies. A technical basis assessment includes an analysis of failure modes and effects, determination of applicable degradation mechanisms, and development of monitoring and mitigating tasks and frequencies. These tasks are then executed using Bruce Power processes for preventive maintenance field activities, inspections, surveillance tests, and equipment refurbishments or replacements.

Fitness for service for major components—fuel channels, feeders, and boilers/pre-heaters—is addressed through Life Cycle Management Plans (LCMPs). LCMPs for the major components are undergoing revision, with issuance expected in Q2 of 2017. Supporting documents for LCMPs include technical basis assessment, periodic inspection program documents, condition assessments captured in health reports, and fitness for service documents, all of which are used as inputs for online and outage work scope definition and execution.

Bruce Power makes capital investments at Bruce A and Bruce B to improve equipment reliability through projects to replace and upgrade key equipment.

Bruce Power prepared an integrated Lifetime Asset Management Plan to support long-term operation of the Bruce site. This plan coordinates capital projects, maintenance outages, and Major Component Replacement (MCR) outages, to align with the business planning cycle and to ensure that end-of-life strategies for assets are prepared and executed at the right time.

The Equipment Reliability program is supported by the following Bruce Power programs:

- Online and Outage Work Management: these programs ensure timely identification, screening, scoping, planning, scheduling, preparation, and execution of the work necessary to maximize the availability and reliability of station equipment and systems. These programs also manage the risk associated with work through proactive identification of situations or activities that could adversely impact safety margins and through the development and execution of mitigation strategies.

- Plant Maintenance: this program ensures maximization of availability for safety-related and production-sensitive equipment. This program includes execution of preventive maintenance, as well as predictive maintenance, which provides early detection of degradation (prior to failure).

- Design Management: this program ensures that the design basis is defined, documented, and controlled such that safety margins and regulatory requirements are met. Additionally, this program includes safety analysis to ensure that plant operation remains within the bounds of analyzed conditions and the Safe Operating Envelope (SOE).

6.1.2 Past performance

The Equipment Reliability Index (ERI) is the industry-standard metric for measuring and demonstrating status of overall equipment performance.

Both Bruce A and Bruce B continued to exhibit an improving trend in performance of this indicator. Bruce A ERI reached 77 points as of the end of 2016, as compared to an ERI value of 58 reported in the Performance Review for the previous Licensing cycle.

Similarly, Bruce B ERI reached 85 as of the end of 2016, as compared to an ERI value of 70 reported in the Performance Review for the previous Licensing cycle.

This strong performance and continuing improvement of the ERI metric at both stations is a clear indication of the effectiveness of the integrated programs in place to monitor and manage equipment performance and condition, and to ensure safe, reliable operations at both Bruce A and Bruce B.

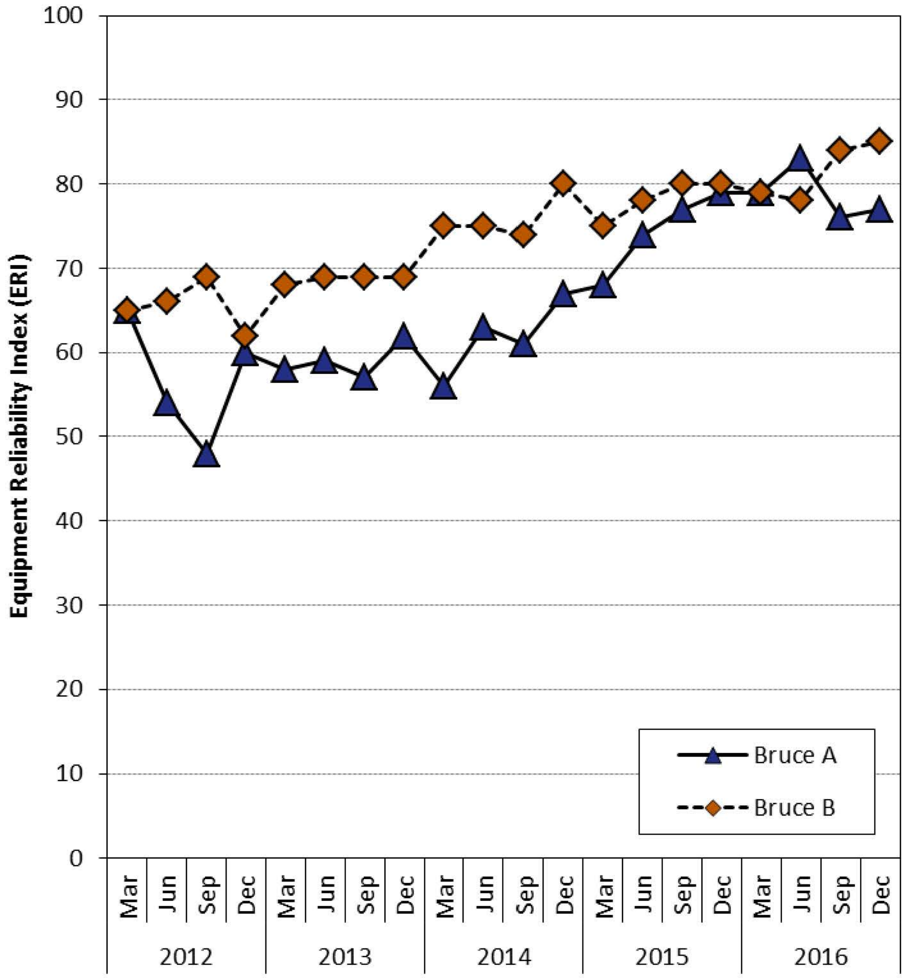


Figure 14. Equipment Reliability Index (2012-2016)

Performance and condition monitoring of major reactor components—fuel channels, feeders, and steam generators/pre-heaters—are managed via the LCMPs with results fed back into the plan, following the PLAN-DO-CHECK-ACT model. After each inspection or maintenance campaign, Bruce Power notifies the CNSC through inspection assessment reports or component dispositions, in accordance with requirements of CSA N285.4, *Periodic Inspection of CANDU Nuclear Power Plant Components.* Maintenance activities for major components include feeder replacement and fuel channel mitigation activities (to prevent pressure tube to calandria tube contact, to guarantee fuel channel on-bearing operation, to repair end fittings and Grayloc seal surfaces, etc.) to ensure the components are fit for service.

All Bruce A and Bruce B reactor vaults have been inspected and tested at regular intervals, in accordance with CSA N287.7, *In Service Examination and Testing Requirements for Concrete Containment Structures for CANDU Nuclear Power Plants*. No deteriorations were observed that would compromise containment integrity, and no significant changes were identified when compared to previous inspections.

Containment performance at both Bruce A and Bruce B is monitored and trended via the quarterly on-power leak rate test, which measures the leak tightness of the containment structure at negative pressure. The leakage rate for main containment at Bruce A and Bruce B remains within the OP&P limit, and there is no indication of any negative performance trend.

Bruce Power has implemented improvements to inspection and maintenance tooling for fuel channels. Advanced Non-Destructive Evaluation (ANDE) and Circumferential West Scrape Tool (CWEST) provide increased reliability in data acquisition. Modal Detection and Repositioning (MODAR) has been developed to move tight-fitting garter springs to manage the gap between the pressure tube and the calandria tube. De-tensioning of the Liquid Injection Shutdown System (LISS) nozzles reduces risk and worker dose. Feeder thinning analysis improvements have significantly improved predictions for replacement frequency.

6.1.3 Future plans

Bruce Power continues to develop new tools to better understand and manage the risks within the core.

Major components will be replaced in Life Extension Outages.

6.1.4 Challenges

Management of obsolescence issues continues to be a major focus area, with strategies to address obsolescence incorporated into health reports and health improvement plans.

6.1.5 Requests

None.

6.2 Maintenance

6.2.1 Relevance and management

The Bruce Power Plant Maintenance Program establishes processes to effectively maintain plant structures, systems, and components such that the availability and reliability of safety-related and production sensitive equipment is maximized, and operators are not challenged by equipment failure. This program also focuses on managing identification and execution of preventive maintenance and repetitive task work activities by using modeling work orders in support of operation and testing of equipment. Predictive maintenance using thermography and vibration analysis is an integral part of the program, which provides early detection of degradation prior to failure of the equipment.

Management of the plant design basis is described in Section 5.1.

6.2.2 Past performance

In 2016, the focus was on oversight of preventative maintenance deferrals. As a result, maintenance backlogs were reduced throughout the year.

In 2017, a new set of maintenance peer metrics was established. The change in metrics reflects a maturing of performance and a deeper quest for excellence.

6.2.3 Future plans

Rework metrics are currently within industry standard guidelines. However, Bruce Power has an opportunity to improve identification of probable rework. Increased scrutiny may provide significant time and cost savings.

The "Ready to Work" initiative will improve the site's effectiveness at preparing preventative and corrective work for execution. This initiative will focus on improved work preparation processes, improved parts availability, and resource qualifications that match the demand of the station work programs.

6.2.4 Challenges

Reducing the backlog for revisions to maintenance procedures is a focus for Bruce Power. In 2016 Bruce Power revised nearly 600 maintenance procedures, resulting in the reduction of technical document change request to below the target value of 5, which is better than industry best practice (25). This significant reduction in the number of backlog technical document change requests has allowed Bruce Power to shift its focus to decreasing the age of the technical document change requests. The opportunity for 2017 is to improve efficiency and reduce human performance traps in the technical procedures.

6.2.5 Requests

None.

6.3 Structural integrity

6.3.1 Relevance and management

Adherence to safe work practices during the construction and maintenance of facilities is fundamental to the safety of personnel, equipment, and the environment. Standard methods for construction and maintenance are essential in maintaining the nuclear plant design basis and ensuring that structural integrity requirements are met. Work that impacts concrete structures (drilling, chipping, coring, saw cutting, rotary hammer drilling, etc.) is performed in accordance with approved procedures. A process for locating underground utilities ensures that excavation activities are planned in a manner that shall prevents damage or injury to personnel, equipment, or property.

6.3.2 Past performance

In accordance with CSA N285.5, *Periodic Inspection of CANDU Nuclear Power Plant Containment Components*, inspections of spray headers were performed by an external vendor during the April 2015 Bruce B vacuum building outage. The 16 spray headers were found to be in good condition with no significant signs of aging-related degradation. A few minor findings were detected and repaired.

In accordance with CSA N287.7, *In Service Examination and Testing Requirements for Concrete Containment Structures for CANDU Nuclear Power Plants*, inspections of the Bruce B concrete containment structures were performed by an external vendor during the Bruce B vacuum building outage. Relevant components include components in vacuum building, Unit 0, and the unit reactor vaults, in accordance with periodic inspection program requirements. The concrete was found to be in good condition, with minor deteriorations that do not threaten containment integrity. Some areas in the vacuum building were patched to repair concrete spalling.

In accordance with CSA N285.5-08, over 600 inspections of Bruce A containment boundary components were performed during the Bruce A station containment outage in 2016. Some common service water lines showed minor signs of wall thinning, which were still well within the design basis. A few additional minor findings were detected and repaired.

6.3.3 Future plans

None.

6.3.4 Challenges

None.

6.3.5 Requests

None.

6.4 Aging management

See Section 6.1.

6.5 Chemistry control

6.5.1 Relevance and management

The Chemistry Management program is intended to:

- Preserve the integrity of structures, systems, and components important to safety by limiting and controlling corrosion that can cause degradation;
- Preserve the integrity of the barriers retaining radioactivity by limiting and controlling corrosion that could weaken or breach of those barriers;
- Ensuring the application of chemistry specifications to prevent operation outside of the safe operating envelope and Operating Policy and Principles (OP&P);
- Maintain conditions for the over-poisoned guaranteed shutdown state in support of reactor shutdown guarantees;
- Limit or reduce the amount harmful materials released to the environment; and,
- Minimize the buildup of radioactive materials and activated corrosion products to reduce radiation dose to workers.

The Chemistry Management program is prepared in consideration of WANO Performance Objectives and Criteria and INPO Guidelines for the Conduct of Chemistry at Nuclear Power Stations.

The Chemistry Management program consists of several key processes:

- Preparation, maintenance, and application of system chemistry specification documents for all the systems requiring chemistry control. The system chemistry specification documents describe specifications and required actions for effective control of plant chemistry during all operational states. Chemistry control is managed in a graded manner commensurate with deviation from normal chemistry control limits through (where applicable) actions levels adopted from the Electric Power Research Institute (EPRI);

- Preparation and maintenance of station chemistry control procedures, which define activities, action levels, notifications, and chemistry data evaluation;

- Preparation and maintenance of chemistry laboratory procedures, which define sampling and analysis requirements for chemical properties (pH, conductivity, impurities, etc.). These procedures include quality control/quality assurance requirements for test methods and associated instrumentation, including intra- and inter-laboratory performance testing.

- Management of hazards associated with the composition and use of chemicals on-site. Risk assessments are performed, and colour-coded chemical risk labels are applied. These labels indicate the restrictions or limitations associated with the use of chemicals;

- General standards for roles, responsibilities, and conduct for workers in the chemistry organization. These standards provide the tools to ensure safe, reliable, and consistent plant operation by promoting behaviours and oversight associated with the following key performance areas: safety, record keeping, data management and quality control/quality assurance, procedure use and adherence, training and competencies, and plant status control; and,

- Expectations for performing, assessing, and reinforcing the chemistry and environment fundamentals to ensure chemistry and environment-related activities achieve industry best performance.

6.5.2 Past performance

Pursuant to REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*, Bruce Power reports the chemistry index and chemistry compliance index for Bruce A (Figure 15) and Bruce B (Figure 16). Both indices reflect the fraction of time that various chemistry parameters are within specifications, with 95% as industry average.

Chemistry performance remains strong at both Bruce A and Bruce B.

Typical impacts to the chemistry index at Bruce A and Bruce B include levels of condensate dissolved oxygen above the EPRI limit, as well as transport of feedwater copper and iron. The impact of condensate dissolved oxygen is well-understood, and the industry expects that revised EPRI guidelines will no longer include a control limit for condensate dissolved oxygen at stations with a deaerator. As equipment reliability improves at Bruce A, and shutdowns/startups due to forced outages become less frequent, challenges to the transport of feedwater copper and iron will also be reduced.

The chemistry compliance index is impacted largely by moderator isotopic which is lower than specification. The heavy water program is currently executing plans to upgrade the moderator isotopic across all units on site. In Q1 2016, the chemistry compliance index for Bruce A was lower than usual due to fuel defects as well as spent ion exchange columns on the liquid zone system that could not be isolated. These issues were corrected during a planned outage on the impacted unit.

In preparation for MCR, the chemistry specifications for each system were reviewed in 2016. Only minor revisions were needed, as all of the significant systems already include layup specifications. Going forward, there is still significant logistical and planning work to ensure proper chemistry conditions and timely execution of work between shutdown and the end states prescribed for layup.

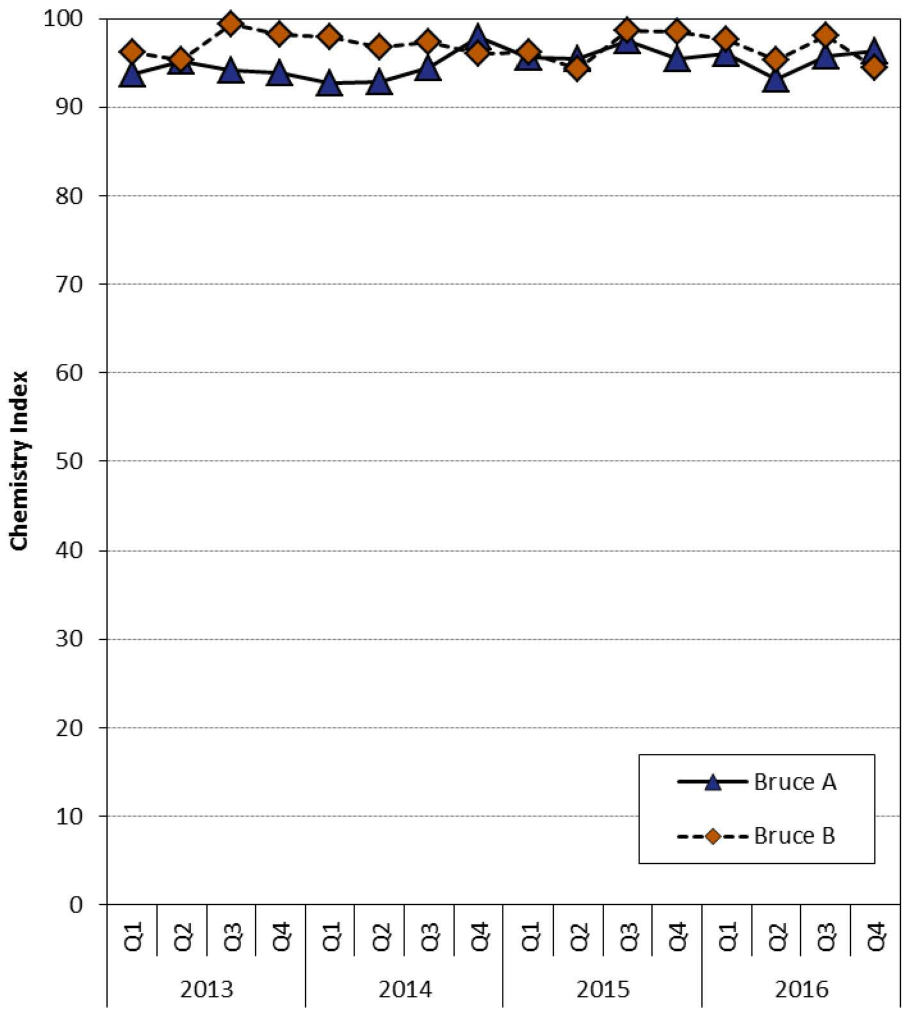


Figure 15. Chemistry Index (2013-2016)

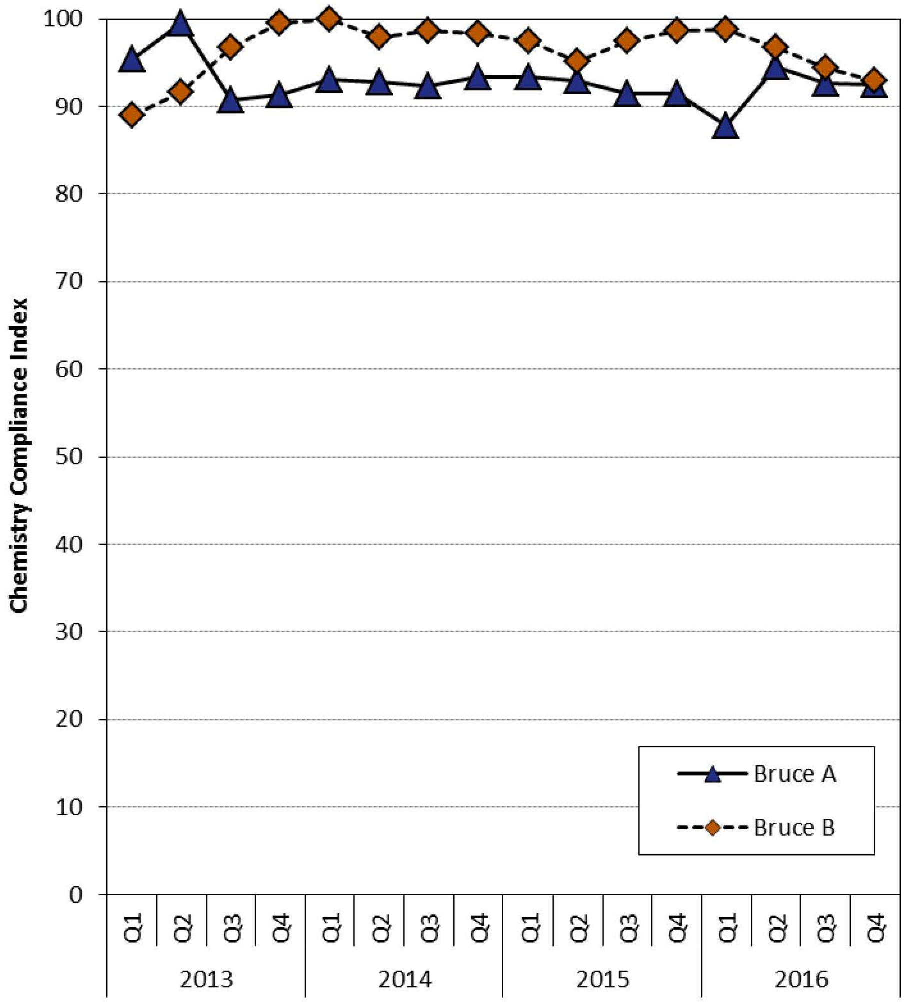


Figure 16. Chemistry Compliance Index

6.5.3 Future plans

Targets for performance are reviewed and adjusted to drive improvements.

Chemistry improvement focus areas are reviewed and selected by the chemistry peer team on an annual basis to address gaps in performance. The primary focus area for self-assessment in 2017 is chemistry fundamentals.

In 2017, the following key improvements are planned:

- Implementation of administrative changes to support Major Component Replacement;
- Implementation of a new Laboratory Information Management System (LIMS) at Bruce A, Bruce B, and the Bruce site (Centre of Site), including update of governance;
- Implementation of new EPRI PWR Secondary Guidelines;

- Implementation of improvement plans for current and potential Bruce A and Bruce B WANO Findings;
- Assessment of quality control/quality assurance requirements with respect to CSA N288.5-11, *Effluent Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills*.

In the future, improvements to governance and execution will primarily focus on leveraging the benefits of the new LIMS system, support for MCR, and a focus on chemistry fundamentals.

6.5.4 Challenges

The largest challenge for the chemistry program is equipment reliability, as chemistry performance is excellent during steady-state operation. Significant improvements in equipment reliability are occurring (Section 6.1), which will improve chemistry performance.

6.5.5 Requests

None.

6.6 Periodic inspection and testing

6.6.1 Relevance and management

Management of periodic inspection and testing is one element of the Equipment Reliability program, which is described more fully in Section 6.1.

The periodic inspection and testing process ensures the requirements for periodic inspection of safety-related plant structures, systems and components (SSCs) are established and documented through creating, updating, and revising Periodic Inspection Plans (PIPs) and schedules. Procedures are used to document the methods for review, evaluation, and disposition of periodic inspection findings, and are used to identify the roles and responsibilities for relevant workers.

6.7 Fuel channels

The fuel channel assembly life cycle management and fitness for service program supports operation throughout the proposed licence period and beyond. In order to ensure long-term fuel channel fitness for service, the fuel channel life cycle management plan will be updated periodically using inspections, internal and external operating experience, research and development, and joint industry project findings.

The life cycle management and fitness for service programs are based on a sound understanding of the changes to fuel channel assemblies over their operational life. Based on in-reactor inspection data and tests on pressure tubes removed from operating reactors, the fuel channel component affected most by degradation mechanisms is the pressure tube itself.

6.7.1 Pressure tubes

During operation, pressure tubes experience an environment of high temperature, high pressure, and neutron irradiation. These stressors cause changes in pressure tube dimensions and material properties through irradiation effects and microstructural changes. The pressure tubes are also subject to corrosion, and the resulting deuterium ingress affects the fracture toughness and flaw tolerance of the pressure tubes. The pressure tubes sustain varying degrees of material wear caused by the passage of fuel bundles. Repeated residence of fuel bundle bearing pads in the same location and small pieces of trapped debris can lead to fretting and crevice corrosion. These local stress concentrators are monitored to protect against development of initiation sites for Delayed Hydride Cracking (DHC).

The consequence of pressure tube axial elongation is the potential for a channel to be off bearing. Fuel channel positions relative to their bearings are frequently measured during planned outages and used to update models of fuel channel elongation in order to preclude off-bearing operation. Elongation management through fuel channel shifting, reconfiguration ,and selective defueling is planned in some units to ensure all channels remain on-bearing throughout their planned operating life.

The fitness for service issues due to pressure tube sag are pressure tube to calandria tube and calandria tube to liquid injection shutdown nozzle contact. Degradation is monitored via pressure tube to calandria tube gap measurements, pressure tube sag measurements, and calandria tube to liquid injection shutdown nozzle gap measurement.

Pressure tube wall thickness measurements are regularly performed using ultrasonics during planned outages, which are in turn used to determine rates of wall thinning. Wall thinning will be continuously monitored per periodic inspection requirements, but is not currently life-limiting, nor is it expected to become life-limiting.

The primary implication of pressure tube diametral expansion is the potential for pinching of the spacer between the pressure tube and the calandria tube around the full circumference which may make it difficult to relocate the spacers when required. Pressure tube diameter measurements are regularly performed using ultrasonics during planned outages, which are in turn used to determine rates of diametral expansion.

Current pressure tube diametral expansion assessments show design limits will not be reached for some time for all pressure tubes except three tubes in Unit 8. These channels are known to have higher diametral expansion due to a different manufacturing process and are being closely monitored by Bruce Power. Bruce Power will continue to monitor diametral expansion and refine assessments to demonstrate fitness for service, or else take mitigating actions which may include defueling or replacement of susceptible fuel channels.

Deuterium ingress in pressure tubes throughout operation has a negative impact on fracture toughness and the propensity to initiate and propagate cracks through delayed hydride cracking. The impact of deuterium ingress is included in all relevant fitness for service condition assessments including flaw assessments, probabilistic core assessments for flaws and leak-before-break, and evaluations of protection against fracture. Bruce Power performs pressure tube scrape sampling for all units during each planned outage to monitor deuterium ingress behavior and to validate the models used to predict deuterium concentration values used in fitness for service assessments.

A summary of the number of scrape samples taken for each unit during its most recent successful scrape campaign in the body of tube and rolled joint regions is provided in Table 9. Bruce Power consistently performs scrapes beyond the requirements of CSA N285.4, *Periodic*

Inspection of CANDU Nuclear Power Plant Components, in order for more accurate modeling of deuterium ingress behaviour.

Table 9. Scrape samples taken for each unit (3-8) in 2015-2017.

Unit	3	4	5	6	7	8
Year	2016	2015	2017	2015	2016	2016
Body of tube	12	8	29	19	21	12
Rolled joint	12	5	26	18	20	11

6.7.2 Spacers

The integrity of the spacer that maintains the gap between the pressure tube and the calandria tube is affected mainly by neutron irradiation, imposed loads, rolling wear, and deuterium uptake during operation.

The movement of loose-fitting annulus spacers and the potential small movement of tight-fitting spacers (as discovered in the Bruce Unit 8 2013 outage) can increase the risk of pressure tube to calandria tube contact. Such contact, in the presence of sufficiently high hydrogen concentrations, can lead to hydride blister formation on the outside of the pressure tube. With prolonged contact, hydride blisters may grow to sufficient size to initiate DHC and thereby compromise the integrity of the pressure tube.

The material properties of loose-fitting spacers (Zr-Nb-Cu material), which are installed in most channels in Bruce Units 3 to 7, are not considered to be a life-limiting concern, based on operational experience and testing of ex-service material.

Tight-fitting spacers (Inconel X-750 material) are used for all spacers in Bruce Units 1, 2 and 8, and in a limited number of channels in Bruce Units 3 to 7. Testing of tight-fitting Inconel X-750 spacers has demonstrated that significant margin on load carrying capability remains within operational limits. Continued monitoring of Inconel X-750 spacer condition through testing of spacers from removed pressure tubes, along with research and development and modeling activities, will be used to demonstrate fitness-for-service for continued reactor operation.

Bruce Power has removed a surveillance tube from Unit 8 in 2016 in order to obtain more information on Inconel X -750 spacer degradation. Material surveillance analysis of the Unit 8 pressure tube and spacers are in progress.

6.7.3 Calandria tubes

The main integrity issue for calandria tubes is irradiation-enhanced deformation which causes sag and localized deformation at spacer locations. The main issues associated with sag are the potential difficulty to pass fuel bundles through the sagged channel, the potential difficulty to replace pressure tubes through a sagged calandria tube, and the risk of contact between sagged calandria tubes and other reactor structures such as Liquid Injection Shutdown System (LISS) nozzles. Contact could lead to fretting damage of the calandria tubes, compromising integrity.

Calandria tube to liquid injection shutdown nozzle gap closure is monitored through measurements, which are in tum used to refine models to predict gap closure rates. Bruce Power has used new tooling since 2014, which allows for the measurement of calandria tube to liquid injection shutdown nozzle gaps at locations which were not previously visible. These measurements have allowed for significant improvements in the modeling accuracy for calandria tube to liquid injection shutdown nozzle gap closure predictions, and Bruce Power plans to continue acquiring such measurements and working to improve inspection capabilities. In addition, Bruce Power performed de-tensioning of one liquid injection shutdown nozzle in the Unit 3 2016 outage, which deferred predicted contact from 2016 to 2020. Further de-tensionings are planned for future Bruce A and Bruce B unit planned outages to eliminate predicted contact until MCR projects are executed.

6.7.4 Other fuel channel components

The remaining fuel channel components—including the end fitting hardware, closure plugs, shield plugs, liner tubes, bellows, positioning assemblies, and the feeder grayloc connections—have not shown significant signs of aging or degradation and therefore are not expected to limit the service life of the fuel channels.

However, feeder grayloc surfaces in Units 3 and 4 have been shown to be susceptible to surface corrosion, compromising the leak tightness of the joint. This degradation is monitored closely, and appropriate maintenance is performed periodically.

6.7.5 Inspections and maintenance

The current fitness for service condition of the Bruce Power fuel channels is verified each outage through inspections.

The Advanced Non-Destructive Examination (ANDE) system is implemented to monitor volumetric and dimensional inspections, including spacer locations and replicas of flaws. Spacer Location And Re-positioning (SLAR) maintenance on loose-fitting fuel channels and Modal Detection And Repositioning (MODAR) maintenance (on tight-fitting channels) are used to relocate the spacers to reduce the risk posed by pressure tube to calandria tube contact.

After each planned outage, dispositions and inspection and/or analysis reports are prepared to meet the requirements of CSA N285.4. Indications are detected and characterized using ultrasonic examination and replication techniques during planned outages. All known indications must satisfy the acceptance criteria of CSA N285.4 or be dispositioned prior to the restart of a unit from outage. Continued monitoring and reassessment of known indications, coupled with targeted inspections of new channels, assures fitness for service.

6.7.6 Continued operation

The predicted Equivalent Full Power Hours (EFPH) for fuel channels at the date of the corresponding Life Extension Outage is provided in Table 10. The predicted EFPH values are estimates which include predicted outages. At this time, operation beyond 247,000 EFPH is not permitted without Commission approval. Bruce Power plans to seek Commission approval to operate to approximately 300,000 EFPH, based on supplemental technical information already provided and additional information to be provided in Fall 2017.

Table 10. Predicted EFPH for fuel channels at time of replacement during Life Extension Outages.

Unit	Outage date	Predicted EFPH
3	2023	242,000
4	2025	251,000
5	2026	294,000
6	2020	243,000
7	2028	297,000
8	2030	298,000

Bruce Power uses two fracture toughness models to demonstrate that the pressure tubes are safe to operate and meet the design intent to support safe operation now and into the future. These fracture toughness models are a statistical model for the upper shelf temperature region and a cohesive-zone model for the transition temperature region. These models are key inputs into the leak-before-break and fracture protection assessments, which demonstrate the safe operation of pressure tubes in the unlikely event of a through-wall crack penetration.

The fracture toughness models have been reviewed by two independent third-party reviewers, who have concluded that the models are adequate for engineering applications.

Before the current licence was issued in 2015, the fracture toughness models were validated to a hydrogen equivalent concentration of 124 ppm (corresponding to 247,000 EFPH). Additional burst tests were conducted in 2016, including one at a hydrogen equivalent concentration of 145 ppm, with results consistent with model predictions. A burst test at a hydrogen equivalent concentration of 160 ppm (corresponding to 300,000 EFPH) is currently underway in 2017.

Burst tests are planned through 2019 (Table 11). The planned burst test program includes additional proposed tests at 160 ppm on the outer section of the pressure tube as well as lower hydrogen equivalent concentration to understand the effect of hydride morphology on the inlet section of the pressure tube. The burst test results will be used to expand the validity of the fracture toughness models up to 160 ppm.

There is ongoing discussion with the CNSC on the burst test program, and the latest test results and planned test schedule through 2019 will be provided to the CNSC this fall as supplemental technical information to support the request to operate beyond 247,000 EFPH.

Table 11. Draft burst test plan (subject to change)

Year	Target [H_{eq}] (ppm)	Temperature (°C)	Objective
2017	As received	250	Compliance with CSA N285.4 surveillance requirements
	160	250	Evaluate bounding [H_{eq}] at target life on fracture toughness
	As received	250	Compliance with CSA N285.4 surveillance requirements
	60/70	225	Evaluate hydride orientation effects on fracture toughness at PT inlet of a low toughness tube
2018	60/70	<225 (if upper shelf at 225)	Evaluate hydride orientation effects on fracture toughness at PT inlet of a different tube
	160	250	Evaluate bounding [H_{eq}] at target life on fracture toughness
	60/70	<225 (if upper shelf at 225)	Evaluate hydride orientation effects on fracture toughness at PT inlet of a different tube
	60/70	<225 (if upper shelf at 225)	Evaluate hydride orientation effects on fracture toughness at PT inlet in the transition region
2019	160	<250 (if upper shelf at 250)	Evaluate bounding [H_{eq}] on a different tube at target life on fracture toughness in transition region
	60/70	<225 (if upper shelf at 225)	Evaluate hydride orientation effects on fracture toughness at PT inlet in the transition region
	TBD	<250	Evaluate bounding [H_{eq}] for some tubes at target life on fracture toughness in the transition region
	TBD	<250	Evaluate bounding [H_{eq}] for some tubes at target life on fracture toughness in the transition region

6.8 Primary Heat Transport feeder piping

Bruce Power's primary heat transport feeder piping program ensures safe and reliable operation of the units by demonstrating fitness for service (FFS). This program also complies with N285.4, *Periodic Inspection of CANDU Nuclear Power Plant Components*. The standard specifies requirements for inspection of feeders.

The Bruce Power feeder piping life cycle management program consists of three complementary documents which describe, assess and plan the management of feeder degradation mechanisms at Bruce A and Bruce B:

- The Technical Basis Assessment (TBA) describes feeders (configuration, material, dimensions, operating conditions, associated components) and summarizes the known feeder degradation mechanisms and the maintenance strategy.

- The Periodic Inspection Plan (PIP) defines the inspections which must be performed to satisfy the requirements of CSA N285.4. The Periodic Inspection Plan is subject to CNSC acceptance as per CSA N285.4 Clause 3.6(a).

- The Life Cycle Management Plan (LCMP) incorporates the Technical Basis Assessment and Periodic Inspection Plan to establish the strategy for In-Service Inspection (ISI). The Life-cycle Management Plan summarizes the current practice for management of expected degradation mechanisms, and identifies the technically feasible inspection and maintenance activities required to manage the consequences of aging and degradation in feeders.

The Bruce Power Feeder program documents are revised every 3 years (or earlier If required) to include updated findings, industry experience, updated outage schedules and ongoing research activities.

Bruce Power performs inspection of feeders and feeder-related components during planned outages in accordance with the Life-cycle Management Plan, to confirm that the feeders will remain fit for service beyond the next operating cycle. The requirement for future inspection scope is summarized in Table 12.

Table 12. Scope for feeder inspections

Inspection	Minimum requirements (CSA N285.4, Clause 13)	Scope per lifecycle management plan
Wall thickness	10 outlet and 10 inlet feeders every inspection interval (approximately 6 years) with 50% of feeders inspected being repeat inspections.	20 to 165 feeders (unit-specific) every outage in the limiting area at the tight radius bends and adjacent to the Grayloc weld, plus measurements at downstream locations.
Visual	Supports, hangers, spacers, seismic restraints, and clearance to adjacent components in one quadrant every inspection interval (approximately 10 years)	Supports, hangers, spacers, instrument lines, cabinet hangers, structural lateral restraints, and clearance to adjacent components. Each half (East or West) is inspected every other outage (every 4 to 6 years).
Volumetric	As per inspection program accepted by CNSC for any credible feeder cracking mechanisms	3 Repaired Grayloc welds per outage alternating between East face in one outage and the West face in the next outage. (There is no evidence that cracking is an active degradation mechanism on the Bruce units.)

Each unit has an inspection outage approximately every 2 to 3 years. The limiting active degradation mechanism in Bruce A and Bruce B feeders is wall thinning due to Flow Accelerated Corrosion, which is monitored by thickness measurements in the area of the tight radius bends near the Grayloc connection. In-service thickness inspections are focused on monitoring the leading feeders for wall thinning. Leading feeders are those feeders with thicknesses approaching their Design Minimum Allowable Wall Thickness (DMAWT), and feeders which have had further feeder-specific analysis consistent with fitness for service guidelines to a Minimum Allowable Wall Thickness (MAWT). Additional feeders are included in the measurement scope to obtain multiple data points for more accurate thinning rates on feeders predicted to require replacement before end of unit life. In addition, thickness measurements are taken on downstream feeder locations in order to understand the condition of the balance of the feeder piping.

In-service visual inspections are consistent from outage to outage and unit to unit, with additional specific inspections added to follow up on findings from previous inspections.

Visual inspections monitor and confirm that all supports are in good condition, that there is no evidence of any serious deterioration, that there are no changes in support conditions that can affect loading on feeders, and that there is acceptable clearance to adjacent components to preclude unacceptable external wear on feeders.

Inspections completed in the most recent outages in each Bruce unit are provided in Table 13.

Table 13. Recent feeder inspections for each unit

Unit	Outage	Year	Completed Inspections
1	A1511	2015	57 downstream thickness inspections; full West visual inspections
2	A1621	2016	80 thickness measurements at tight radius bends;97 downstream thickness inspections; full West visual inspections
3	A1631	2016	116 thickness measurements at tight radius bends; 76 downstream thickness inspections; 6 volumetric Inspections on repaired Grayloc welds; West visual inspections
4	A1541	2015	149 thickness measurements at tight radius bends; 88 downstream thicknesses; full East visual inspections
5	B1751	2017	292 thickness measurements at tight radius bends; 71 downstream thickness inspections; 3 volumetric Inspections on repaired Grayloc welds; East and West visual inspections
6	B1561	2015	270 thickness measurements at tight radius bends and adjacent to Grayloc welds; 47 downstream thickness inspections; East and West visual inspections
7	B1671	2016	201 thickness measurements at tight radius bends and adjacent to Grayloc welds; 58 downstream thickness inspections; 3 volumetric inspections on repaired Grayloc welds; East and West visual inspections
8	B1681	2016	247 thickness measurements at tight radius bends and adjacent to Grayloc welds; 99 downstream thicknesses; 1 volumetric Inspection on a repaired Grayloc weld; East visual inspections

During an outage inspection campaign, the feeders are assessed to confirm they will remain above the required Design Minimum Allowable Wall Thickness during the next operating interval. All feeders have a specific Design Minimum Allowable Wall Thickness value based on piping analysis completed following ASME SEC III NB-3600 rules. If a feeder is predicted to reach its Design Minimum Allowable Wall Thickness before the next planned outage, then a Component Disposition is required and further analysis can be completed using either ASME SEC III NB-3200 rules or the feeder Fitness for Service Guidelines to demonstrate continued fitness for service.

The feeder piping is assessed after each outage inspection campaign, and the results are provided to the CNSC in the form of a Thickness Measurement Inspection Report, Visual Inspection Report, and Operational Thinning/Condition Monitoring Assessment.

The Operational Thinning Assessment is a forward-looking fitness-for-service assessment used to predict future thickness to confirm that the acceptance criteria are satisfied for all feeders during the next operating period. Any feeders predicted to be below the Design Minimum Allowable Wall Thickness before the next planned inspection outage are subject to a

Component Disposition requiring CNSC acceptance. Additional analysis may be performed for a lower feeder-specific Minimum Allowable Wall Thickness to allow operation to beyond the next planned inspection outage, subject to CNSC acceptance.

The Condition Monitoring Assessment is a backward-looking assessment comparing the current thickness results against the thinning predicted by the previous evaluation, and is utilized to confirm that acceptance criteria were satisfied during the previous inspection interval, and to adjust thinning rate calculation methodologies where necessary for the next operating interval.

A Feeder Thinning Status Report is provided to the CNSC on an approximately annual basis to provide an up-to-date summary of the state of feeders with regards to wall thinning across all units in both Bruce A and Bruce B.

The limiting area for feeder thinning is the tight radius bends adjacent to the Grayloc connection. The lower feeder sections including these tight radius bends are replaced before reaching Design Minimum Allowable Wall Thickness or a feeder-specific Minimum Allowable Wall Thickness. All lower feeder sections were replaced on Unit 1 and Unit 2 before restart of these units in 2012. In Units 3-8, 49 feeder sections have been replaced to date as indicated in Table 14.

Table 14. Feeder sections replaced in Units 3-8

Unit	Feeder	Year
3	A15E	2007
	A14W, A16W	2010
	A09E, A11E, A17E	2011
	A08W, A10W, A14W[1]	2012
4	A09E, A11E, A15E, A10W, A14W, A16W	2012
	A08W, A17E, F11W[2]	2015
5	A10W, A11E, A15E	2011
	A14W, A16W	2013
6	A10W, A15E, A17E	2009
	A09E, A11E, A14W, A16W	2010
	S09W,R12W	2013
	C14W, O11W	2015
7	A10W, A15E	2011
	A09E, A11E, A14W, A16W	2014
8	LO5E, F13W	2009
	Q10E, N04W	2011
	L21E	2012
	A09E, A11E	2013
	T08W, W13W	2016

Note 1: Unit 3 A14W has been replaced twice.

Note 2: F11W was proactively replaced due to limited margin of hub material to machine onto the feeder in the event of a subsequent leak.

Feeder replacements planned for the next outages in Units 3 through 8 are provided in Table 15, although it should be noted that future analysis and/or inspection results may alter this list.

Table 15. Planned feeder replacements (may be subject to change)

Unit	Outage	Year	Replacements
3	A1831	2018	0
4	A1841	2018	0
5	B1951	2019	1
6	B1761	2017	1
7	B1971	2019	0
8	B1881	2018	4

The Feeder Life Cycle Management Program provides appropriate processes to identify the applicable degradation mechanisms, evaluate the current feeder conditions, define appropriate feeder inspection plans and scope of inspection work, and demonstrate Fitness for Service. Through implementation of the Life Cycle Management Plan for feeders, Bruce Power continues to demonstrate that active degradation mechanisms are known, stable, and acceptable via condition monitoring. In addition, Operational Thinning Assessments continue to be acceptable to support the operating intervals between planned inspections over the remaining life of Bruce A and Bruce B.

The current feeder piping degradation mechanisms are well understood and managed. The Flow Accelerated Corrosion-induced wall thinning is the most active and limiting aging degradation mechanism which affects the fitness for service of Bruce A and Bruce B feeders. The current feeder life cycle management process of inspection, fitness for service analysis and replacement as required has ensured the overall structural integrity of feeder piping. The processes are in place to monitor feeder aging effects and take proactive actions to ensure fitness for service on an ongoing basis. For each unit, the required feeder dispositions have been accepted by the CNSC for continued operation. Going forward, Bruce Power will continue to adhere to the provisions of the Life Cycle Management Plan, as adjusted by new findings, and will continue to demonstrate fitness for service to support the operating intervals into the Licence renewal period and beyond.

6.9 Steam generators and pre-heaters

The steam generator and preheater aging management program ensures safe and reliable operation of the units by demonstrating fitness for service. This program complies with CSA N285.4, *Periodic Inspection of CANDU Nuclear Power Plant Components*.

Bruce Power has recently revised the steam generator and preheater life cycle management plan into three new complementary documents which describe, assess and plan the management of steam generator and preheater degradation mechanisms at Bruce A and Bruce B:

- The Technical Basis Assessment describes steam generator and preheater Failure Modes and Effects Analysis and summarizes the known steam generator and preheater degradation mechanisms as well as the relevant maintenance options.

- The Periodic Inspection Plan defines the inspections which will be performed to satisfy the requirements of CSA N285.4. The Periodic Inspection Plan is subject to CNSC acceptance as per CSA N285.4.

- The revised Life Cycle Management Plan utilizes the basis of the Technical Basis Assessment and establishes the strategy for the implementing in-service inspection plans. The Life Cycle Management Plan and associated in-service inspection plans summarize the current practice for management of expected degradation mechanisms, and identify the inspection and maintenance activities required to manage the consequences of aging and degradation steam generators and preheaters. The in-service inspection plans also implement the inspections defined and accepted in the Periodic Inspection Plan.

These documents are periodically updated according to inspection findings, identified best practices and regulatory requirements. This supports the long term operation of the steam generators and preheaters through a PLAN-DO-CHECK-ACT process for continuous improvement.

Bruce Power inspects the tubes and other internal components of the steam generators and preheaters during planned maintenance outages. This occurs in accordance with the steam generator and preheater in-service inspection plans, to confirm that the conditions of the components are as expected. Fitness for service evaluation of inspection data ensures that the steam generators and preheaters will operate safely and reliably during the next operating cycle. Fitness for service criteria are well defined and specified in the industry Steam Generator Tube Fitness for Service Guidelines document that was developed by the CANDU Owners Group.

Each Bruce Unit has 8 steam generators and 4 preheaters. The main inspection tool for the steam generator and preheater tubes are eddy current probes. This non-destructive examination technique is well proven and is capable of detecting flaws in steam generator and preheater tubes. Bobbin and X-Probe are the two main inspection probes used to perform tube inspection requirements as defined in CSA N285.4 and the in-service inspection plans. The inspections required by CSA N285.4 for volumetric examination of the steam generator and preheater tubes is summarized in the table below. Also included in the table is the typical inspection done in each planned outage defined by the in-service inspection plans (much greater than the minimum requirements). This is done to support reliable and event-free operation.

Table 16. Scope for steam generator and preheater inspections

Component	Minimum requirements (CSA N285.4)	In-service inspection plans
Steam generators (4200-4805 tubes)	Every 6 years: in two steam generators, minimum of 10% of the tubes with specific samples (25 tubes) for each postulated and plausible degradation mechanism	Inspect four steam generators nominally every 3 or fewer years. At least 25% and up to 80% of the tubes are examined, full length (including tubes with known indications for monitoring).
Preheaters (2800-2900 tubes)	Every 10 years: in one preheater, minimum of 2% of the tubes with specific samples (25 tubes) for each postulated and plausible degradation mechanism	Inspect two preheaters nominally every 3 or fewer years. Greater than 50% of the tubes are examined, full length (including tubes with known indications for monitoring)

Bruce Power performs additional inspections according to the in-service inspection plans, including visual inspections and tube removal examinations. These additional examinations meet or exceed the requirements of CSA standard N285.4. Though not required by CSA N285.4, ultrasonic inspection is also a requirement of the in-service inspection plans. Ultrasonic inspection occurs on a subset of tubes examined by eddy current probes to provide additional fitness for service data.

These inspections, along with strict chemistry control specifications, have demonstrated fitness for service following planned operating periods. Steam generator tube integrity is assessed after each steam generator and preheater inspection in accordance with CSA N285.4 acceptance criteria and the Fitness for Service Guidelines. The purpose of the integrity assessment is to ensure that the fitness for service performance criteria were met during the previous operating period (Condition Monitoring) and are assured for the next operating period (Operational Assessment).

Condition Monitoring is carried out during outages to verify the accuracy of predicted conditions. The results for the latest outages have been acceptable, and the Operational Assessments have demonstrated that the Bruce Units can safely and reliably operate. The Condition Monitoring assessments are typically carried out every two to three years. These assessments are provided to the CNSC for acceptance.

Operational Assessments identify any tubes that do not meet the fitness for service acceptance criteria for safe and reliable operation over the next operating period. These tubes are removed from service by plugging. The number of tubes that have been plugged in each unit during the last outage is indicted below:

Table 17. Tubes plugged in each unit during last planned outage.
SG=steam generator; PH=preheater.

Unit	Year	Tubes plugged	
		SGs	PHs
1*	2015	0	0
2*	2016	0	5
3	2016	6	2
4	2015	1	25
5	2014	6	7
6	2015	5	4
7	2016	17	20
8	2016	80	11

Note 1: Unit 1 and 2 steam generators were replaced during the U12 refurbishment.

There has been no steam generator or preheater leak requiring shutdown in the Bruce A Units in the last 9 years. No steam generator or preheater leak requiring shutdown has occurred in the Bruce B steam generators and preheaters in more than 4 years. Most of the previous Bruce B steam generator leaks were due to debris and loose parts resulting in fretting of tubes. Bruce Power's efforts to remove loose parts and debris from the Bruce B steam generators has had significant results in no tube leaks due to loose part or debris fretting in more than 9 years. If an indication of a leak is detected, Bruce Power has procedures in place to monitor and make repairs to ensure that regulatory release and administrative limits are not exceeded.

In summary, the Life Cycle Management Plans, in-service inspection plans and fitness for service guidelines have been used for years to ensure safe and reliable operation of the steam generators and preheaters. A Technical Basis Assessment and Periodic Inspection Plan support these documents. Bruce Power continues to make improvements to processes based on operating experience and industry research. Through continued implementation of the Steam Generator and Preheater Aging Management Program, Bruce Power will continue to demonstrate acceptable Condition Monitoring, Operational Assessments, and safe and reliable operations.

7.0 RADIATION PROTECTION

Covers the implementation of a radiation protection program in accordance with the Radiation Protection Regulations. The program must ensure that contamination levels and radiation doses received by individuals are monitored, controlled and maintained ALARA.

7.1 Application of ALARA

7.1.1 Relevance and management

The Bruce Power Radiation Protection Program governs the processes used to control contamination and monitor radiation doses received by workers. Radiological hazards are identified, measured, and controlled to ensure worker doses remain below regulatory limits and collective dose is reduced to be As Low As Reasonably Achievable (ALARA).

Radiological hazards are identified and measured through routine and work-specific surveys. If possible, the radiological hazards are eliminated. Otherwise, the hazards are controlled with engineered barriers and signage identifying the level and extent of hazard areas. Shielding is used to reduce radiation exposures to workers during operational and maintenance activities. Shielding is also used to lower background radiation to ensure monitoring equipment can be used effectively in identifying radiological hazards and controlling the spread of radioactive contamination. Specialized tooling may be used for remote operation. Ventilation systems and strategies are used to mitigate airborne hazards.

With radiological hazards identified, measured, and controlled, work is then planned and executed in a manner that controls worker doses and prevents dose to the public. Personnel protective equipment, alarming dosimeters, and area radiation monitors are used extensively—in addition to work surveys—to prevent unplanned exposures and to ensure worker doses do not exceed regulatory limits. Monitoring, tracking, and restricting the movement of radioactive material prevents the escape of radioactive contamination.

Extensive work planning and dose reduction initiatives are used to reduce collective dose to levels that are ALARA. Techniques typically include mock-up rehearsals for higher risk or long duration work activities, in order to improve worker skill and reduce the chance of errors. Improved system filtration and chemistry control are used to reduce the radioactive source term available to expose workers.

7.1.2 Past performance

The Radiation Protection Program is, and has been, effective at identifying and controlling radiological hazards. During the current licensing period, Bruce Power has maintained worker doses below regulatory limits.

Bruce Power's collective radiation exposure has improved during the licensing period. Bruce Unit 2 and 8 are in the top quartile, and Unit 1 is in median quartile, for CANDU reactors.

Bruce Power has implemented many technological initiatives during the previous licensing period, including:

- Worker contamination monitoring standards are at an industry best level, with selected whole body monitors capable of alpha contamination detection. Projects are underway for the placement of permanent whole body monitors at vault exits;

- Bruce Reactor Inspection and Maintenance System (BRIMS) technology and the Circumferential Wet Scrape Tool (CWest) were implemented during the previous licensing period to replace Spacer Location and Repositioning (mini-SLAR) activities. Implementing this technology has had a significant collective dose savings of 400 mSv (40 rem) per outage;

- Gas bottle monitors have been implemented at Bruce A and Bruce B. Additionally, a large article monitor has been implemented, which allows for verification surveys for items too large to fit into a small article monitor or barrel monitor;

- Replacement of small article monitors is ongoing. The new model automatically links monitor alarms with the user. The new model permits the use radionuclides consistent with the source term (if selected), which will allow Bruce Power to explore the use lower set points in the future; and,

- Enhancements to remote monitoring capability (radiation area monitors and radiation meters).

7.1.3 Future plans

The following ALARA initiatives are ongoing or are planned:

Bruce Power continues to focus on the following ALARA initiatives:

- Implementation of nano-fibre filtration in the primary heat transport system. This will improve retention of colloidal material, improve performance of the primary heat transport purification system, and reduce the source term (and therefore dose). This will additionally reduce dose due to a reduced source term originating in the fuelling machine;

- Continued improvements to the implementation of BRIMS technology to reduce overall dose;

- Ongoing monitoring is required for the Antimony-124 (Sb-124) removal strategy which continues to be a focus through PHT Purification IX Optimization. Additional benefits of Sb-124 reduction include improved chemistry control.

- Implementation of sub-micron filtration on fueling machines for fuel handling heavy water purification. Bruce A will transition to 0.45 micron filters. Bruce B has successfully made this transition and is awaiting the opportunity to restart a trial using 0.1 micron filters;

- Other opportunities to use robotics to reduce worker dose will be explored for MCR, life extension, outage, and routine tasks.

Bruce Power will make provisions during the design and implementation of methodologies and strategies for the MCR and life extension activities to adopt processes that keep all radiation doses ALARA, social and economic factors taken into account. These provisions will include source term mitigation, shielding, radiological engineering controls, and schedule optimization.

7.1.4 Challenges

The MCR project and life extension activities will be very dose intensive, with large-scale cutting and removal of contaminated components. Therefore, a continued focus will be maintained on contamination control, as well as the mitigation and control of tritium and other airborne radiological hazards

7.1.5 Requests

None.

7.2 Worker dose control

7.2.1 Relevance and management

See Section 7.1.

7.2.2 Past performance

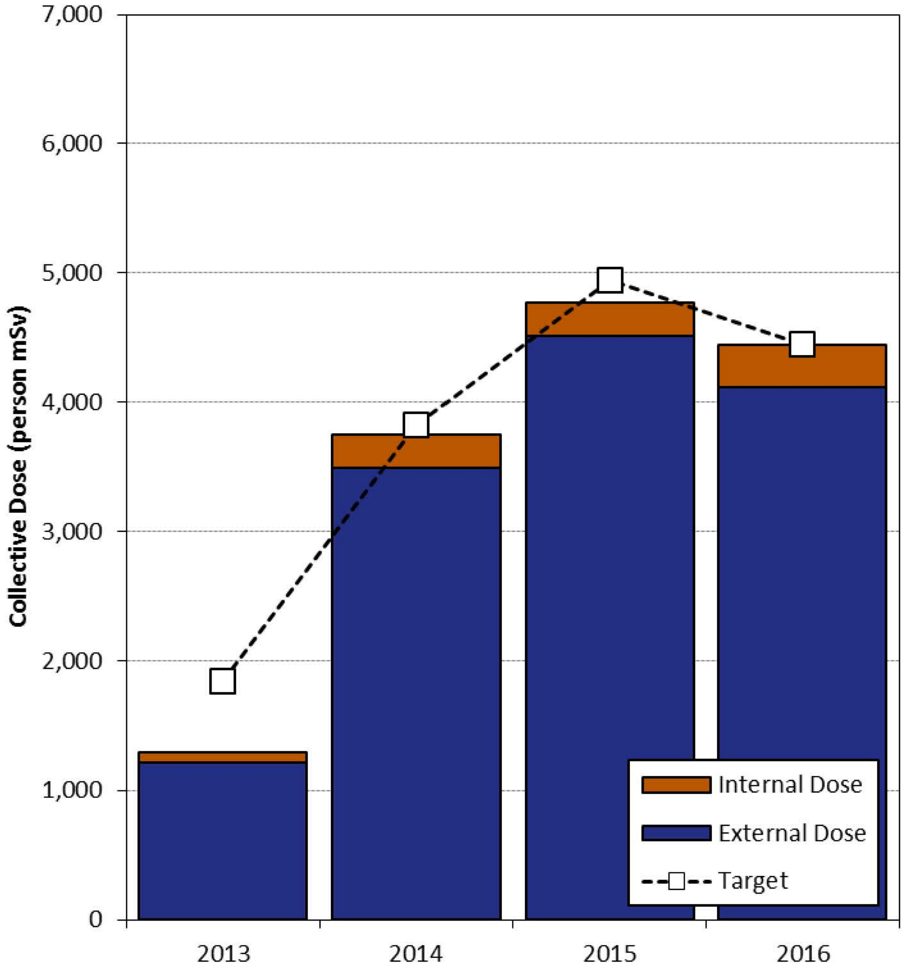


Figure 17. Collective effective dose (Bruce A; 2013-2016)

During 2016, the internal dose was approximately 8 percent of the total Bruce A collective dose (see Figure 17). This is a slight increase from 2015 (when the internal dose contribution was 6 percent), attributed to increased primary heat transport leak inside containment.

At Bruce A, all four units were operational with a total of approximately 290 outage days during 2016. In 2016, outage activities accounted for approximately 93 percent of the total collective dose (see Figure 18). Routine operations accounted for approximately 7 percent of the total collective dose. The collective dose from outage activities has overall increased since 2013 due to an increase in planned maintenance outages. The collective dose from routine operations has approximately remained constant during this licence period.

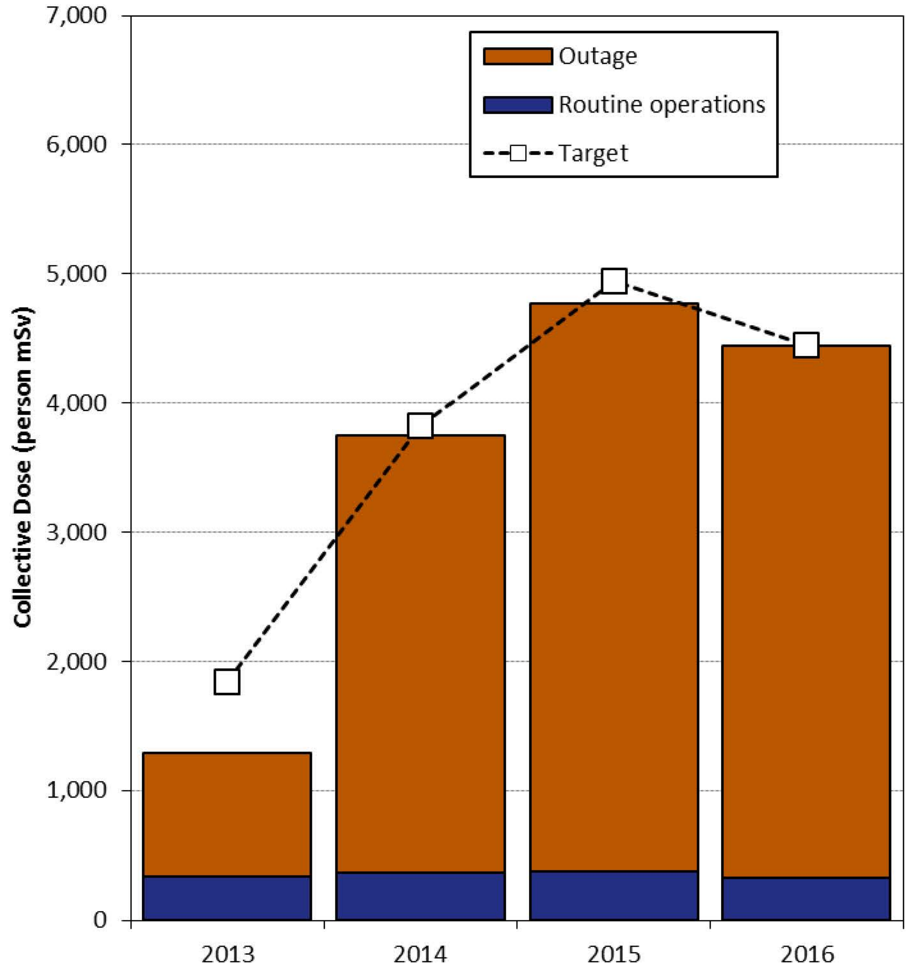


Figure 18. Collective effective dose by operational state (Bruce A, 2013-2016)

During 2016, the internal dose was approximately 4 percent of the total Bruce B collective dose (see Figure 19). This is a slight decrease from 2015 (when the internal dose contribution was 6 percent), attributed to a decrease in primary heat transport leaks.

At Bruce B, all four units were operational with a total of approximately 220 outage days during 2016. In 2016, outage activities accounted for approximately 91 percent of the total collective dose (Figure 20). Routine operations accounted for approximately 9 percent of the total collective dose. The collective dose from routine operations has overall remained constant during this licence period.

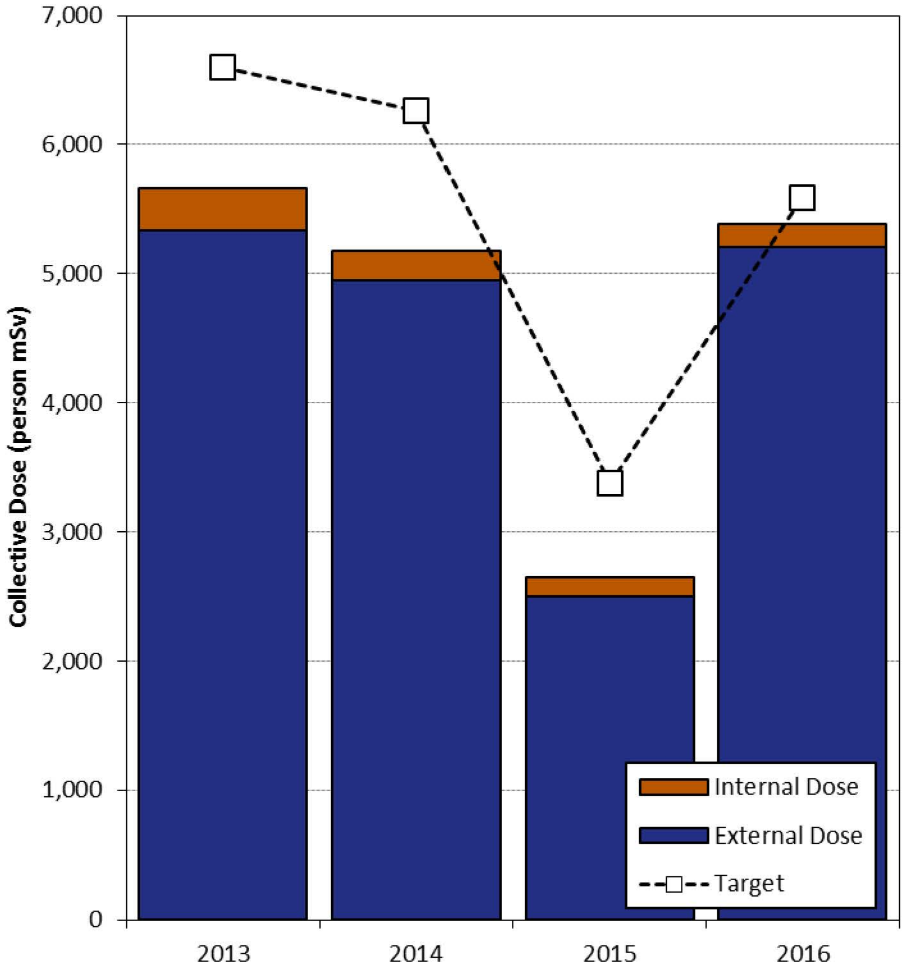


Figure 19. Collective effective dose (Bruce B, 2013-2016)

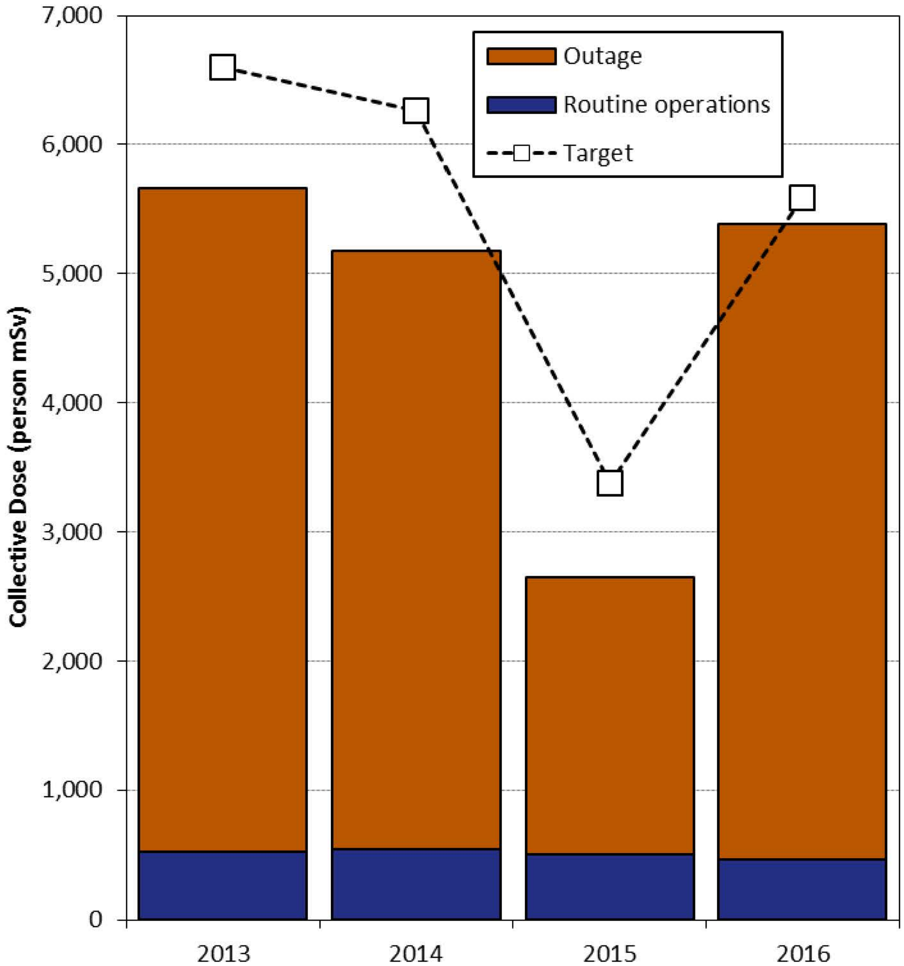


Figure 20. Collective effective dose by operational state (Bruce B; 2013-2016)

A number of dose reduction and dose control initiatives at Bruce A and Bruce B have been completed during this licence period. As a result, the collective effective dose for 2016 was approximately 200 person mSv below target. The initiatives included:

- Improved oversight of activities by the radiation protection department;
- Installation of alpha sensitive whole body monitors for improved detection of personal contamination with alpha radiation;
- Installation of a gas bottle monitor at Bruce A and Bruce B; installation of a large article monitor at Bruce A for efficient and reliable release of materials from the site;
- Created a source term database for all units as well as a process to maintain the information up to date; and,
- Replacement of aging small articles monitors with newer monitors to maintain sensitivity for monitoring radiological material.

7.2.3 Future plans

See Section 7.1.5.

7.2.4 Challenges

Bruce Power has reduced collective radiation exposure by more than 2 Sv (200 rem) over the past 2 years. However, with the planned MCR and life extension and outage programs, collective radiation exposure will remain a challenge to the radiological safety pillar and could potentially impact the availability of resources.

During the next 10-year licensing period, Bruce Power has approximately 30 outages planned, in addition to the Life Extension Outages, which will contribute to Bruce Power's total collective radiation exposure. In order to proactively manage Bruce Power's collective radiation exposure, organizations within Bruce Power are working collaboratively to ensure work is planned thoroughly, in accordance with ALARA and Radiation Protection program requirements.

7.2.5 Requests

None.

7.3 Radiation protection program performance

7.3.1 Relevance and management

The Bruce Power Radiation Protection ensures the following:

- Public and occupational exposures to ionizing radiation are controlled such that doses are below regulatory limits, unplanned exposures are avoided, and individual and collective doses are maintained at levels As Low As Reasonably Achievable (ALARA), social and economic factors being taken into account;
- The movement of people and materials are controlled to prevent releases of contamination or radioactive materials;
- Legal obligations are met; and,
- Radiation protection performance achieves high standards in accordance with industry best practices and WANO GL 2004-01 (Rev 1), *Guidelines for Radiological Protection at Nuclear Power Plants*.

Line managers are responsible for the safe execution of radiological work in accordance with processes governed by the Radiation Protection program. Line managers also encourage workers to execute radiological work conservatively and with a sense of responsibility for radiation protection.

ALARA committees provide oversight of ALARA practices and processes. ALARA committees include:

- Site ALARA committee which provides overall oversight of ALARA practices and processes. The site ALARA committee is chaired by the Chief Nuclear Officer. Members include vice presidents responsible for Bruce A, Bruce B, outage and maintenance services, and nuclear operations support.

- Station ALARA committees, which provide oversight of ALARA practices and processes at each of Bruce A and Bruce B. Each station ALARA committee is chaired by the plant manager. Members include senior managers from each of the major departments that either receive dose or have a role in radiation exposures and radiation exposure planning.

Additionally, Bruce Power holds quarterly meetings with the CNSC staff, including site inspectors, to ensure clear communication between Bruce Power and the CNSC.

7.3.2 Past performance

Contamination control, radiation protection training and implementation improvements have been made during this licence period have reduced the number of personal contamination events.

Overall, there has been a decrease in personal contamination events since 2013. In 2016, Bruce Power achieved an industry-best performance for Personnel Contamination Events (PCEs) with less than 0.4 PCEs per outage day, compared to an industry standard of 1.0 PCEs per outage day.

Bruce Power has performed better than the industry standard for PCEs during outages. The following graph illustrates Bruce Power's improved performance in personal contamination events since 2013.

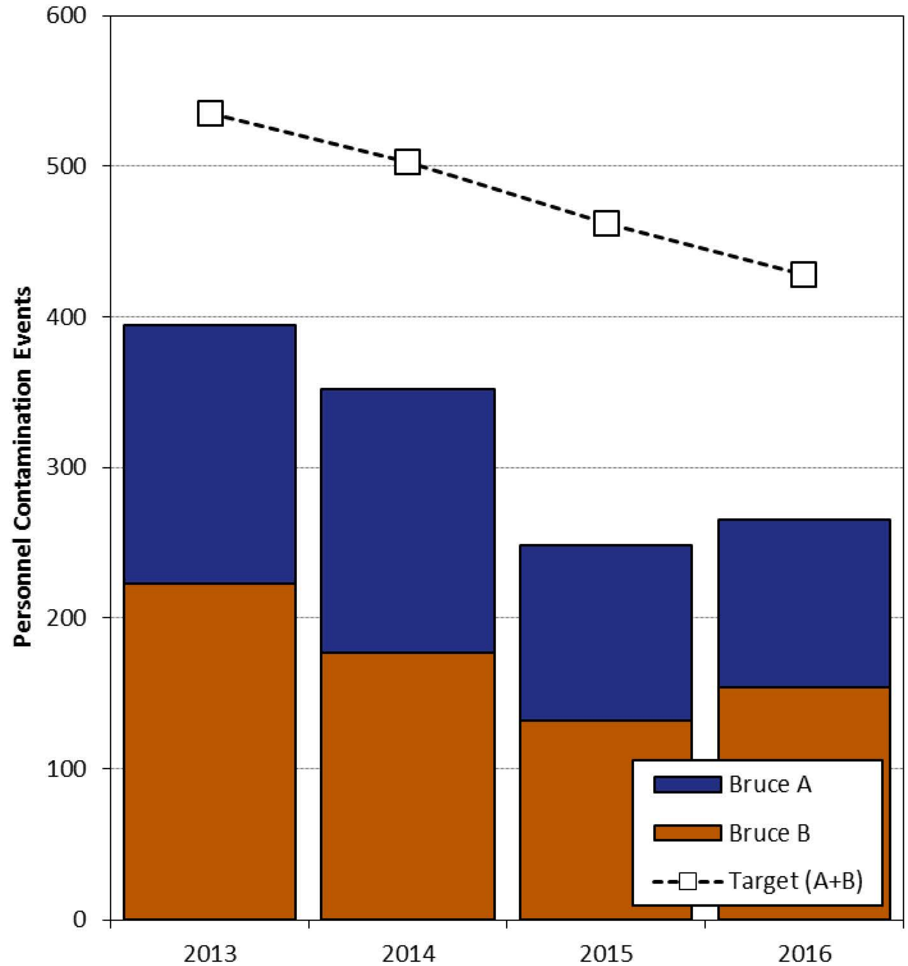


Figure 21. Personnel Contamination Events (2013-2016)

7.3.3 Future plans

Plans to improve the radiation protection program include:

- Streamlining program governance, and aligning program governance new CSA standards and new or revised CNSC regulations;
- Replacement of portal monitors, which used as a final check for workers exiting zoned areas. These newer portal monitors will provide more sensitivity for monitoring radiological material applicable to nuclear security requirements;
- Transitioning from a monthly to a quarterly dosimetry period. Quarterly dosimetry will allow Bruce Power to meet industry best practice by improving precision and accuracy;
- Procurement of robotic systems to perform radiation protection tasks; and,

7.3.4 Challenges

As discussed in Section 7.1.4.

7.3.5 Requests

None.

7.4 Radiological hazard control

See Section 7.1.

7.5 Estimated dose to the public

7.5.1 Relevance and management

Assessment of doses to the public is an element of the Environmental Management program, which ensures that radiation doses to the public are below regulatory limits.

The radiological environmental monitoring process is used to estimate actual or potential doses to representative persons and populations from the presence of radiation fields or radioactive materials in the environment as a result of operations on the Bruce Power site. The off-site radiological monitoring program includes sampling and analysis for external gamma radiation in air, tritium and Carbon-14 in air, precipitation, water, aquatic samples (fish, sediment, sand), and terrestrial samples (animal products, vegetation, soil). Doses to the public are calculated using IMPACT (used to assess the transport of contaminants through specified environmental pathways), annual meteorological data, annual effluent and environmental monitoring data for the Bruce site (including data for on-site facilities operated by OPG and CNL), and site-specific survey results (last completed in 2011).

7.5.2 Past performance

The maximum dose to a member the public is a very small percentage of the annual legal imit. In fact, since 2001, the maximum dose to a member of the public has been less than 10 microSieverts per year—less than the dose threshold which is considered significant.

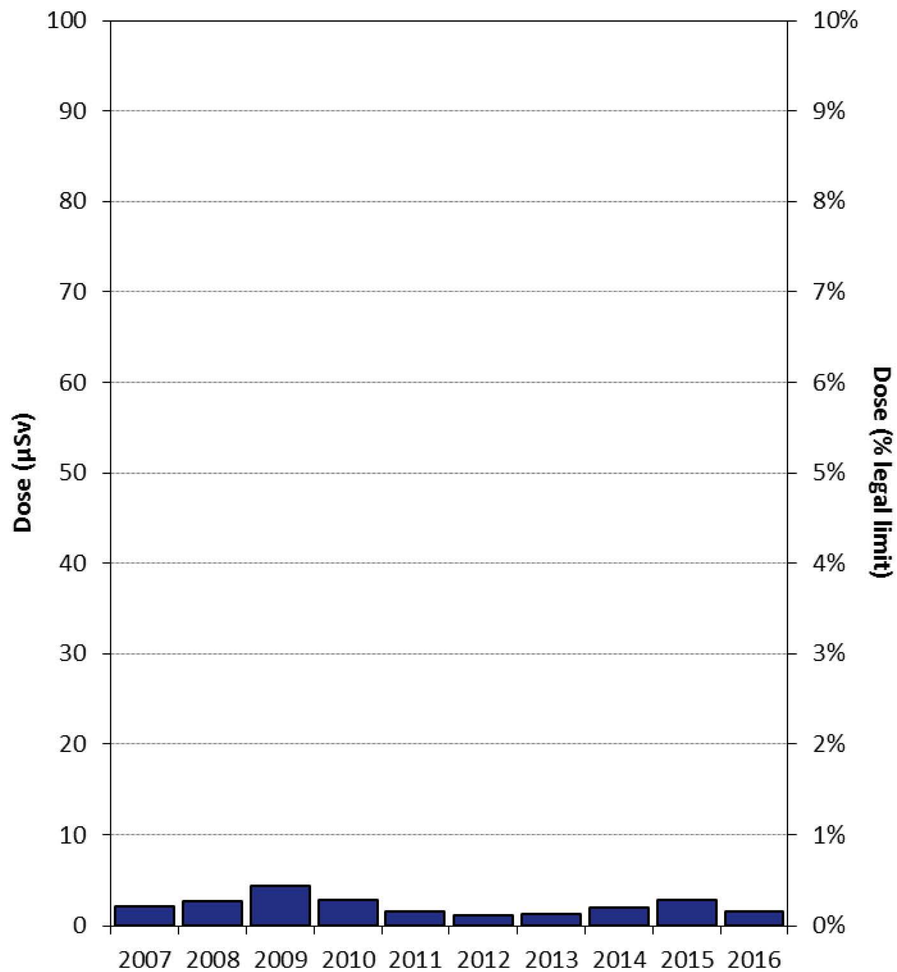


Figure 22. Maximum dose to the public (2001-2015)

The historical dose to public trend is shown in Figure 22. In 2009, the annual sampling of produce was performed during a period of slightly higher tritium emissions due to vacuum building and unit outages. The calculation for public dose assumes that this slightly elevated level of emissions continued through the entire year, and is therefore a conservative assumption (consistent with industry best practice). The true maximum dose in 2009 is less than the reported value. In 2016, milk sampling was re-introduce, following receipt of appropriate documentation from the Dairy Farmers of Ontario. (Conservative estimates were used in place of actual measurements since the suspension of milk sampling in 2012.)

7.5.3 Future plans

Bruce Power reports the annual maximum dose to a member of the public through the environmental monitoring program report, which is posted on Bruce Power's external website.

A site-specific survey is completed approximately every five years. The latest site-specific survey was nearing completion at the time this application was prepared (Q1 2017).

7.5.4 Challenges

None.

7.5.5 Requests

None.

8.0 CONVENTIONAL HEALTH AND SAFETY

Covers the implementation of a program to manage workplace safety hazards and to protect personnel and equipment.

8.1 Performance, practices, awareness

8.1.1 Relevance and management

Bruce Power manages conventional workplace safety hazards through health and safety management program, which complies with the Occupational Health and Safety Assessment Series (OHSAS) 18001:2007 standard.

OHSAS 18001 is an internationally-recognized standard for achieving improved and sustained performance through controls and the systematic management of hazards and the associated risk. OHSAS 18001 is appropriate for Bruce Power as application of the standard integrates well with ISO 14001, Environmental Management, and ISO 9001, Quality Management.

As part of our Occupational Health and Safety Management System (OHSMS), Conventional Safety follows the Plan-Do-Check-Act model to continually improve the health and safety program. In striving for excellence, legal requirements are considered the minimum standard. Bruce Power adopts proven and effective best-in-class practices to provide enhanced safeguards vital to sustainable performance.

8.1.2 Past performance

In the past licensing period, the following improvements have been made to the health and safety management program:

Some of these initiatives include:

- Extensive revision of the program-level document to align with the requirements of CSA N286-12;
- Revision of the Bruce Power Safety Rules. This document is written by a tripartite committee, to ensure robust feedback from site stakeholders is considered, assessed and included when applicable; and,
- Gap analysis between new legislation and Bruce Power's fall protection requirements. The findings were that Bruce Power is already compliant with the new legislation. The major change completed was to implement new Ministry of Labour training programs.

Bruce Power's conventional health and safety metrics align with CANDU Owners' Group guidelines. The Industrial Safety Accident Rate (ISAR) is shown in Figure 23.

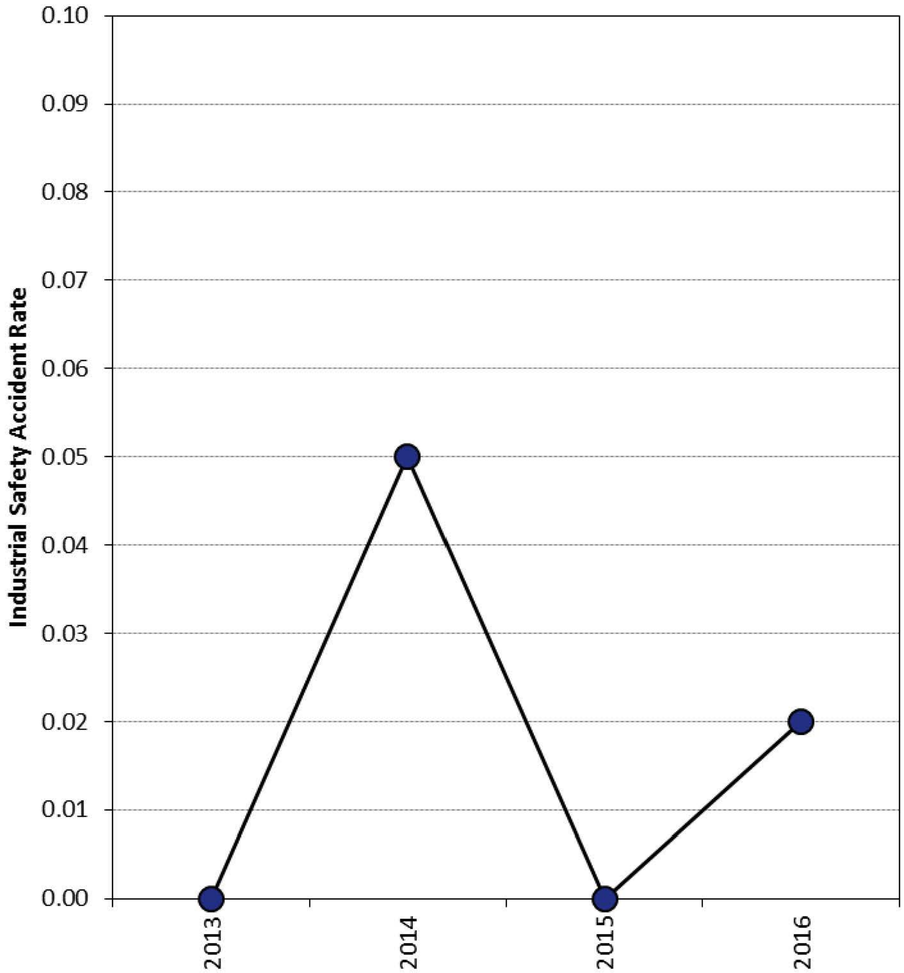


Figure 23. Industrial Safety Accident Rate (2013-2016). The Industrial Safety Accident Rate is the number of Lost Time Injuries x 200,000 / hours worked.

Bruce Power's industrial safety accident rate is low when compared to the industry average. However, there is always opportunity for improvement. A decline in safety performance was observed with recent events in 2016 (a worker burned by a hydrogen release) and 2017 (a worker burned by electrical contact). This decline in safety performance resulted in a decision to renew the Health and Safety Management Program with respect to hazard recognition, behavioral observation, and coaching (see Section 3.1.3).

8.1.3 Future plans

Currently we are working with an industry expert to develop a machine guarding program.

Annual internal and external audits of the OHSMS will identify areas for improvement and drive corrective action through the corrective action program.

Beginning in 2017, Bruce Power is developing plans to improve the Health and Safety Management Program, focusing on hazard recognition, controls, observation, coaching, and related processes to safely prepare and complete work. This improvement is planned to be complete by the end of 2017.

8.1.4 Challenges

None.

8.1.5 Requests

None.

9.0 ENVIRONMENTAL PROTECTION

Covers 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.

9.1 Effluent and emissions control (releases)

9.1.1 Relevance and management

The Environmental Management program defines governance for processes used to identify, control, and monitor releases of radioactive and hazardous substances. In accordance with the effluent monitoring process, Bruce Power monitors airborne and liquid effluents under normal and abnormal operating conditions.

Radiological emissions are identified, controlled, and monitored. These emissions are subject to the following tiers of limits and levels:

- Legal limit for release: the derived release limit is upper bound of emissions for a specific radionuclide (or radionuclide group) and specific emissions pathway. The derived release limit is based on the legal limit for dose to a member of the public. These limits are determined in accordance with CSA N288.1-08, *Guidelines for Calculating Derived Release Limits for Radioactive Material in Airborne and Liquid Effluents for Normal Operation of Nuclear Facilities*;

- Level for external (regulatory) notification: action levels are set well below the derived release limits, in order to permit the detection of unusual emissions without interfering with normal operations. Roughly speaking, the action levels are set based 10% of the legal limit for dose to a member of the public. Exceedance of an action level requires regulatory notification and corrective actions to return to normal operating conditions. (In addition to action levels for specific radionuclides, Bruce Power also applies a combined dose action for all radionuclides together.)

- Level for internal investigation: internal investigation levels are set below the action levels. Exceedance of an internal investigation level requires identification of cause and corrective actions to return to normal operating conditions.

The Environmental Management program also includes off-site monitoring. The off-site radiological monitoring program includes sampling and analysis for external gamma radiation in air, tritium and ^{14}C in air, precipitation, water, aquatic samples (fish, sediment, sand), and terrestrial samples (animal products, vegetation, soil). Doses to the public are calculated using IMPACT (used to assess the transport of contaminants through specified environmental pathways), annual meteorological data, annual effluent and environmental monitoring data for the Bruce site (including data for on-site facilities operated by OPG and CNL), and site-specific survey results (last completed in 2011).

Note: The maximum dose received by a member of the public due to Bruce site operations is a very small percentage of the annual legal limits.

With respect to conventional emissions, additional processes are used to comply with federal and provincial requirements for sampling, analysis, and reporting.

9.1.2 Past performance

In 2016, a revised quality assurance/quality control manual for chemistry laboratories was issued, to ensure alignment with CSA N286-12, *Management System Requirements for Nuclear Facilities*.

Additional details on the Environmental Monitoring program are provided in annual reports (Reference B2).

9.1.3 Future plans

Bruce Power has acquired a new Laboratory Information Management System and is working towards implementation across all on-site laboratories.

See also Section 9.5.3.

9.1.4 Challenges

None.

9.1.5 Requests

None.

9.2 Environmental management system (EMS)

9.2.1 Relevance and management

Bruce Power has an environmental policy that establishes guiding principles for environmental management and environmental performance. As such, Bruce Power is committed to the following:

- Compliance with relevant legislation, regulations, and other requirements;
- Minimization of the environmental footprint in pursuit of target net zero by preventing pollution in the area of emissions, spills, and waste and by reducing impact on the environment;
- Managing the Bruce Power environmental footprint by protecting, conserving, and restoring our resources through energy conservation, reducing water consumption, and by reusing or recycling materials;

- Adopting applicable best industry standards, and use of ISO 14001 as a framework for achieving continual improvement and sustainable performance excellence;
- Integrating environmental safety into Bruce Power's nuclear safety culture to promote and instill a sense of environmental responsibility beyond compliance;
- Conducting open and transparent communication with partners, Indigenous groups, and stakeholders on environmental interests;
- Demonstrating leadership in initiatives that encourage environmental stewardship and awareness at work, in the community, and across Ontario; and
- Leading by example through the application and practice of sustainability principles by incorporating environmental, social, and economic considerations in decision making.

The Environmental Management program is part of the Bruce Power Management System and works within the framework for integrating requirements with respect to safety, environmental management, quality, and economic factors. This program is structured to address the requirements of:

- The Bruce Power Management System (see Section 1.0);
- ISO 14001:2015, *Environmental Management Systems*;
- CSA N288.1, *Guidelines for Calculating Derived Release Limits for Radioactive Material in Airborne and Liquid Effluents for Normal Operation of Nuclear Facilities*;
- CSA N288.3.4, *Performance Testing of Nuclear Air-Cleaning Systems at Nuclear Facilities*;
- CSA N288.4, *Environmental Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills*;
- CSA N288.5-11, *Effluent Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills*;
- CSA N288.6, *Environmental Risk Assessments at Class I Nuclear Facilities and Uranium Mines and Mills*;
- CSA N286-12, *Management System Requirements for Nuclear Facilities*; and,
- REGDOC-2.9.1 (2013), *Environmental Protection: Environmental Protection Policies, Programs and Procedures*.

Environmental protection encompasses the lifecycle of the Bruce site facilities. The Environmental Management program includes the establishment of environmental objectives and targets, with periodic review and reporting to the Chief Nuclear Officer (bimonthly), environmental oversight committee (quarterly), the Nuclear Safety Review Board (quarterly), and the Environmental Management Review Team (annually).

Environmental monitoring includes areas inside and outside the nuclear facility boundaries. The monitoring processes are based on an Environmental Risk Assessment. The objective of environmental monitoring includes:

- Assessment of the level of risk on human health and safety, and the potential biological effects in the environment of the contaminants and physical stressors of concern arising from the facility;
- Demonstration of compliance with limits on the concentration and/or intensity of contaminants and physical stressors in the environment or their effect on the environment;
- Check, independently of effluent monitoring, on the effectiveness of containment and effluent control, and provide public assurance of the effectiveness of containment and effluent control; and,
- Verify the predictions made by the Environmental Risk Assessment, refine the models used in the ERA, and/or reduce the uncertainty in the predictions made by the ERA.

Environmental risks and environmental aspects associated with new or changed activities or projects are assessed with DPT-ENV-00016. Projects with an elevated risk ranking are reviewed by line management, to ensure that controls or barriers are put in place, commensurate with the risk.

All environmental activities across the Bruce site are tracked with an Environmental Aspect database. All activities with Significant Environmental Aspects are managed with operational controls.

Environmental risks associated with plant condition and deficient equipment are assessed via the station prioritization matrix.

Reviews of environmental risks are conducted according to several different avenues, including:

- Board of Directors: review of board-level corporate risk logs, which includes an environmental risk review, at quarterly meetings;
- Nuclear Safety Review Board: senior management communicate environmental safety performance, risk, and environmental events at quarterly meetings;
- Nuclear Oversight and Regulatory Affairs: this division provides independent, systematic oversight and evaluation to determine the effectiveness of the Bruce Power management system;
- Station Environmental Oversight Committee (for each of Bruce A and Bruce B): significant environmental risks are presented and reviewed at meetings on a quarterly basis.
- Corporate Environmental Oversight Committee: the corporate environmental risk matrix is reviewed at quarterly semi-annual meeting;
- Environmental Peer Group: review of site-wide environmental risks according to business risk management processes on at least a monthly basis; and,
- Annual Environmental Management Review Team meeting.

9.2.2 Past performance

The Environmental Management program is audited with respect to compliance with ISO 14001 on an annual basis. The last such audit did not identify adverse conditions that were non-compliant. However, opportunities for improvement and non-compliances with respect to corrective actions were identified.

Recent successes include:

- The Bruce A Station Containment Outage and Bruce B Vacuum Building Outage. During these major activities, Bruce Power worked closely with the Ministry of Environment and Climate Change to obtain the appropriate regulatory instruments. In addition to completing work within the bounds of these regulatory instruments, Bruce Power completed the required reporting after the outages;
- Bruce B copper line replacement at pumphouses: removal of copper piping eliminates a threat of toxicity to aquatic life; and,
- Bunker C fuel oil removal: removal of the Bunker C fuel (previously used to provide heating steam for on-site buildings) reduces overall site emissions and eliminates risks associated with transport of fuel.

The Environmental Performance Index (EPI) continues to be strong as the company continues with staff awareness and driving environmental items as a key safety pillar (see Figure 24). The EPI is aligned with regulatory definitions, industry definitions, and industry best practice. Specifically, the EPI is a composite indicator based on compliance to environmental regulations (such as reportable and non-reportable spills, derived release limits, and action levels), as well as aggressive administrative targets that drive continuous improvement (internal investigation levels and other administrative targets). Although there is no industry-wide EPI, the sub-indicators utilized in the Bruce Power EPI are similar to those used by other

CANDU operators; these are based on regulatory definitions and requirements and best industry practice.

Note: Exceedances of internal administrative limits or investigation levels will result in corrective actions being taken to avoid exceeding legal limits. This ensures that operations are safe for the environment.

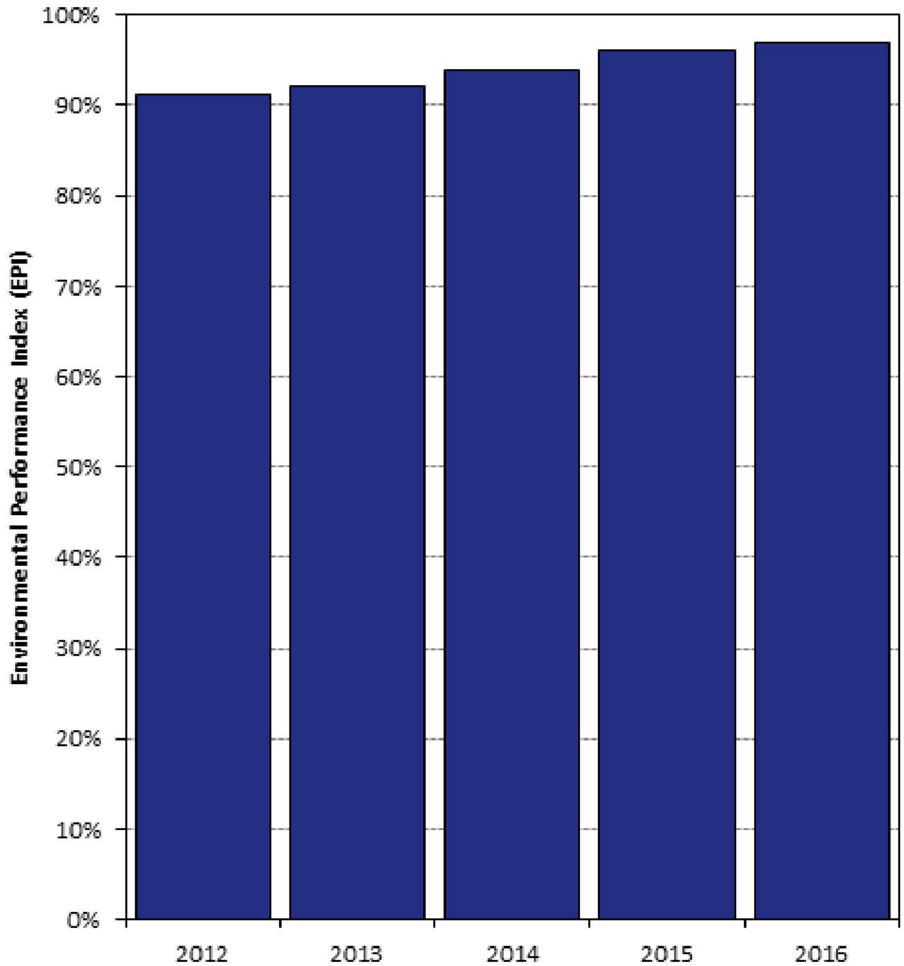


Figure 24. Environmental Performance Index

9.2.3 Future plans

Bruce Power is transitioning to ISO 14001:2015 (effective September 14, 2018). ISO 14001:2015 focuses on the Environment Management System (EMS) being integrated throughout business processes to aid in the organization's knowledge and understanding of external and internal issues, stakeholders needs and expectations, and risks and opportunities impacting the organization.

Bruce Power is transitioning to full compliance to REGDOC-2.9.1 (effective December 31, 2018), CSA N288.4-10, *Environmental Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills* (effective December 31, 2018), CSA N288.5-11, *Effluent Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills* (effective December 31, 2018), and N288.6-12, *Environmental Risk Assessments at Class I Nuclear Facilities and Uranium Mines and Mills* (effective December 31, 2018). Additionally, Bruce Power is transitioning to N288.1-14, *Guidelines for Calculating Derived Release Limits for Radioactive Material in Airborne and Liquid Effluents for Normal Operation of Nuclear Facilities*, by January 1, 2020.

Bruce Power is developing an implementation plan for CSA N288.7*, Groundwater Protection Programs at Class I Nuclear Facilities and Uranium Mines and Mills*.

Bruce Power anticipates using CSA N288.8-17 to develop action levels, replacing the previous guidance of CNSC G-228, *Developing and Using Action Levels*.

9.2.4 Challenges

None.

9.2.5 Requests

None.

9.3 Assessment and monitoring

9.3.1 Relevance and management

The Bruce Power Environmental Management program is described at a high level in Section 9.2.

The program includes assessment of environmental risks in terms of likelihood and magnitude. This assessment is integrated into environmental and overall business practices.

An Environmental Risk Assessment (ERA) is completed every 5 years, or earlier if significant operational or facility changes occur that would necessitate an update. The ERA is completed in accordance with CSA N288.6.

Internal assessments are made to evaluate the performance of the Environmental Management program. These assessments include Focus Area Self-Assessments, as well as internal audits conducted by the Nuclear Oversight and Regulatory Affairs division. Following these assessments, Bruce Power takes action to correct deficiencies, in accordance with the corrective action program.

External audits are conducted annually, with respect to compliance with ISO 14001. A surveillance audit is conducted for two years, with a re-registration audit in the third year. These audits are conducted by the external registrar for ISO 14001 registration.

9.3.2 Past performance

See Section 9.2.2.

9.3.3 Future plans

See Section 9.2.3.

9.3.4 Challenges

Bruce B is currently replacing stack monitors. Updates are provided to the CNSC at quarterly meetings.

9.3.5 Requests

None.

9.4 Protection of the public

9.4.1 Relevance and management

The Environmental Management program defines requirements for the processes which are established, implemented, and maintained in order to prepare for and respond to potential emergency situations. Emergency preparedness and response as a whole is managed through the Emergency Management program (Section 9.6). Relevant requirements include:

- Preparedness and response to prevent or mitigate adverse environmental impacts from emergency situations.
- Emergency Response Organization (ERO) annual testing via drill/exercise.
- Review of the program at a minimum of five years or when deemed necessary by the Emergency Management Oversight Committee or CNSC and review of emergency procedures every three years, in particular after an incident or tests.
- Provision of relevant information and training to relevant interested parties (e.g., employees, public, regulatory agencies), including persons working under its control. ERO staff receives initial orientation and training and participate in an annual drill/exercise.

Bruce Power has very detailed spill plans for Bruce A, Bruce B, and the overall Bruce site (“Centre of Site”). The purpose of these plans is to harmonize the procedures and documentation associated with emergency spill response. An environment spills drill is conducted each year and is integrated into the Emergency Response Organization drill and exercise schedule.

A key element of the Environmental Management program is a process to prevent and mitigate spills. This includes identification of spill risks and their pathways to the natural environment, evaluation of the overall degree of risk associated with each pathway, and mitigation of spill. Restoration and remediation activities are also defined.

Protection of the public is ensured in part through the monitoring and control of radiological emissions (Section 9.1). Releases are controlled through the application of derived release limits, action levels, and internal investigation levels. Monitors in the Bruce A and Bruce B stacks will alarm upon high rates of release for noble gases, particulates and radioiodine. Upon high releases of radioactive liquid effluent to the discharge duct, the liquid effluent monitor will provide an annunciation in the main control room and will automatically shut off the discharge.

Impacts on human health are assessed through the Environmental Risk Assessment (Section 9.5).

9.4.2 Past performance

Dose to the public is described in Section 7.5.2.

Bruce Power has a long-standing stakeholder commitment to ensure low levels of tritium in drinking water. The administrative target is 100 Bq/L, which well below the provincial drinking water limit of 7000 Bq/L. The tritium levels in local drinking water supplies are near provincial background levels (Figure 25).

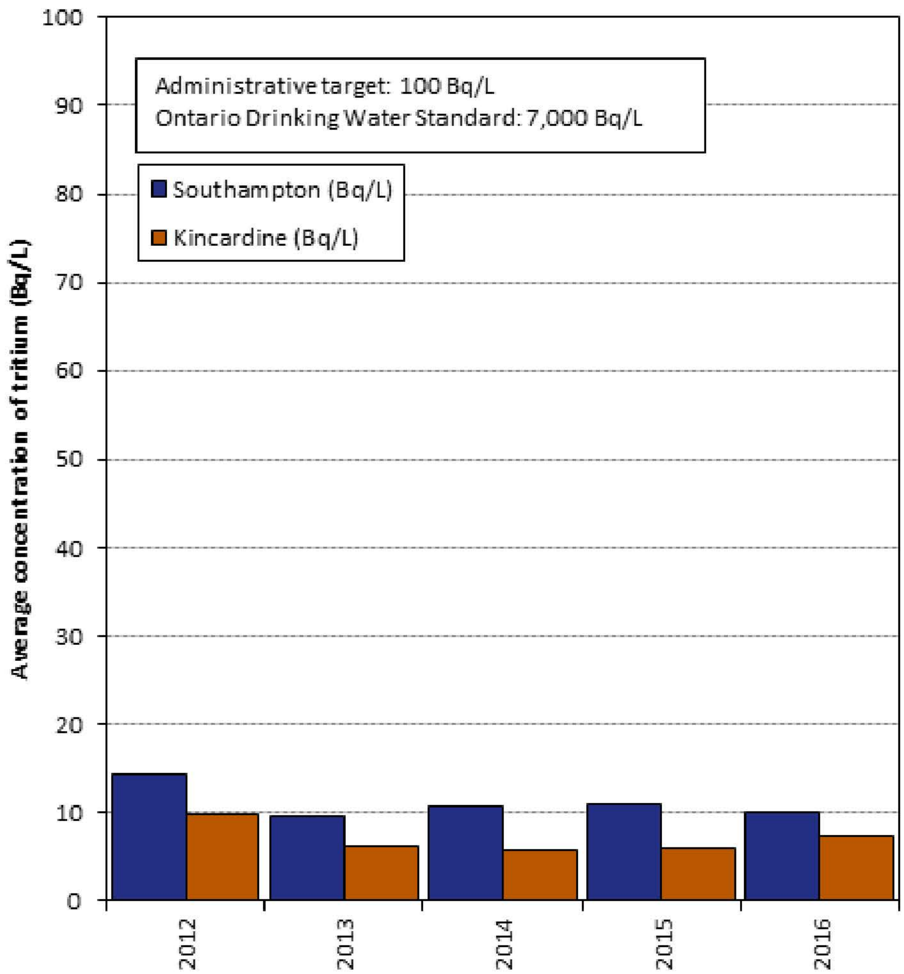


Figure 25. Annual average concentration of tritium in municipal water supply plants

9.4.3 Future plans

None.

9.4.4 Challenges

None.

9.4.5 Requests

None.

9.5 Environmental risk assessment

9.5.1 Relevance and management

Effects on the environment are assessment through an Environmental Risk Assessment, prepared in accordance with N288.6-12, *Environmental Risk Assessments at Class I Nuclear Facilities and Uranium Mines and Mills*. A screening-level assessment (B-REP-03443-00011) was completed in 2013, and a higher-level assessment (B-REP-03443-00012) was completed in 2015. The ERA is to be updated at least every five years.

Briefly, the screening level risk assessment is conducted to identify receptors and stressors that require further quantitative assessment. For those receptors and stressors, a subsequent quantitative assessment is completed at a preliminary level (Tier 2) or, if of potential concern, at a detailed level (Tier 3).

B-REP-03443-00012 includes a human health risk assessment as well as an ecological risk assessment. Key conclusions include:

- The operation of the Bruce A and Bruce B facilities has not resulted in adverse effects on human health of nearby residents or visitors, including radiological exposure and non-radiological substances.

- Risks to ecological receptors are limited to exposure in soil in a small number of former industrial areas.

9.5.2 Past performance

CNSC staff confirmed that the Bruce Power ERA met the requirements of CSA N288.6-12 (Reference B3). Bruce Power will review and consider CNSC recommendations and other comments for disposition in a future ERA.

9.5.3 Future plans

Bruce Power is transitioning to full compliance to REGDOC-2.9.1, *Environmental Protection*, (effective December 31, 2018).

Bruce Power plans to submit to the CNSC an updated ERA that includes the Major Component Replacement activities. The updated ERA will be submitted at the same time as this licence renewal application, three years in advance of the next required update.

9.5.4 Challenges

None.

9.5.5 Requests

None.

9.6 Update on the status of the Fisheries Act Authorization

Bruce Power and the Department of Fisheries and Oceans (now Fisheries and Oceans Canada) have been in dialogue with respect to a *Fisheries Act* authorization since 2011, well before changes to the *Fisheries Act* in 2013. Following a memorandum of understanding between Fisheries and Oceans Canada and the CNSC that came into effect in 2014, those discussions have included the CNSC.

Bruce Power submitted a draft application in 2015, an application in 2016, and a revised application in 2017 (Reference B4).

The revised application addresses discussions with the CNSC and Fisheries and Oceans Canada with respect to methodology for the quantification of annual losses due to entrainment and impingement of fish at Bruce A and Bruce B. Annual losses, which are based on based on many years' of impingement monitoring and two years of intensive entrainment monitoring (2013-2014), are estimated at less than 2200 kg of age-1-equivalent fish. In addition, the revised application addresses other comments from the CNSC and Métis Nation of Ontario. The revised application includes an Indigenous consultation log and proposed projects for offsets.

Following submission of the revised application, CNSC will determine (within 60 days) whether the application is complete, and will then notify Fisheries and Oceans Canada.

10.0 EMERGENCY MANAGEMENT AND FIRE PROTECTION

Covers emergency plans and emergency preparedness programs that exist for emergencies and for non-routine conditions. This area also includes any results of participation in exercises.

10.1 Conventional emergency preparedness and response

The overall Emergency Management program is described in Section 10.2.

Conventional emergency preparedness and response is delivered through the following key plans:

- Conventional Emergency Plan: addresses the response required to minimize the impacts of hazards to workers, the public, and the environment from non-radiological hazards;

- Fire Safety Management Plan: addresses the planning, implementation, and control of activities related to fire safety.

10.2 Nuclear emergency preparedness and response

10.2.1 Relevance and management

The Emergency Management program has been established to meet the requirements of the Bruce Power Emergency Management policy, which commits to the following:

- Readiness to respond to any emergency;

- Continuously striving for industry excellence in all-hazard emergency management through a site-wide integrated approach focused on prevention, preparedness, response, mitigation, and transition to recovery.;

- Ensuring that the organizational functions, processes, procedures, equipment, and material are in place, and conducting training (including drills and exercises) in order to be ready to respond quickly and effectively to all events; and,

- In the event of an emergency, working with federal, provincial and municipal partners to manage consequences and to protect workers, the public, and the environment while reducing the impact on the facilities and the business.

The Emergency Management program is used to manage the consequences of events, such as spills, releases, fires, and security incidents, which have the potential to impact on worker, public, and environmental safety and the continuity of the business. Elements of the program include processes and response mechanisms for planning, reporting, providing assistance, and testing plans.

Following the Incident Management System approach, the Emergency Management program describes the functional requirements, implementing approaches, and key responsibilities for applying an all-hazards emergency management process to identified threats, ensuring rapid, effective responses to events.

Preparedness and response plans and procedures have been prepared to mitigate the consequences of identified hazards. These plans and procedures have been developed to ensure key objectives are satisfied, including:

- Communication to applicable stakeholders (workers, public, regulatory agencies, etc.),
- Establishment of response organizations,
- Establishment of response facilities and equipment, and,
- Evaluation of program effectiveness.

Nuclear emergency preparedness and response is delivered through the following key emergency response plans and their implementing procedures:

- Bruce Power Nuclear Emergency Plan: addresses the response required to minimize the impacts of radiological hazards to workers, the public, and the environment, from operating incidents and reactor accidents;

- Winter Storm Transportation Plan: addresses the response required to minimize the impact of site access restrictions due to weather, road conditions, car accidents, etc.;

- Bruce Power Electricity Emergency Plan: addresses the response required to alleviate the effects of a major electricity emergency. This plan is integrated with Ontario's Electricity Emergency Plan;

- Business Continuity Management Plan: identifies critical functions and defines the process to implement business continuity procedures to ensure the continuity of Bruce Power's business operations;

- Radioactive Material Transportation Emergency Response Plan: addresses the response required to minimize the impacts of radiological hazards to workers, the public, and the environment from transportation accidents.

Additionally, procedures are in place to address the following:

- Event response and reporting;
- Spills to the environment;
- Radioactive emissions response;
- Roles and responsibilities, including Shift Emergency Controller, Emergency Management Centre Commander, and Emergency Recovery Director; and,
- Emergency preparedness drills and exercises.

The Emergency and Protective Services Fire organization supports nuclear emergency preparedness and response. EPS Fire workers are trained and tested through drills and exercises with respect to the following:

- Selection and use of personal protective equipment,
- Evaluation of radiation hazards at an emergency medical scene,
- Control of contamination at the source,
- Establishment of a Contaminated Casualty Treatment Area,
- Decontamination of a patient when required,
- Transportation of a contaminated patient to the hospital,
- Management of a contaminated patient while at the hospital,
- In-plant survey team actions,
- Source term survey team actions, and,
- Search and rescue of unaccounted personnel

Bruce Power works with local municipalities (Kincardine and Saugeen Shores) to ensure their nuclear emergency response plans are adequate. Offsite drills are conducted twice annually with each of the municipalities. Therefore, Bruce Power is confident the municipal plans are adequate.

Bruce Power meets twice annually with Kincardine through the Emergency Management Program Committee. Committee members include: Kincardine Fire Department, Bruce County EMS, Ontario Provincial Police, Grey Bruce Health Unit, Ministry of Transport, Bruce County Public Works, Kincardine Public Works, Blue Water School Board, Grey Bruce Catholic School Board, Bruce County Social Services, Bruce County Community Emergency Management Coordinator. All stakeholders participate in reviewing the Kincardine municipal emergency response plan.

Additionally, mutual aid meetings are held twice annually with Saugeen Shores.

10.2.2 Past performance

Bruce Power has invested in world-class equipment, created programs, established procedures, and implemented a training regime consistent with industry top performers.

Bruce Power trains and exercises extensively and rigorously to evaluate performance against the very best in the industry. Bruce Power's workers are well-equipped, well-trained and well-prepared, but are not complacent, as emergencies will present new and unique challenges that have not been drilled or exercised.

The Emergency Management program relies on quality tools and equipment, solid processes, scalable response strategies, and a high level of staff proficiency. These cornerstones ensure Bruce Power is resilient and capable of responding to and mitigating all hazards. This includes preparedness and response for conventional emergencies, nuclear emergencies, and fire emergencies.

Following the Fukushima disaster, Bruce Power identified the need to expand the site's defense-in-depth through the purchase of Emergency Mitigating Equipment, completion of plant modifications, and implementation of command and control improvements through the adoption of a standard Incident Management System. These enhancements were validated as part of Exercise Huron Challenge in 2012.

Bruce Power continued to evaluate and to improve the Emergency Management program. A new governance structure was applied to ensure sustainability and to measure and drive continuous improvement. This governance evolution, largely completed in 2014-2015, included:

- Substantial revision to the Emergency Management program document,
- Development of an "all hazards" emergency management policy statement,
- Establishment of an Emergency Preparedness peer team,
- Creation of the Emergency Preparedness Senior Advisory Group,
- Assignment of high-impact Station Functional Area Managers, and,
- Creation of the Emergency Management Oversight Committee.

In 2016, the program governance was largely stable and therefore suitable for establishing a baseline level of performance. The program was assessed and challenged internally and externally through Focus Area Self Assessments, extensive benchmarking across the industry, internal audits, and oversight assessments. Corrective actions were applied to observed gaps. Bruce Power is confident that the Emergency Management program is world-class.

The previous licence renewal application identified a series of activities that were in progress or planned to fully implement the Emergency Management Center (EMC) and the Incident Management System (IMS). The following provides an update on these previously committed activities:

- Development of a new 5-crew Emergency Response Organization (ERO) based on IMS: complete. The ERO structure includes organizational roles and responsibilities that align with the IMS structure. The 5-crew ERO structure was modified in 2017 to a 4-crew structure with two pool crews. This change was implemented to support a demanding training regime for all ERO positions.

- Implementation of a new, fully-redundant Emergency Management Centre (EMC): complete. The EMC is fully redundant with two alternate EMC locations in Kincardine and Port Elgin. These alternate locations and the relocation procedure have been tested through drill and exercise activities, including the Huron Resolve Provincial exercise in October 2016.

- Development and delivery of a new Systematic Approach to Training-based emergency response training program. This was completed in January 2016.

- Revisions to governance: complete. The suite of Emergency Response Procedures (ERPs) has been updated to support the Incident Management System (IMS) and the "all hazards" approach. ERPs are used by ERO members during quarterly drills and annual corporate exercises. Procedure deficiencies and opportunities for improvement are identified through the drill and exercise evaluation process, and revisions are implemented as appropriate for continuous improvement.

- Training on Emergency Mitigating Equipment (EME) deployment: complete. All staff have been fully trained and qualified on the deployment and activation of the EME. EME Drills are now part of the Station Emergency Drill Schedule, and each crew is required to conduct a back shift practice with EME deployment.

- Off-site gamma monitoring: implemented. Bruce Power has implemented remote gamma monitoring at on-site and off-site locations within 10 km (primary zone). This system augments the thermoluminescent dosimeter gamma monitoring system. The new system is designed to monitor, to assess, and to dispatch real-time monitoring. This system also includes air sampling stations within 10 km (primary zone) and in local communities. The system has been used in station and EMC drills and exercises.

Additionally, Bruce Power has also completed the following:

- Bruce Power supported the Canadian Radio-television and Telecommunications Commission (CRTC) public consultation for wireless service providers to participate in Canada's National Public Alerting System which will ensure that Canadians receive timely warnings of imminent threats to life and property on mobile devices.

- In partnership with the Municipality of Kincardine, Alert FM's receivers were distributed to Primary Zone residences as a redundant means of communicating directions to residents supplementing the off-site sirens. These receivers were also distributed to "Category A" workers as redundant means of communicating staff direction during an event where there is a loss of offsite power and traditional means of communications.

- Commissioning of the EPS training facility, a state-of-the-art training ground that provides plant mock-ups and fire props to enable a highly realistic training environment for Bruce Powers own fire responders and for our local mutual aid fire department. The EPS training facility is also used by station operations to provide a challenging, realistic environment when performing emergency field operations training.

- Implementation of an electronic, automated accounting system in the stations. This new capability has enabled Bruce Power to better assess performance and identify areas for improvement with respect to accounting of workers during emergencies.

- Implementation of a new process to monitor and to communicate the readiness status of Equipment Important to Emergency Response on a continuous basis.

- In support of the Provincial Nuclear Emergency Response Plan (PNERP), Bruce Power completed an Evacuation Time Estimate study in 2016. This study will help confirm planning assumptions used in the development of emergency plans.

Bruce Power's "all hazards" approach to Emergency Management is tested and assessed through a continuous series of quarterly drills and annual corporate-level exercises to test whether the integrated emergency response processes, command structure, equipment, systems, and workers are capable of responding to and mitigating the effects of design basis accidents.

The latest provincial-level exercise, Huron Resolve, was held over a five-day period in October 2016. This event challenged more than 30 agencies and more than 1,000 people to respond to a large-scale radiological event, in addition to a variety of other related and unrelated incidents.

The exercise tested Bruce Power's integrated emergency response to an external initiating event, triggering a design basis accident transitioning to a beyond design basis accident. This permitted testing the implementation of the severe accident management guides.

During the exercise, Emergency Mitigating Equipment was successfully deployed to provide back-up power and cooling water to the station. The automated on-site and off-site remote radiation monitoring network was fully utilized to provide scenario simulation injects, which prompted actual deployment of the off-site survey team and deployable remote radiation monitoring equipment.

Additionally, the scenario tested the transportation emergency response procedure and the contaminated casualty procedures, with active participation of the local hospital.

The scenario involved coordination of provincial and federal agencies in developing and implementing on-site and off-site protective measures, both pre-release and post-release. Bruce Power's EMC relocated to one of the back-up facilities as part of the on-site pre-release protective measures.

In addition, the Crisis Management Team was activated which included full participation of the President and Chief Executive Officer and members of the executive team throughout the five-day exercise. Following the exercise, a continuation of the scenario was used to conduct a table-top exercise of various elements of the business continuity plan.

In 2016, emergency management performance exceeded established targets in areas related to Emergency Response Organization staffing, qualifications, and the drill program. Additionally, the station performance metrics exceeded targets for emergency preparedness facilities and equipment. However, site-wide drill performance scores were slightly below target due to increased rigor in drill evaluation criteria, aimed to drive performance improvement.

In 2017, the performance measures were expanded to assess less-frequently performed emergency response activities to further challenge Bruce Power's all-hazards emergency response capabilities.

10.2.3 Future plans

Bruce Power continues to strive for industry excellence through improvement plans to enhance program performance. These plans include:

- Mobile emergency management center: to enhance redundancy, Bruce Power will purchase and implement a fully mobile emergency management center (vehicle equipped with ERO back-up systems and equipment) that can be deployed to any location;

- On-site/off-site communications enhancement: improvements to the EMC and Emergency Operations Center communications redundancy;

- Site radio system replacement: upgrades to on-site infrastructure and improvements to radio communications for site areas that have poor reception/signal. This project will enhance interoperability between Bruce Power and our off-site response organizations through a feature that enables a radio frequency "patch." In addition, a new Distributed Antenna System will enhance communications within a 30 km range.

- Centre-of-Site accounting: to enable robust accounting for all on-site workers (not just the station) as an industry best practice; and,

- Permanent hard-wired stand-by generator at the EMC: to eliminate the need to deploy the existing manual stand-by generator.

The nuclear facilities were constructed in the 1970s. As part of the transition to compliance with CSA N293-07 (now complete), Bruce Power identified non-conformances with modern fire codes. A 7-year implementation plan (2014-2020) is underway to address these design non-conformances. Mitigation measures are in place, where appropriate, for design non-conformances. The implementation plan was accepted by the CNSC, and semi-annual updates are being provided to CNSC staff.

Bruce Power works closely with federal, provincial, and regional authorities to ensure Emergency Preparedness for any and all hazards. While all levels of government are responsible for planning and responding to a nuclear emergency, Health Canada is the lead federal agency for the federal off-site response, including support of provincial actions. However, the primary responsibility for planning and response rests with the Province of Ontario's Office of the Fire Marshal and Emergency Management (OFMEM), which develops and maintains the Provincial Nuclear Emergency Response Plan (PNERP). The local municipalities also have nuclear emergency response plans, and work closely and exercise with Bruce Power to support effectiveness and continual improvement.

Bruce Power provides funding local municipalities to support the required resources and facilities that enable external agencies to put in place and maintain enhanced response measures. These measures are captured within the provincial and municipal nuclear emergency response plans and are drilled each year.

OFMEM is in the planning stage of revising the PNERP to incorporate lessons learned following the Fukushima nuclear accident. As part of Bruce Power's review and submission during the public consultation phase, Bruce Power is preparing a technical full-spectral analysis report that takes into account international practice with respect to the planning basis and also considers the Emergency Mitigating Equipment installed after the Fukushima event. This supplement is anticipated to be submitted to OFMEM by end of June 2017.

Bruce Power is examining the feasibility of using mobile portal monitors in place of contamination meters for identifying vehicular contamination at off-site municipal decontamination centres.

10.2.4 Challenges

Bruce Power provides plant data to the CNSC during drills and emergencies via fax. Filling out forms manually and sending faxes is time-consuming. In addition, it is difficult for the CNSC to conduct a trending analysis. As a result, Bruce Power is in the process of implementing a software application called DLAN (Disaster LAN; see Section 15.15). This will allow the Bruce Power Emergency Response Organization to complete emergency forms (plant data) electronically and send the data to the CNSC, who will be able to view and trend changing data by logging into the same application. For more details, see Section 15.15.

10.2.5 Requests

None.

10.3 Fire emergency preparedness and response

The overall Emergency Management program is described in Section 10.2.

The Fire Safety Management Plan addresses the planning, implementation, and control of activities to minimize the risk of fire-related consequence to nuclear safety systems, workers, power generation, structures, systems, equipment, and the environment.

The Emergency and Protective Services (EPS) Fire organization, and associated processes, support the nuclear emergency preparedness and response plans. EPS Fire workers are trained, and regularly assessed through drills and exercises that evaluate the following elements while responding to potential radiation releases:

- Selection and use of the appropriate PPE,
- Evaluation of radiation hazards at an emergency medical scene,
- Control of contamination at the source,
- Establishment of a Contaminated Casualty Treatment Area,
- Decontamination of a patient when required,
- Transportation of a contaminated patient to the hospital,
- Management of a contaminated patient while at the hospital,
- In Plant Survey Team actions, and,
- Source Term Survey Team actions.

In 2015, Bruce Power opened a 23,000 square-foot fire training facility, which provides training opportunities for the Emergency and Protective Services department, as well as co-training opportunities with municipal fire departments.

11.0 WASTE MANAGEMENT

Covers internal waste-related programs that form part of the facility's operations up to the point where the waste is removed from the facility to a separate waste management facility. This area also covers the planning for decommissioning.

11.1 Waste characterization

11.1.1 Relevance and management

Some Zone 2 waste is anticipated to be free of radioactive contamination ("likely clean" waste). Bruce Power packages and handles this waste separately from other Zone 2 wastes. After monitoring in the facility, this waste is cleared for disposal as non-radioactive waste. A portal radiation monitor at the Bruce site main gate will identify any unplanned release of solid radioactive waste from the site.

To measure procedural compliance, on an annual basis, a random sample of radioactive waste bags is collected at each station during an outage, and during online work. These random bags are evaluated by Waste Handling workers to determine if they have been effectively segregated or not. This survey establishes a baseline and measure of how effectively radioactive waste is being segregated by the waste generator in the field.

Bruce Power conducts an annual audit of landfill, compost, and recycling waste, in accordance with provincial requirements. The results of this audit are used to develop an annual waste reduction work plan, which continues to drive down the volume of waste generated across site.

11.1.2 Past performance

Waste segregation continues to improve. To allow more effective radioactive waste segregation in the field, radioactive waste segregation cans are being provided across the site.

11.1.3 Future plans

In 2017, a waste segregation survey will be completed at both Bruce A and Bruce B, during an outage and during online work at each station respectively. This survey also identifies opportunities for improvement in waste segregation.

11.1.4 Challenges

None.

11.1.5 Requests

None.

11.2 Waste minimization

11.2.1 Relevance and management

Bruce Power complies with all applicable waste regulations and requirements. Additionally, reducing all forms of waste is in the best interest of the company from an environmental and financial standpoint. As such, waste minimization has been a company focus for many years.

The goals of waste minimization are:

- To reduce waste at the consumer level;
- To generate less waste;
- To reuse materials when possible; and,
- To explore all opportunities to sort and recycle.

Bruce Power has several initiatives that focus on these areas.

Waste volumes are minimized through application of the principles of reduce, reuse, recycle, and recover. Wastes are processed in a safe, environmentally responsible manner.

11.2.2 Past performance

Bruce Power continues to maintain strong performance with waste minimization by increasing site awareness of the importance of waste volume reduction.

All planned outages in 2016 generated less low-level radioactive waste than planned.

Additionally, online work across site generated less low level radioactive waste than planned. In Q1 of 2016, Bruce Power produced 30% less waste (by volume) than planned.

11.2.3 Future plans

Bruce Power is exploring the possibility of reducing spent resin volumes by a factor of five. In the future, spent resin may be processed by an external vendor prior to transfer for long-term storage.

11.2.4 Challenges

None.

11.2.5 Requests

None.

11.3 Waste management practices

11.3.1 Relevance and management

Bruce Power manages many different forms of waste, including radioactive, hazardous (oils and chemicals), recyclables (glass, cardboard, plastic, paper, metal), and organic (compost). Waste which is not radioactive, not hazardous, non-recyclable, and non-compostable is landfill waste.

Bruce Power's waste management policy is to ensure that safe, reliable disposal pathways are available for all waste produced onsite, while striving to reduce the volume of waste generated.

Radioactive solid waste produced by Bruce Power is not normally removed from the Bruce site. Instead, this waste is typically transferred to the Western Waste Management Facility, which is operated by Ontario Power Generation on the Bruce site, for long-term storage.

With respect to conventional (non-radioactive waste), the Environmental Management program ensures compliance with applicable federal, provincial, and municipal regulations with respect to the generation, handling, storage, and disposal of waste, including polychlorinated biphenyl waste.

Daily radioactive waste volume targets are tracked for online and outage days. Oversight of performance versus these targets is provided during each outage. Through continued oversight and communication, the Waste Management and Reduction team is targeting an additional 5% reduction in the volume of radioactive waste generated across site. Achieving a 5% reduction in volumes will improve performance versus planned volume targets.

11.3.2 Past performance

Bruce Power has achieved the following successes with respect to radioactive waste:

- Achieved CNSC fully satisfactory rating;
- Reduced the volume of radioactive waste sent to OPG through processing (metal melt, incineration, and compaction);
- Identified waste reduction opportunities;
- Developed a waste management strategy for the Major Component Replacement project; and,
- Completed annual radioactive waste segregation survey.

Bruce Power has improved its recycling program, with a new vendor that accepts boxboard and polystyrene.

11.3.3 Future plans

Bruce Power plans to explore options for new options for disposal of selected wastes, including plastic film, vinyl, ear plugs, coffee cups, coffee lids, and coffee pods.

Bruce Power will develop a site-wide reduction work plan to ensure removal of equipment with PCB concentrations in the range of 50 to 500 mg/kg by December 31, 2025.

Bruce Power plans to increase awareness for workers with respect to the removal of packaging, in order to reduce the amount of radioactive waste produced on site.

Bruce Power plans to develop an effect waste management process for MCR activities.

11.3.4 Challenges

None.

11.3.5 Requests

None.

11.4 Decommissioning plans

11.4.1 Relevance and management

The scope of financial guarantee by Ontario Power Generation (OPG) to the CNSC (Reference B5) includes decommissioning Bruce A, Bruce B, and the Central Maintenance and Laundry Facility, as well as lifecycle management of all used fuel as well as low- and intermediate-level waste produced by these facilities.

The preliminary decommissioning plan is publically available (Reference B6).

11.4.2 Past performance

Not applicable.

11.4.3 Future plans

Not applicable.

11.4.4 Challenges

Not applicable.

11.4.5 Requests

Bruce Power requests that no licence conditions related to decommissioning be included in the Bruce A and Bruce B licence, except for a requirement to inform the Commission of any change in the arrangement with OPG.

12.0 SECURITY

Covers the programs required to implement and support the security requirements stipulated in the regulations, the licence, orders, or expectations for the facility or activity.

12.1 Facilities and equipment

12.1.1 Relevance and management

The Bruce Power site is protected by a series of defense-in-depth security measures, starting at the outer boundary of the Bruce site.

The first layer of defense encompasses the site access check-points. Bruce Power has invested in a world-class main security check-point facility, which enables nuclear security officers to perform best-in-business security practices. All individuals entering the Bruce site are verified to have a legitimate business need prior to entry.

Secondary site access points (open during peak periods) also include security check-points.

Bruce A and Bruce B are each surrounded by two security fences. The security fences are equipped such that intrusion can be detected, as well as tampering or component failures. Additional physical protection measures mitigate forced land or marine vehicle penetration of the protected area. Inside the facilities, exterior powerhouse doors are equipped with locking systems to prevent and to delay unauthorized access.

Access to the protected area is controlled by a combination of physical, administrative, and logical systems, including proximity cards and biometric readers for verification of identify. All workers entering the protected area have a valid security clearance, unless escorted by an individual with such a clearance.

Searches for weapons and explosives are conducted on all personnel, vehicles, packages, and equipment entering the protected area. Dedicated search equipment at Bruce A and Bruce B include walk-through and desktop explosive detectors, walk-through and hand-held metal detectors, and x-ray machines.

All personnel leaving the protected area must be searched for Category I, II, or III nuclear material by exiting through portal monitors. Hand-held radiation monitors are used by security workers to perform searches of vehicles exiting the protected area.

In addition to static security facilities and equipment, Bruce Power is also patrolled by armed nuclear response team members on a 24/7 basis using light armored vehicles, duty patrol vehicles, and associated security equipment.

12.1.2 Past performance

Bruce Power has continued to improve security facilities and infrastructure through upgrades, equipment replacement, and new equipment, including:

- Replacement and upgrade of the X-ray system (2014),
- Construction of a new Emergency and Protective Services (EPS) training facility (2015),
- Upgrade of the security monitoring room (2015),
- Enhancements to the nuclear response team rifle sights (2015),
- Replacements and upgrades of security cameras (2016),
- Enhancements to primary and back-up communications (2016),
- Ballistic personal protective equipment (2016),
- Ballistic bunker defense systems equipment (2016),
- Vehicle portal gate replacement (2016), and
- Enhancements to Emergency Management Centre response capability (2017).

12.1.3 Future plans

The existing infrastructure and processes in place at Bruce Power currently satisfy the regulatory requirements, with areas for improvement identified. Infrastructure upgrades and other improvement initiatives are currently in progress to enhance physical protection systems performance in the areas identified for improvement.

Bruce Power plans to enhance the security search process for bulk materials by implementing a large vehicle scanning capability using technology similar to what is used at our Canadian border crossings. This solution will also support efficient movement of the high volume of materials expected throughout the Major Component Replacement and Asset Life Extension projects.

Details of these improvements and progress reports are communicated quarterly to the CNSC through security-protected quarterly reports, pursuant to REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*.

12.1.4 Challenges

As site infrastructure continues to age and new regulatory requirements are introduced, Bruce Power must strategize infrastructure upgrades and programs on a risk-based priority. Bruce Power manages these challenges through performance testing, systems health monitoring and business planning.

12.1.5 Requests

None.

12.2 Response arrangements

12.2.1 Relevance and management

Bruce Power has established response arrangements with the Ontario Provincial Police (off-site response force) through a memorandum of understanding.

12.2.2 Past performance

During the current licence period, Bruce Power has worked closely with the Ontario Provincial Police to improve the effectiveness of the exercise program, and to integrate the off-site response force into larger scale activities, including the Bruce Power Corporate Exercise (2015) and the Performance Testing Program / Force on Force Exercise (2016).

The Nuclear Security Tactical Deployment Plan was revised, which included implementation of a Quick Response Force. Bruce Power also evolved response tactics and training in consultation with the CNSC, and developed and implemented an Incident Command Course intended for all Security front line managers and crew sergeants

12.2.3 Future plans

Bruce Power works closely with provincial and regional response agencies to ensure interoperability and to continuously enhance response capabilities. To support these enhancements, a key focus is being placed on interoperability among all tri-services organizations (police, fire services, and paramedics).

To support enhancements to communications between tri-services organizations, Bruce Power is a partner in a 2-year, $230,000 rural interoperability study in the Bruce-Grey-Huron region (see Section 15.15). This study is funded through the Canadian Safety and Security Program.

The primary purpose of the study is to develop a rural interoperability plan. The secondary purpose is to identify opportunities for additional savings and collaboration. Following development of the interoperability plan, it is expected that further work with be done to enhance interoperability communications in the Bruce-Grey-Huron region. In the meantime, Bruce Power will continue to maintain equipment to support communications with tri-services organizations.

12.2.4 Challenges

None.

12.2.5 Requests

None.

12.3 Security practices

12.3.1 Relevance and management

The Nuclear Security program establishes the governance to provide best-in-business nuclear security services. The processes enable timely and effective protection of nuclear materials, company assets, workers, and the public from malicious and malevolent acts.

Security practices are designed using a defense-in-depth approach.

The first layer of defense is the requirement that all workers, including contractors, must be security cleared. Visitors without clearance must be sponsored by a site employee with security clearance.

All workers accessing the Bruce site are required to show identification to confirm security clearance and to validate a business need for entry. Workers and visitors who do not have valid site identification are required to have a site sponsor and must register with security workers to record the business need for entering site. All delivery vehicles and visitor vehicles are searched at the main security check-point prior to being granted access to the Bruce site.

At protected area access points, security search practices are based on an “alarm-free” policy, which requires nuclear security officers to fully investigate and identify the cause of any alarm prior to granting access to the protected area.

Visitors without a security clearance may access the protected area, subject to a valid business need and the escort by a site employee with security clearance.

The protected areas are continuously patrolled by an armed nuclear response team consisting of an adequate number of fully trained and qualified members, capable of effectively intervening and defending against the design basis threat.

Nuclear Response Team members are required to meet conditions set out in the *Nuclear Security Regulations*, RD-363 *Nuclear Security Officer Medical, Physical and Psychological Fitness*, and REGDOC-2.12.1, *High Security Sites: Nuclear Response Force*, for authorization as a Nuclear Response Team member.

12.3.2 Past performance

During the past licensing period, Bruce Power has enhanced site security practices through the following:

- Implementation of random vehicle and property searches within the Bruce site, supplemented by contract canine search services (2014),
- Implementation of site lockdown drills (2016),
- Completion of a security awareness campaign (2016), and,
- Assessment of security culture as part of the safety culture assessment (2016).

In addition to internal audits by the nuclear oversight group, Bruce Power participated in a security program evaluation by the International Atomic Energy Agency (IAEA) International Physical Protection Advisory Service (IPPAS) mission (2015).

CNSC has rated the Security Safety and Control Area as “Fully Satisfactory” for the past 6 years. This rating is based on CNSC inspections, the CNSC Performance Testing Program, and reports submitted to the CNSC as required.

12.3.3 Future plans

Bruce Power plans to support the development of the Centre for Excellence for Nuclear Security as part of a joint effort with the World Institute for Nuclear Security (WINS) and other stakeholders.

Emergency and Protective Services workers plans to continue to offer an Incident Command Course for Security Operations and Tactical/Incident Command personnel to develop the ability to effectively demonstrate Incident Command as it pertains to high-risk security incidents.

The Nuclear Security program will continue to operate at a high standard and will continue meet CNSC licensing requirements.

12.3.4 Challenges

None.

12.3.5 Requests

None.

12.4 Drills and exercises

12.4.1 Relevance and management

Security drills are performed by shift crews on a monthly basis to test the operation of one or more of the physical protection measures and the readiness of the nuclear response team members. A series of drill scenarios are provided to the shift crews to utilize for the monthly drill program. First line managers are provided latitude to modify the scenario to introduce realism and new challenges to the security team.

Details of the drills and exercises, facilities and equipment, security practices, and response arrangements with the Ontario Provincial Police are provided in the “Security Program Description – Bruce Nuclear Generating Station A and B” (Reference B7)

12.4.2 Past performance

During the past licensing period, Bruce Power participated in the CNSC Performance Testing Program, which evaluated the integrated response capabilities of the nuclear response team and the effectiveness of physical protection systems against adversaries equipped within the design basis threat.

These evaluations were successfully conducted at Bruce Power in 2014 and 2016. The 2016 Performance Testing Program exercise was the largest combined exercise to date coordinated between Bruce Power’s nuclear response team and the Ontario Provincial Police.

The CNSC has recognized Bruce Power’s progress in evolving the Performance Testing Program by introducing elements of realism and challenge to the exercises performed.

12.4.3 Future plans

Large-scale security exercises are performed at the Bruce site at least once every two years, in consultation with the CNSC, to test the effectiveness of the site security contingency plan and the physical protection system. Exercises are performed as part of the CNSC evaluated performance testing program.

12.4.4 Challenges

None.

12.4.5 Requests

None.

13.0 SAFEGUARDS AND NON-PROLIFERATION

Covers the programs and activities required for the successful implementation of the obligations arising from the Canada/International Atomic Energy Agency (IAEA) safeguards agreements, as well as all other measures arising from the Treaty on the Non-Proliferation of Nuclear Weapons.

13.1 Nuclear material accountancy and control

13.1.1 Relevance and management

Bruce Power facilitates Canada’s compliance with INFCIRC/164, Agreement Between the Government of Canada and the International Atomic Energy Agency for the Application of Safeguards in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons, including Addendum 1.

The Bruce Power safeguards program is implemented through the Nuclear Fuel Management program and the CNSC Interface Management program. The safeguards program complies with regulatory requirements as well as RD-336, Accounting and Reporting of Nuclear Material, and REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*.

13.1.2 Past performance

Bruce Power prepares reports for submission to the CNSC and/or IAEA, including:

- Inventory changes at a material balance area,
- Monthly listing of inventory at a material balance area,
- Summary of information for foreign-obligated materials (if applicable),
- Monthly summaries with respect to the internal transfer of material,
- Additional clarifications, upon request, of nuclear material movement, and,
- Informal summaries of IAEA inspections.

13.1.3 Future plans

Bruce Power will continue to provide information to and support the IAEA and CNSC to comply with all Safeguards licence conditions and IAEA requirements.

13.1.4 Challenges

None.

13.1.5 Requests

None.

13.2 Access and assistance to the IAEA

13.2.1 Relevance and management

In order to facilitate Canada's compliance with INFCIRC/164, Bruce Power works closely with IAEA staff. Key elements of the safeguards program include:

- Provision of reports and information regarding nuclear materials and activities,
- Support of IAEA inspector access to site facilities to enable verification activities,
- Accommodation of servicing and installation of IAEA safeguards equipment, and,
- Prevention of damage to, or interference with, IAEA safeguards equipment.

The Fuel and Physics department has overall responsibility for safeguards, as supported by a designated safeguards officer at each of Bruce A and Bruce B.

13.2.2 Past performance

Bruce Power continues to maintain and to foster open communications with the IAEA on safeguards issues.

13.2.3 Future plans

Bruce Power will continue to facilitate Canada's compliance with international obligations through the implementation of a safeguards program and through a close working relationship with the CNSC and the IAEA.

13.2.4 Challenges

None.

13.2.5 Requests

None.

13.3 Operational and design information

13.3.1 Relevance and management

To facilitate Canada's compliance with international obligations, Bruce Power provides the following to the CNSC and/or the IAEA:

- Quarterly updates on safeguards significant activities (dry storage container loadings, dry storage container transfers, cobalt harvest, cobalt shipments, post-irradiated examination shipments, unit outages, flask loadings, flask discharges, etc.); and,
- Updates to the design information questionnaire, upon request from the CNSC.

13.3.2 Past performance

Bruce Power has provided the information as required to facilitate Canada's compliance with international obligations.

13.3.3 Future plans

Bruce Power will continue to provide the information required to facilitate Canada's compliance with international obligations.

13.3.4 Challenges

None.

13.3.5 Requests

None.

13.4 Safeguards equipment, containment and surveillance

13.4.1 Relevance and management

As part of Bruce Power's commitment to support safeguards measures, Bruce Power accommodates the installation and servicing of IAEA safeguards equipment. Procedures are in place to prevent damage to or interference with IAEA safeguards equipment.

13.4.2 Past performance

Bruce Power has provided the necessary accommodation for installation and safeguards of IAEA safeguards equipment.

13.4.3 Future plans

Bruce Power will continue to provide the necessary accommodation.

13.4.4 Challenges

None.

13.4.5 Requests

None.

13.5 Import and export

13.5.1 Relevance and management

The PROL does not authorize the import or export of nuclear substances, nuclear equipment, or nuclear information (including controlled nuclear substances, equipment, or information).

Bruce Power may submit or receive technical data with respect to international vendors competing for, or executing, service contracts. In some cases, that technical data is prescribed by regulation (controlled nuclear information) and therefore requires a licence for import or export.

Therefore, Bruce Power applies for import and export licences if and when required.

13.5.2 Past performance

Not applicable.

13.5.3 Future plans

Preliminary discussions have been held with the CNSC with respect to managing import and export in accordance with a longer-term, multi-destination licence.

13.5.4 Challenges

Not applicable.

13.5.5 Requests

Not applicable.

14.0 PACKAGING AND TRANSPORT

Programs that cover the safe packaging and transport of nuclear substances to and from the licensed facility.

14.1 Package design and maintenance

14.1.1 Relevance

Any packages which are owned by Bruce Power and used for the transport of nuclear substances are maintained by Bruce Power. Standards and processes have been established for all activities related to the purchase, use, and maintenance of radioactive material packages and containers.

Bruce Power does design packages for the packaging and transport of nuclear substances.

14.1.2 Past performance

Bruce Power uses a wide variety of packages. Many of these packages are single-use packages or are packages owned and maintained by other companies.

14.1.3 Future plans

Bruce Power is in the process of procuring a new set of dedicated Type A packages for the transport of contaminated outage tooling.

14.1.4 Challenges

None.

14.1.5 Requests

None.

14.2 Packaging and transport

14.2.1 Relevance and management

Packaging and transport of radioactive material is addressed as an element of Bruce Power's Radiation Protection program. Briefly, Bruce Power processes are used to ensure radioactive material is packaged and transported in a safe and efficient manner, complying with all federal and provincial regulations, as well as CNSC licensing requirements. Radioactive material may be transported on site, between Bruce Power facilities or between Bruce Power facilities and other licensed facilities operated by Ontario Power Generation or Canadian Nuclear Laboratories.

The processes for packaging and transport include the following elements:

- Worker selection and training;
- Classification of material for transport;
- Selection and use of shipping/transfer packages;
- Movement of radioactive material for transport;
- Transport events and emergency response; and,
- Oversight and inspection.

14.2.2 Past performance

Typically, Bruce Power ships 300-500 packages of radioactive material on public roads. Approximately 30-50% of these packages are Type B(U) packages. Each one of these packages has been shipped safely, without a release or dangerous occurrence.

Procedures and processes supporting these shipments ensure strong compliance with transport regulations. The packaging and transport processes are mature and are periodically reviewed for the purpose of continuous improvement. The last CNSC inspection of radioactive transport processes was conducted in 2013 and found no non-compliances.

Bruce Power completed minor updates to the transport processes, primarily with respect to labelling and placarding, to align with changes to *Regulations for the Safe Transport of Radioactive Material* (IAEA; incorporated by reference into the *Packaging and Transport of Nuclear Substances Regulations, 2015*).

14.2.3 Future plans

Bruce Power conducts periodic reviews of the regulations to ensure continued compliance with all relevant regulatory requirements.

Bruce Power plans to make organizational changes to ensure adequate staffing and appropriate support for the MCR and life extension projects.

14.2.4 Challenges

None.

14.2.5 Requests

None.

14.3 Registration for use

14.3.1 Relevance and management

Bruce Power meets the requirement to be a registered user of packages of certified designs, pursuant to the *Packaging and Transport of Nuclear Substances Regulations, 2015*. Specifically, Bruce Power is a registered user of Type B packages.

14.3.2 Past performance

Bruce Power meets the regulatory requirements associated with registration for use.

14.3.3 Future plans

None.

14.3.4 Challenges

None.

14.3.5 Requests

None.

15.0 OTHER MATTERS OF REGULATORY INTEREST

Other Matters of Regulatory Interest include the following Specific Areas (Reference B8, Attachment 1):

- Environmental assessment,
- Cost recovery,
- Financial guarantees,
- Improvement plans and significant future activities,
- Licensee public information program, and,
- Nuclear liability insurance.

For purposes of this licence application, CNSC staff identified the following additional matters of regulatory interest (Reference B8):

- Current lease agreement,
- Reference to regulations by other authorities, as well as permits, certificates, or licences,
- Description of any other activity to be authorized under the operating licence and purpose of that activity;
- Storage and management of booster fuel assemblies at Bruce A, and,
- Information regarding the receipt, storage, and handling of cobalt-60 at Bruce B.

Additionally, Bruce Power has also provided information with respect to the following issues:

- Indigenous engagement,
- Overall strategy for Life Extension
- Physical modifications made as a response to Fukushima,
- Emergency communications systems, and,
- Elements of the licence application package.

15.1 Environmental assessment

15.1.1 Relevance and management

As discussed in Reference B8, an environmental assessment is not required under the *Canadian Environmental Assessment Act*, 2012. CNSC staff have concurred with this assessment (Reference B9), but have informed Bruce Power that the CNSC will conduct an environmental assessment under the *Nuclear Safety and Control Act.*

A reference to the information required by the CNSC to conduct the environmental assessment under the *Nuclear Safety and Control Act* is provided in the cover letter to this application (Reference B10).

15.1.2 Past performance

As CNSC staff will conduct an environmental assessment under the *Nuclear Safety and Control Act*, this section is not applicable.

15.1.3 Future plans

Not applicable.

15.1.4 Challenges

Not applicable.

15.1.5 Requests

Not applicable.

15.2 Cost recovery

15.2.1 Relevance and management

Pursuant to the *Canadian Nuclear Safety Commission Cost Recovery Fees Regulations*, the CNSC recovers the full cost associated with the annual regulatory activity plan associated with the Power Reactor Operating Licence applicable to Bruce A and Bruce B.

For each fiscal year, the CNSC prepares a regulatory activity plan and fee notification. Payments are made quarterly upon receipt of an invoice.

15.2.2 Past performance

Over the last three years, payments to the CNSC to cover the full cost of regulatory activities associated with Bruce A and Bruce B have totaled more than $20 million annually.

Table 18. Actual and estimated CNSC regulatory costs for Bruce A and Bruce B.

Fiscal year	Total
2019-2020 (est.)	$22,488,700
2018-2019 (est.)	$22,047,700
2017-2018 (est.)	$21,615,400
2016-2017	$21,746,800
2015-2016	$22,424,216
2014-2015	$20,684,483

15.2.3 Future plans

Going forward, payments are expected to total approximately $22 million annually (Reference B11).

15.2.4 Challenges

None.

15.2.5 Requests

None.

15.3 Financial guarantees

15.3.1 Relevance and management

No specific guarantees are contemplated under the *General Nuclear Safety and Control Regulations*, Section 3(1)(l). Bruce Power is a financially robust company with income based on multiple operating units, making guarantees unnecessary.

15.3.2 Past performance

Not applicable.

15.3.3 Future plans

Bruce Power will inform the CNSC in writing within forty five days of any drop below Investment Grade of any of the Credit Ratings of BPLP.

15.3.4 Challenges

None.

15.3.5 Requests

None.

15.4 Improvement plans and significant future activities

Improvement plans have been described, as applicable, for each Specific Area.

Significant future activities have been described, for Bruce Power as a whole, in Section 0.4.

The Periodic Safety Review has been described in Section 15.16.1.

15.5 Licensee public information program

15.5.1 Relevance and management

In accordance with the Public Disclosure Protocol and Commitment to Openness Policy, Bruce Power commits to open and transparent communication and to ensuring information is provided in a timely manner to the public, community, stakeholders and organizations with an interest in our operations.

Bruce Power strongly believes it must earn a “social licence” from the neighbouring communities each and every day. The immense support of local communities is key to Bruce Power’s success—and Bruce Power will never take it for granted.

Bruce Power goes to great lengths to maintain open lines of communication with the public. In addition to outreach, Bruce Power will make provide fact-based and verifiable information to anyone who wants to know more about Bruce Power's business. Bruce Power also, without question, conducts its business safely, ethically, respectfully, and professionally.

The Bruce Power Stakeholder Interaction program includes processes for provision of public information which exceed the requirements of RD/GD-99.3, *Public Information and Disclosure*. The Stakeholder Information program ensures consistent standards and processes for all public disclosure of both material and non-material information.

Bruce Power connects with various audiences through a wide variety of communication vehicles and adds new methods when needed to reach new audiences. The primary communication methods include:

- the corporate website,
- social media (Twitter, Facebook, YouTube, and Instagram),
- the Bruce Power app for iPad and iPhone users,
- the "Community Update" print publication,
- electronic newsletters,
- a public visitors' centre,
- media releases,
- stakeholder briefings,
- tours,
- mailings
- sponsorship presentations
- open houses, and
- community events.

In addition, Bruce Power recognizes that its employees have a strong voice in the community and serve as ambassadors for the company and the nuclear industry. Bruce Power keeps employees informed and engaged through employee communications vehicles that include newsletters, an internal website, electronic information screens, monthly "Safety and Business Performance" videos, and "Team Talks" led by senior managers.

15.5.2 Past performance

Bruce Power strives for continuous improvement in regard to its public information program.

Specific improvements since 2014 include:

- Enhancements to the corporate website and electronic newsletters;

- Upgrades of visitors' centre exhibits, with extended summer hours and a successful public bus tour program;

- Launch of www.bepreparedgreybrucehuron.com in 2015, in partnership with agencies and municipalities with an interest in public safety. This website provides residents of Grey, Bruce, and Huron counties with the information they need to prepare for emergencies.

- Distribution of potassium iodide tablets to all residents within a 10-kilometre radius of the site, as per a new mandate from the CNSC. All residents within 50 km were given a voucher for the tablets.

Bruce Power hosted the International Atomic Energy Association Operational Safety Review Team (OSART) Mission in December. Effective communication and engagement, such as the CEO town hall event, was identified as one of ten specific good practices.

15.5.3 Future plans

Stakeholder engagement continues to be a high priority. Currently, and in the near future, the focus of Bruce Power's communications is with respect to licence renewal and with respect to the major component replacement project.

Bruce Power continues to monitor new approaches to engaging the public and continues to add information and interactive features to the Bruce Power app for iPad and iPhone users.

In 2017, Bruce Power will participate in a benchmarking visit to U.S. nuclear plant to review best practices.

Bruce Power continues to enhance communication methods, particularly in the area of social media, in order to reach a wider audience.

15.5.4 Challenges

None.

15.5.5 Requests

None.

15.6 Nuclear Liability Insurance

15.6.1 Relevance and management

The *Nuclear Liability and Compensation Act*, which came into force January 1, 2017, updated Canada's nuclear liability regime in the following ways:

- Increased liability for nuclear operators from $75 million to $650 million, progressively increasing to $1 billion by January 1, 2021;
- Required nuclear operators to maintain insurance for the liability limit, except for uninsurable damages addressed through an indemnity agreement with the Natural Resources Canada. For clarity, commercial nuclear insurance (including approved financial securities) combined with the indemnity provided by the Government of Canada will cover 100% of the compensable damages that an operator may be liable to pay third parties.

15.6.2 Past performance

To comply with the *Nuclear Liability and Compensation Act*, Bruce Power has taken the following actions:

- Secured nuclear liability insurance for $525 million;

- Provided an approved alternate financial security for $125 million; and,
- Entered into an indemnity agreement with Natural Resources Canada.

15.6.3 Future plans

Bruce Power will increase the coverage each year as required to meet the progressive increases to the nuclear liability insurance requirement.

15.6.4 Challenges

None.

15.6.5 Requests

None.

15.7 Lease Agreement

15.7.1 Relevance and management

As discussed in Section 0.1.1, Bruce Power leases the Bruce A and Bruce B facilities from Ontario Power Generation. The lease agreement (Reference B12) demonstrates that Bruce Power has the authority from the owner of the site to carry on the activities to be licensed.

15.7.2 Past performance

Not applicable.

15.7.3 Future plans

Not applicable.

15.7.4 Challenges

Not applicable.

15.7.5 Requests

None.

15.8 Other regulations, permits, certificates, or licences

15.8.1 Relevance and management

The Bruce Power management system ensures compliance with applicable regulations. With respect to environmental regulations specifically, compliance is governed by the Environmental Management program.

A description of the Environmental Management program is provided in Section 9.0. Note that regulatory agencies that govern aspects of Bruce Power's operation include:

- Canadian Nuclear Safety Commission,
- Environment Canada,
- Ministry of Environment and Climate Change,
- Grey Bruce Health Unit,
- Municipality of Kincardine, and,
- Municipality of Saugeen Shores.

Approvals or permits may be required from various regulators for the following:

- Establishing or modifying works that may interfere with navigation (Transport Canada),
- Altering fish habitat, placing fill, altering waterways (Department of Fisheries and Oceans),
- Driving away or exterminating migratory birds (Environment Canada),
- Disposing of Polychlorinated Biphenyls (Environment Canada),
- Establishing or altering a drinking water system (Ministry of Health and Long Term Care),
- Working on shore or on public lands (Ministry of Natural Resources and Forestry),
- Exterminating pests (Ministry of Environment and Climate Change), and,
- Removing or damaging trees (Ministry of Natural Resources and Forestry).

The most commonly required types of environmental regulatory approvals are obtained from the Ministry of Environment and Climate Change for the following activities:

- Taking water in quantities > 50,000 liters or more per day;

- A new or amended Permit to Take Water (PTTW) may be required for new withdrawal point or water taking exceeds limits in PTTW;

- Operating an industrial sewage works (Environmental Compliance Approval, or ECA);

- Operating and Maintaining a PCB Storage Facility (ECA);

- Discharging contaminants into the air or water (ECA, Environmental Activity and Sector Registry, or EASR); and,

- Discharging contaminants into the water (ECA).

15.8.2 <u>Past performance</u>

Bruce Power has obtained the following permits and licences, as applicable to the activities discussed in this document:

- Environmental Compliance Approval (ECA; Ministry of Environment and Climate Change): Bruce Power has an ECA for releases to air, and three additional ECAs for releases to water for each of Bruce A, Bruce B, and the rest of the Bruce site (Centre of Site). A temporary amendment has been obtained for the Bruce A ECA with respect to discharge temperature limits;

- Permits to take water (Ministry of Environment and Climate Change): Bruce Power has separate permits for each of Bruce A, Bruce B, and the rest of the Bruce site (Centre of Site). Bruce Power has two additional permits for the Bruce B pump and treat remediation systems;

- Registration of standby power systems (Ministry of Environment and Climate Change): registration (analogous to a permit or approval) for two off-site mobile standby power systems;

- Licence to operate the Bruce site sewage system (Ministry of Environment and Climiate Change);

- Scientific research licences/permits (Ministry of Natural Resources and Forestry): a licence to conduct creel surveys and obtain fish scale samples in a provincial park, and a permit to collect fish for gas bubble trauma measurements;

- Migratory bird damage or danger permit (Environment and Climate Change Canada): to remove nests and eggs of gulls and geese as necessary in order to establish a safe working environment;

- Two licences for PCB waste storage facilities (Ministry of Environment and Climate Change) at Bruce A and Centre of Site, and registration as a Waste Generator; and,

15.8.3 Future plans

Permits, certificates, or licences will be obtained from the applicable regulator.

15.8.4 Challenges

None.

15.8.5 Requests

None.

15.9 Other authorized activities

15.9.1 Relevance and management

In very general terms, the power reactor operating licence PROL 18.00/2020 authorizes the following:

- Operation of Bruce A and Bruce B;

- Possession and use of the nuclear substances, prescribed equipment, prescribed information, and heavy water, that are associated with operation of Bruce A and Bruce B;

- Possession of booster fuel assemblies at Bruce A; and,

- Production and transfer of cobalt-60 at Bruce B.

Note: The above is intended to be a general description only. The specific authorizations encompassed by the licence and required by the *Nuclear Safety and Control Act* are stated precisely in application (as provided in Reference B10, Attachment A).

At the time this document was prepared, Bruce Power has requested a revocation of Waste Nuclear Substance Licence WNSL-W2-323.06/2017 (Reference B1), which authorizes the following activities carried out on the Bruce site at the Central Maintenance and Laundry Facility:

- Radiological laundry;
- Maintenance of Bruce A and Bruce B equipment which may be contaminated (machine shop); and,
- Maintenance and calibration of portable radiation instruments.

These support activities—which relate directly to the operation of Bruce A and Bruce B—are already authorized by the power reactor operating licence. Therefore, upon receipt of revocation of licence WNSL-W2-323.06/2017, these activities will continue unchanged under the power reactor operating licence PROL 18.00/2020.

Note: For clarity, Bruce Power does not request any authorization beyond authorizations already included in the power reactor operating licence. However, additional Commission approvals have been requested as discussed in cover letter to the application (Reference B10).

15.9.2 Past performance

Not applicable.

15.9.3 Future plans

Not applicable.

15.9.4 Challenges

Not applicable.

15.9.5 Requests

Not applicable.

15.10 Storage and management of booster fuel assemblies

15.10.1 Relevance and management

Enriched nuclear booster fuel is stored at Bruce A booster storage facility.

The booster fuel assemblies have been in long-term dry storage since the late 1990s. The booster fuel assemblies are stored and managed in a manner that ensures physical security and the prevention of criticality under normal and credible abnormal conditions.

15.10.2 Past performance

There were no criticality safety incidents involving the booster fuel assemblies or the booster storage facility over the licence period.

Booster fuel storage is considered a legacy nuclear criticality safety project however it is still considered part of Bruce Power's nuclear criticality safety program albeit in a "parked" state. Any changes to current storage status could invoke BP-PROC-00324 processes depending on the nature of the change.

15.10.3 Future plans

There are no planned changes to the storage or handling of the booster fuel assemblies.

15.10.4 Challenges

None.

15.10.5 Requests

None.

15.11 Receipt, storage and handling of Co-60

15.11.1 Relevance and management

Cobalt adjuster rods are used in the Bruce B reactor cores to aid in neutron flux flattening. The adjusters, which are owned and supplied by Nordion, are made of Cobalt-59. This non-radioactive isotope is converted to radioactive cobalt-60 with neutron irradiation.

After 1 to 2 years of irradiation in the reactor core, adjuster rod bundles are removed and shipped to Nordion for processing and industrial use. The spent cobalt is also returned from Nordion to Bruce B for long-term storage.

Bruce Power has a formal process for the receipt, storage, and handling of cobalt. Briefly, cobalt adjusters are treated in a similar manner to fuel. Irradiated cobalt is winched directly into a flask and stored in the secondary irradiated fuel bay. The adjuster rod is disassembled into bundles, loaded into a carrier, placed in a shipment flask, and shipped to Nordion. Flasks are opened under water for safety.

All cobalt moves are closely controlled and monitored, with activities shared between operations, maintenance, and engineering workers.

15.11.2 Past performance

Cobalt is safely removed from reactor cores during scheduled reactor maintenance outages.

The total amount of cobalt shipped off-site is shown in Figure 26.

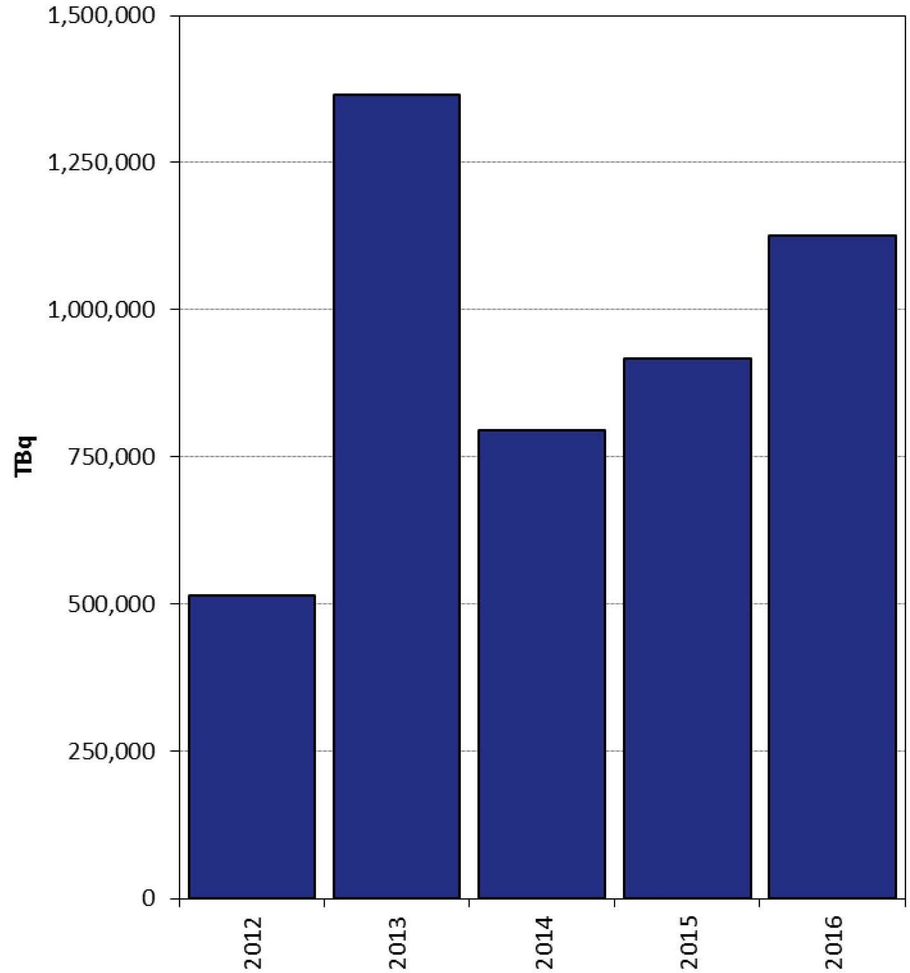


Figure 26. Annual shipments of cobalt-60 (TBq).

15.11.3 Future plans

Shipping and receipt of cobalt-60 will continue in alignment with scheduled maintenance outages, shipping campaigns, contractual requirements, and regulatory requirements.

15.11.4 Challenges

None.

15.11.5 Requests

None.

15.12 Indigenous engagement

15.12.1 Relevance and management

The Bruce Power site lies within traditional Indigenous territory. Bruce Power routinely engages with all three local Indigenous communities: the Chippewas of Nawash Unceded

First Nation and Chippewas of Saugeen First Nation who together form the Saugeen Ojibway Nation (SON), the Métis Nation of Ontario (MNO), and Historic Saugeen Métis (HSM). As such, Bruce Power continues to:

- Build and maintain a positive, long term relationship with local Indigenous groups or communities that are based on mutual understanding, respect and open and honest communication;
- Develop strategies in several key areas including employment, business development, education, training and community sponsorship that appropriately reflect the interests of Indigenous peoples;
- Enter into appropriate relationship/protocol agreements with local Indigenous groups and communities who wish to be informed and involved with the key areas of our business;
- Conduct timely and meaningful consultation with Indigenous groups and communities whose Treaty or Indigenous rights may be directly affected by elements of our operations.
- Enhance our employees understanding of Indigenous history and culture and the role Indigenous groups and communities play in Canada and in our communities; and,
- Identify opportunities to increase our knowledge of the local environment and ways we can work together with Indigenous groups or communities to preserve or enhance that environment for all to enjoy.

Bruce Power has an Indigenous Policy that has been in place since 2012. The policy outlines Bruce Power's commitment to developing and maintaining positive relationships with Indigenous communities, with a particular focus on the local communities who share traditional territory in the vicinity of the Bruce site. The policy directs Bruce Power to work on strategies that focus on employment, education, training, community sponsorship, and business development with the local Indigenous communities.

Since 2012, Bruce Power has formal relationship/protocol agreements in place with all three communities. These agreements provide the framework for engagement, consultation, and collaboration between Bruce Power and each community. Each agreement provides for meaningful routine discussion, information sharing, and annual funding, as well as a mechanism to discuss funding (beyond annual funding) to ensure meaningful participation for each community. The agreements also set out a process to collaborate in several areas including: training, employment, and business development. The scope of the relationship agreement includes consultation on any regulatory approvals as defined in the REGDOC-3.2.2, *Aboriginal Engagement*. These agreements are confidential but provide the foundation on which we continue to work together.

Overall, Bruce Power interactions with Indigenous groups are governed by the Stakeholder Interaction program (Section 15.5.1), which ensures that Bruce Power identifies stakeholders, understands their interests and requirements, and provides appropriate levels of communication according to a defined disclosure protocol.

Bruce Power is committed to treating its stakeholders with openness and respect. Regularly scheduled meetings develop and maintain positive working relationships with First Nations and Métis communities.

Bruce Power tracks and analyzes developments that occur within an international, national, and local context that may impact relationships with local Indigenous communities. This ensures that Bruce Power is a leader in Indigenous relationship building and fulfills its social responsibilities.

Elements of the Stakeholder Interaction program include:

- Indigenous education and work experience opportunity: Bruce Power provides a tuition scholarship for ten students in educational programs (power engineering, administrative, police foundations, and radiation protection), along with a future work experience and internship placement at Bruce Power.

- Indigenous internship program: Bruce Power assists Indigenous candidates in the internship program by providing one-on-one support and mentorship to ensure candidates for administrative assistant and shift control technician internships meet the qualifications and are successful during interviews. Bruce Power additionally provides ongoing support to those seeking assistance in applying for employment at Bruce Power.

- Summer student program: Bruce Power has two student programs that offer both development opportunities and exposure to trades-type of work during the summer months. Bruce Power also has a high school co-operative work program.

- Training, employment, business opportunities working group: a joint forum established to address the barriers faced by SON members in accessing employment, training, and opportunities within Bruce Power.

- Indigenous relations working group: an internal working group composed of individuals from the corporate affairs, environment, regulatory affairs, law, human resources, and supply chain divisions. This working group meets monthly.

- Indigenous awareness training: an element of Bruce Power's management and leadership training includes awareness of local Indigenous groups, Indigenous rights, legal requirements for Indigenous consultation, and the importance of engaging local Indigenous groups early and often in the planning and implementation of projects.

With respect to this licence renewal application, Bruce Power is committed to having open, transparent, and regular two-way communications with Indigenous communities. In late 2015, upon receipt of the long term agreement with the IESO, Bruce Power began dialogue with the Indigenous communities about the upcoming life extension. This dialogue continues.

Given this active dialogue, Bruce Power is always seeking feedback and addressing questions from the communities. This outreach effort is always enhanced prior to, and during, the CNSC process for renewal of the operating licence.

The licence application supports the extension of an existing license. The scope of the renewed licence includes life extension activities and ongoing operations, both of which have been the subject of numerous consultation processes over the last 15 years.

Bruce Power has taken input from past consultations into account during this process. Given the unique interests and topics raised by Indigenous communities, a review was conducted of feedback provided during the following:

- Restart of Units 3 and 4 at Bruce A (2002)
- Refurbishment of Units 1 and 2 at Bruce A (2005)
- Application for licence renewal for Bruce A and B (2009)
- New Build Project (2009; project subsequently withdrawn)
- Steam generator shipping project (2010), and,
- Application for licence renewal for Bruce A and B (2015).

The purpose of this review was to ensure all items of concern, where applicable, would be addressed within the licence package (i.e., within the Environmental Risk Assessment).

In addition to the review of concerns related to Bruce Power's direct operation of the facility, a review of additional concerns related to ongoing and proposed projects within the Bruce site proper was completed, including:

- Deep Geological Repository (2013-205), and,
- Application for licence renewal for Western Waste Management Facility (2017).

The purpose of this broader review was to understand the broader scope of concerns by Indigenous Communities in relation to the Bruce site, to determine whether common concerns have arisen, and to identify opportunities to work together with our industry colleagues as well as indigenous communities (see the Environmental Risk Assessment). For example, Bruce Power and the Métis Nation of Ontario have re-emphasized discussions on understanding the Métis way of life after concerns were raised during the licence renewal process in 2015. In addition to considering these previous submissions, Bruce Power will continue to engage with SON, MNO, and HSM through the protocol agreements.

15.12.2 <u>Saugeen Ojibway Nation Community Rights and Interests</u>

The Saugeen Ojibway Nation and its members describe themselves as follows (Reference B13):

> "The Saugeen Ojibway Nation ('SON') and its members are the Aboriginal people of the Grey and Bruce region, which they know as the Anishnaabekiing. SON is comprised of the Chippewas of Nawash Unceded First Nation and the Chippewas of Saugeen First Nation. The lands that comprise SON Traditional Territory extend east form Lake Huron to the Nottawasaga River and south from the northern tip of the Saugeen Peninsula (also known as the Bruce Peninsula) to the Maitland River system, eleven miles south of Goderich. The waters that comprise SON Traditional Territory are the waters surrounding these lands and include the lakebed of Lake Huron from the shore to the international boundary with the United States and the lakebed of Georgian Bay to halfway across the Bay. The SON communities occupy large, unceded communal lands (reserves) bordering Lake Huron and Georgian Bay and SON also has exclusive use of a large hunting reserve in the northern part of the Saugeen Peninsula."

SON and its members describe themselves as having "Aboriginal and Treaty rights throughout the SON Territory and [continuing] to rely on their Territory today as they have for countless generations."

Additionally, SON asserts "that its rights include, but are not limited to:

- The right to continue to be a distinct people living within their Traditional Territory;
- The right to maintain their culture, language and way of life;
- The right to be sustained by the lands, waters and resources of their Traditional Territory;
- The right to the exclusive use and occupation of their communal lands;
- The right to continued use of all of their Traditional Territory;
- The right to harvest for sustenance, cultural and livelihood purposes;
- The right to be meaningfully involved in decisions that will affect their Traditional Territory so that they can protect their way of life for many generations to come and;
- The right to be the stewards of their Traditional Territory.

"SON has a proven and exclusive Aboriginal and Treaty Right to a commercial fishery in the waters of Georgian Bay and Lake Huron, within SON Territory, including the waters adjacent to Bruce Nuclear site. Members of SON and their ancestors have been fishing these waters for sustenance and as the basis of trade and commerce for many hundreds of generations, and they continue to do so today."

15.12.3 Métis Nation of Ontario Community Rights and Interests

The MNO has 29 Community councils across the province. Three of these councils (Moon River Métis Council, Georgian Bay Métis Council, and the Great Lakes Métis Council) represent the regional rights-bearing Métis community defined as the Georgian Bay Traditional Territory, which includes the area surrounding the Bruce site.

The MNO and its members describe themselves as follows (Reference B14):

> "The MNO was formed in 1993 as a representative organization with the objective to protect, assert and support the distinct culture, traditions, economic well-being, and Métis constitutional rights embodied in the *Constitution Act, 1982*, section 35, within the Métis Homelands of Ontario…
>
> "The MNO and their Regional Consultation Committee assert that their people exercise Aboriginal rights throughout the territory surrounding the Bruce site, including, among other things, hunting, fishing (food and commercial), trapping (food and commercial), gathering, sugaring, wood harvesting, use of sacred and communal sites (i.e., incidental cabins, family group assembly locations etc.) and use of water."

15.12.4 Historic Saugeen Métis

The Historic Saugeen Métis describes themselves as follows (Reference B15):

> "The local Historic Saugeen Métis (HSM) consists of the politically independent historic Métis, beginning with trader Pierre Piché in 1818, whom have resided along the Lake

Huron proper shoreline from the islands at the tip of the Bruce Peninsula to the Ausable River in the vicinity of Port Franks, Ontario.

"Upon Piche's arrival in the traditional Saugeen territory in 1818 the Ojibwe Piché 'dish with one spoon' bead wampum exchange took place inviting the Piché Métis trading family into the traditional Saugeen territory.

"About the same time Piché was joined by other similar Métis trading families comprised of third and fourth generation members of existing Great Lakes trading networks. Also arriving were trading families from the Northwest who after the NWC/HBC merger in 1821 entered Lake Huron either as HBC employees or former NWC traders trading on their own account.

"From these distinct groups emerged a distinctive Métis community rooted along the shoreline of eastern Lake Huron. For almost three decades prior to settlement of the Saugeen territory, the Historic Saugeen Métis traded in a southnorth axis along the shoreline from above Sarnia to Lake Huron's North Shore.

"Present-day Historic Saugeen Métis community members are descendants of the historic Métis who have lived in, cared for and relied on the shared traditional Saugeen territory since the time of Piché. Some Historic Saugeen Métis Council (2015) and community members descend from the Piché Wampum carrier, Marguerite Lange Gonneville, and other Métis families of that era."

The HSM are concerned with ensuring the safe operation of the Bruce nuclear site and minimizing any impacts on the waters and lands that support their asserted Aboriginal rights. The HSM continue their subsistence fisheries and land-based harvesting practices and assert Aboriginal rights over the lands and waters surrounding the Bruce nuclear site.

The HSM indicate that these lands and waters "provide vital support for [their] Métis culture and way of life, as well as the economy, health and social relationships in the HSM community", and that it is their obligation to ensure a sustainable environment for current and future Métis Families claiming s. 35 Aboriginal rights in the traditional Saugeen territory (Reference B15).

The HSM indicate that they "rely on the lands that include the Bruce site and surrounding area to harvest deer and other mammals, water and land fowl, and plants." According to the HSM, many "community members reside within a few kilometres of the [Bruce] site" or in Southampton (35 km from the site), and "HSM ancestors are buried within a very short distance of the site" (Reference B15).

The HSM acknowledges that Bruce "continues to provide countless opportunities for employment, high-skilled jobs for local Métis" and that "nuclear generation is the safest, cleanest, most reliable source of energy available (Reference B15).

15.12.5 Concerns Raised

During the 2015 licence renewal hearing for the Bruce A and B nuclear generating stations, the SON, MNO, and HSM each highlighted concerns in relation to the Bruce site. Additionally, all three communities have provided input into various licensing processes over the years. Bruce Power is committed to continuing to discuss pertinent issues with the Métis and

First Nation communities, as well as furthering our understanding of their way of life and rights.

15.12.6 Past performance

Bruce Power has raised workforce awareness of the history and culture of the local communities and understanding their perspectives when it comes to environmental awareness. Bruce Power's commitment to the Aboriginal Policy has resulted in a robust and multifaceted approach to fulfilling our obligations and undertakings with SON, MNO, and HSM.

Bruce Power holds gold certification (the highest) from the Canadian Council for Aboriginal Business (CCAB) for excellence in Progressive Aboriginal Relations. Certification is achieved through outcomes and initiatives in employment, business development, community investment, and community engagement, as reviewed by a jury of Indigenous business people. Gold-level certified companies are good business partners, great places to work, and are committed to prosperity in Indigenous communities. This is the highest level of recognition offered by the CCAB, and Bruce Power is one of only fifteen gold-certified companies in Canada.

In 2013, Bruce Power founded an Aboriginal Network (AbNet) to connect Indigenous employees in order to share Indigenous culture and to promote their involvement in the success of Bruce Power.

In 2015, Bruce Power and the CCAB announced an initiative in which suppliers are encouraged to become CCAB members and to adopt policies that including strong Indigenous components.

In 2016, Bruce Power held an inaugural Indigenous employment and business forum, with representatives and information booths from Bruce Power, unions, and suppliers. Approximately 150 local Indigenous people attended and learned about careers in Ontario's electricity sector.

15.12.7 Future plans

Bruce Power is focusing on involving Indigenous people in the economic spin-off activities of plant operations and the major component replacement project. Bruce Power is committed to contracting with Indigenous companies directly, as well as working with vendors to hire, train, and employ Indigenous people.

With the guidance of members from the Indigenous relations team, Bruce Power is developing an Indigenous score card for vendors. Key performance indicators will be used to evaluate vendor commitment to hiring Indigenous employees, sub-contracting with Indigenous businesses, or creating joint ventures with Indigenous people and communities. Bruce Power is developing a template for requests for proposals which will include an Indigenous hiring, employment, and joint-venture bonus structure that is consistent with the key performance indicators.

Bruce Power acknowledges the interests highlighted by each group and has worked over the years through the protocol agreements and routine meetings to improve and strengthen relationships. While much has been accomplished over the recent years with respect to these relationships, further understanding through routine interactions and constructive dialogue will maintain this progress. Bruce Power remains committed to building meaningful relationships with each of the Indigenous communities while complying with regulatory requirements.

15.12.8 Challenges

All three local Indigenous communities are challenged for time and capacity, given the number of other organizations and companies that also engage with these communities.

Licence renewal and the major component replacement project will result in increased consultation by Bruce Power, which will further increase the amount of time required from Indigenous communities.

15.12.9 Requests

None.

15.13 Overall strategy for Life Extension

15.13.1 Relevance and management

In 2005, Bruce Power entered into an agreement with the Independent Electricity System Operator to refurbish Bruce A, Units 1 and 2. This resulted in the return of the eight-unit site to full operating capacity in 2012.

In 2015, Bruce Power entered into an amended agreement to extending the operating life of Units 3 through 8. This allows the province of Ontario to secure, on a long-term basis, the full capacity of the Bruce site.

Bruce Power has committed to extending the operating life of Units 3 through 8 over an 18-year period (2015-2033), through life extension activities that include replacement of major components. Note that refurbishment of units 1 and 2 at Bruce A already achieved a 25-year life extension for those units.

Life extension activities are separated into asset management and major component replacement (MCR) activities. Asset management includes the ongoing maintenance or refurbishment activities necessary to extend the life of components. Major component replacement includes replacement or refurbishment—beyond that expected in a planned maintenance outage—of steam generators, primary heat transport feeders, fuel channel assemblies, and other components.

Therefore, life extension of Units 3 through 8 includes routine maintenance outages (that include asset management activities) as well as targeted MCR activities. As of 2016, Bruce Power has already invested in life extension activities (asset management activities carried out during routine maintenance outages) to support safe and reliable operations. However, MCR activities will begin in 2020.

Bruce B, Unit 6, will be the lead unit for a Life Extension Outage and for MCR project execution, as shown in Table 19. Each Life Extension Outage is planned to last approximately 4 years.

Table 19. Planned Life Extension Outage/MCR project start dates (subject to change).

Unit	Start date
Unit 6	2020
Unit 3	2023
Unit 4	2025
Unit 5	2026
Unit 7	2028
Unit 8	2030

MCR activities have been divided into nine different project areas:

- Program controls and support: includes the MCR Project Controls Office (PCO) and the program support organization. The PCO provides estimating, scheduling, cost-controlling, budget forecasting, risk assessment, reporting, and change control support services to the MCR project teams. PCO ensures that a standard project management approach is applied, and that the projects are aligned with industry best practices.

- Pressure tube replacement: replacement of fuel channels, calandria tubes, and associated components nearing end-of-life.

- Steam generator replacement: removal and replacement of steam generator cartridges and steam drums, as well as reconnection of steam generator assemblies.

- Feeder replacement: replace of 960 feeders per unit, from the Grayloc to the primary heat transport header nozzles.

- Lead-in/lead-out: includes bulkhead installation and draining of the primary heat transport system and moderator. Lead-in will safely transition the unit from an operational state to one that allows for the main life extension activities to be executed. Lead-out will safely transition the unit back to an operational state. Lead-in and lead-out will be the same for all units.

- Facilities and infrastructure: provision of the additional necessary facilities and infrastructure, including a number of on-site new builds, extensions, and renovations, as well as off-site new builds. Additional or refurbished office space, amenities, warehousing, parking, mock-up facilities, and information technology are required to support the MCR project. A centralized office complex is planned to be constructed across from the Bruce Power Visitors' Center.

- Balance of plant: includes core projects that are required for life extension or that take advantage of the longer Life Extension Outage duration;

- Waste management: ensures proper sorting, segregation, and disposal of all radioactive and non-radioactive waste generated by the MCR projects.

- Project demobilization: as with waste management, ensures proper sorting, segregation, and disposal of all radioactive and non-radioactive waste generated by the MCR projects.

The planned Unit 6 MCR schedule is shown in Figure 27.

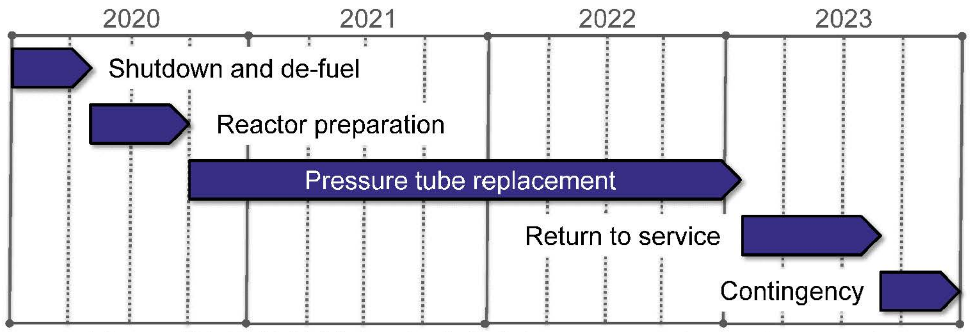


Figure 27. Unit 6 MCR schedule (steam generator replacement will be carried out during the pressure tube replacement window).

MCR activities will be executed by a Major Projects organization led by the Vice President, Major Projects, reporting to the Executive Vice President, Projects. Senior program managers are responsible for each of the above project areas report to the Vice President, Major Projects, as well as the division manager for project management, the MCR engineering support manager, and the department manager for construction. However, the MCR organization structure may evolve through the various phases of the Unit 6 Life Extension Outage.

The Life Extension Division has been formed to support the MCR organization in effectively implementing MCR projects. The mandate of the Life Extension Division is to define operational requirements and interfaces to ensure the successful preparation and execution of Life Extension Outages in a seamless manner through integration with Bruce Power procedures and standards. The Life Extension Division will assume accountability for overall outage performance including safety, regulatory compliance, quality, timeliness, and cost, while also providing oversight and direction during the preparation and execution of the outages. Strong teamwork, aligned purpose, and the lessons learned from Darlington's refurbishment program as well as other international refurbishment activities, will ensure that Bruce Power is successful in delivering its multi-year life extension program, allowing the site to operate to 2064 and beyond.

15.13.2 Past performance

In January 2016, Bruce Power informed the Commission of its intent to extend the operational life of Bruce A, units 3 and 4, and Bruce B, units 5 through 8 (Reference B16).

As discussed above, life extension activities began in 2016.

Bruce Power has conducted a periodic safety review, which will be provided under separate cover with record number NK21-CORR-00531-13543 / NK29-CORR-00531-14165.

Bruce Power has applied for and obtained licences to import and/or export controlled nuclear information, as required to support the life extension activities.

Bruce Power proposed a pressure boundary registration strategy for the fuel channels, calandria tubes, and feeders for the Bruce B Life Extension Outages (Reference B17; Bruce Power plans to provide additional information to respond to Reference B18.)

15.13.3 Future plans

Bruce Power's focus is continuous improvement of ongoing and future life extension activities. A database for lessons learned has been implemented to improve the efficiency of executing future Life Extension Outages (subsequent to the Unit 6 Life Extension Outage).

15.13.4 Challenges

A significant number of approvals by CNSC staff will be required for pressure boundary and other issues, in accordance with the Power Reactor Operating Licence.

15.13.5 Requests

None.

15.14 Physical modifications made as response to Fukushima

Bruce Power developed enhancement plans in response to the Fukushima incident. Subsequently, the CNSC issued a set of Fukushima Action Items. Since that time, Bruce Power has provided regular updates to the CNSC on its enhancement plans, in alignment with the Fukushima Action Items.

The enhancement plans included physical modifications to the nuclear generating stations and supporting facilities. The enhancements include:

- Short-term enhancements (strengthening defence-in-depth) to provide maximum safety benefits in the shortest time;
- Longer-term enhancements (strengthening defence-in-depth) that required completion of relevant analyses, assessments, and modifications; and,
- Enhancements to emergency response facilities and processes.

The relevant physical modifications are listed in Table 20, including the location (by station or unit) and final in-service date. (Multi-unit modifications may have been completed in some units prior to the final in-service date for all units.)

Table 20. Physical modifications made as a response to Fukushima, including station or units and final in-service date for installed modifications.

Modification	Station/units	Date
Short-term actions to provide make-up water		
Installation of dry hydrants	AB	2012
Redundant EME connections to steam generators	AB	2013
Redundant EME connections to irradiated fuel bays	AB	2013
Procurement of Emergency Mitigating Equipment	n/a	2012
Strengthening defence in depth		
Additional provisions for make-up water		
EME connection to Primary Heat Transport System	5	2017
EME connection to Moderator System	5	2017
SAMG connection to Primary Heat Transport System	12345678	2016
SAMG connection to Moderator System	12345678	2016
SAMG connection to Shield Tank	12345678	2016
Installation of Shield Tank overpressure protection	5[1]	2017
Wide-range ECI sump level indication	A	TBD
External power supply enhancements		
Procurement of portable generators, cables, trailers	AB	2011
Installation of receptacle panel for quick connections	AB	2012
Connecting quick-connect panel to QPS/EPS buses	AB	2012
Passive filtration for containment		
Installation of containment venting connection point	AB	2016
Installation of filtered containment venting system	AB	TBD
Passive Autocatalytic Recombiners	0A12340B5678	2015
Enhancing emergency response		
New Emergency Management Centre (EMC)		
Commissioning of new state-of-the-art facility	n/a	2014
Procurement of mobile emergency centre	n/a	2013
Backup power for emergency facilities and equipment		
Portable generator for EMC	n/a	2014
Fuel delivery truck, portable generator for fuel transfer pumps	n/a	2012
Communications upgrades		
Radio and satellite phone upgrades at EMC and CMLF	n/a	2014
Installation of VSAT at EMC	n/a	2014
Offsite monitoring capability		
Installation of remote gamma monitors	n/a	2014
Installation of remote aerosol monitors	n/a	2015

Note 1: installation was partially completed.

15.14.1 Emergency make-up water standpipes (dry hydrants; complete)

This enhancement involves installation of emergency water standpipes (dry hydrants) to draw water from the Condenser Cooling Water outfall via Emergency Mitigating Equipment (EME) firewater pumps. These suction points allow for quick connection of the supply of sufficient water to support water requirements from EME for all the demands discussed below.

15.14.2 Redundant EME connections to steam generators (complete)

This enhancement involves three separate but related modifications:

- Installation of redundant quick-connect couplings to allow emergency water to be added to the steam generators of each unit through the Emergency Boiler Cooling system (Bruce A) or Emergency Water System (Bruce B);

- Installation of redundant quick-connect couplings to allow emergency water to be added to the steam generators of each unit through the Inter-Unit Feedwater Tie; and,
- Installation of air to open the Boiler Safety Relief Valves to allow the steam generators and heat transport system to be rapidly depressurized in the event it is required.

15.14.3 Redundant EME connections to irradiated fuel bays (complete)

This enhancement involves several related modifications:

- Installation of make-up piping to allow emergency water to be introduced to the primary irradiated fuel bay;
- Installation of make-up piping to allow emergency water to be introduced to the secondary irradiated fuel bay; and,
- Construction of irradiated fuel bay guard posts (bollards) for suction standpipes.

15.14.4 Procurement of Emergency Mitigating Equipment (complete)

Emergency water can be provided by means of mobile pumpers (fire trucks) which draw water from the Condenser Cooling Water (CCW) outfall via dry hydrants and deliver it to the steam generators, irradiated fuel bays, and other systems as required. Two trucks are dedicated to each of Bruce A and Bruce B, with one spare. A fuel truck has also been procured which is capable of delivering fuel to the pumpers as well as the portable generators.

The emergency mitigating equipment also includes two 400 kW generator for Bruce A and seven 100 kW generators for Bruce B. The 400 kW generator can be deployed using a fifth wheel truck whereas the 100 kW generators have a standard tow hitch for easy deployment. Equipment capable of deploying the EME and clearing debris from the pathway is available on site.

15.14.5 Makeup water to Primary Heat Transport, Moderator System, and Shield Tank (ongoing)

This project is intended to provide complementary design features which allow emergency makeup water to be added to the primary heat transport systems and moderator systems. The water is provided by portable EME pumps which are stored at a higher elevation in a building adjacent to the site.

This enhancement includes the following:

- Installation of EME quick-connect couplings to allow emergency water to be added to the Primary Heat Transport system of each unit (complete in Unit 5);
- Installation of EME quick-connect couplings to allow emergency water to be added to the Moderator System (calandria) of each unit (complete in Unit 5);
- Deployment of SAMG connection hardware and tooling (toolkits) to allow emergency water to be added to the Primary Heat Transport system, Moderator System (calandria), and Shield Tank in each unit (complete at Bruce A and Bruce B); and,

- Installation of overpressure protection for the Shield Tank (partially complete in Unit 5).

Enhanced shield tank overpressure protection will prevent Shield Tank overpressure failure in the extremely unlikely event of a severe accident which has degraded to the point where the Shield Tank is acting as the primary heat removal medium.

Installation of the Shield Tank overpressure protection was partially completed in Unit 5. The installation was not completed due to the detection of an unanticipated concentration of hydrogen gas. As a consequence, the installed piping prior to the Shield Tank connection was left in a safe state; installation in Unit 5 will resume in 2019. A new purging tool has been designed and is intended to be utilized in subsequent outages for the remaining units.

15.14.6 Bruce A Wide Range Emergency Coolant Injection Sump Level Indication (ongoing)

In response to a beyond design basis accident that results in a loss of heat sink, Bruce Power could add water to the reactor core to prevent fuel melting or to stabilize the accident if core failure has already occurred. Knowledge of the water level inside containment is required to ensure that containment is not breached due to excessive water level in the fuelling machine duct, which runs beneath the reactor units. Adequate level indication can also be used to ensure that any molten corium that has relocated to the concrete floor remains covered, thereby mitigating the corium/concrete interaction. The existing level transmitter has inadequate span for this purpose; this enhancement will upgrade the level transmitter to increase its range.

15.14.7 External power supply enhancements (complete)

This enhancement involves a set of modifications intended to supply emergency electrical power, via existing common Qualified Power Supply (Bruce A) or Emergency Power Supply (Bruce B) buses, to critical reactor control instrumentation and monitoring loads, Secondary Control Area services, Main Control Room and Control Equipment Room selected lights, Emergency Coolant Injection D_20 valve operation, and the Emergency Filtered Air Discharge System through:

- Procurement of new portable generators, associated cables, and deployment trailers;
- Installation of a receptacle panel to allow the quick connection of cables to provide power from one of the generators; and
- Installation of cables connecting the quick-connect panel to the existing Qualified Power Supply buses.

15.14.8 Passive containment filtered venting system (ongoing)

This enhancement will provide a completely passive system for filtration of releases from containment. A conceptual design has been selected, but a detailed design and the installation schedule have not been determined at this time. However, a containment venting connection point has been installed at Bruce A and Bruce B and may provide additional flexibility for installation without the need for a station containment outage.

For additional information, see Section 4.3.2.

15.14.9 Passive Autocatalytic Recombiners (complete)

This enhancement provides completely passive equipment for removing hydrogen from containment, in order to reduce the risk of a hydrogen explosion in the event of a severe accident.

15.14.10 Emergency Management Centre (complete)

This enhancement includes the following:

- Construction of a new state-of-the-art Emergency Management Centre, and,
- Procurement of a mobile emergency centre to act as the command and control center in the event of a nuclear emergency.

15.14.11 Backup power for emergency facilities and equipment (complete)

This enhancement involves procurement of the following:

- Portable generator for the Emergency Management Centre,
- Fuel delivery truck to supply fuel to portable generators, and,
- Portable generator for fuel transfer pumps.

15.14.12 Communications upgrades (complete)

This enhancement includes the following:

- Upgrades to communications infrastructure and installation satellite phone capability on-site as well as at the new Emergency Management Centre;
- Installation of a Very Small Aperture Terminal (VSAT) system at the Emergency Management Centre to provide multiple backup phone hubs and internet connectivity.

These upgrades enhance the connectivity between the Emergency Management Centre and station Emergency Operations Center (EOC) as well as external agencies.

15.14.13 Offsite monitoring capability (complete)

Bruce Power has installed an off-site radiation monitoring system, which minimizes the need for manual off-site data collection by workers. This enhancement involved the installation of 44 gamma spectrometers (as well as 10 additional deployable units that can augment the current system) and 8 aerosol monitors to augment the current system at off-site locations. This enhancement increases data reliability and reduces the staffing burden in an emergency.

15.15 Emergency communications systems

15.15.1 Background

After the severe natural event at Fukushima Daiichi Nuclear Power Plant in 2011, Bruce Power conducted an extensive review of the response to the event to learn lessons that might have application to the Bruce Power nuclear generating stations. Cuclear generating stations are designed to be robust against significant external events. However, after review of the Fukushima Daiichi event, it was concluded that additional provisions should be implemented in preparation of the possibility of these very rare, extreme events.

As a result, Bruce Power implemented additional equipment such as back-up power and coolant water capabilities to support plant operations, as well as additional processes to support emergency response in the very unlikely circumstance that such an event should occur.

As part of these enhancements, emergency communications were reviewed. To ensure an effective approach, Bruce Power considered the Communications Interoperability Strategy for Canada (CISC) that ensures a robust system is established utilizing the following criteria:

- Operability: the ability of emergency personnel to establish and sustain communications in support of mission operations;

- Interoperability: the ability of emergency personnel to communicate and share information and data between organizations on-site, and also with external agencies using a variety of systems; and,

- Continuity of communications: the ability of emergency response agencies to maintain communication in the event of loss of infrastructure.

Following an approach that ensures consistency in policy, equipment and technology, training, and best practice, Bruce Power first established the base infrastructure from which enhancement progress could be made. This staged approach iprovides a process that fully tests effectiveness before implementation and moving on to the next enhancement. To date, Bruce Power has completed several enhancements with more planned for completion in 2017 and beyond, as discussed below.

During an emergency, the ability to effectively communicate information can be a critical aspect of the response to ensure emergency responders maintain capability to exchange information via data, voice, video, on demand or in real-time, to complete missions. Therefore, Bruce Power conducted an initial review beginning in 2011 that considered the following activities as part of the communication need:

- Notification of government agencies,
- Provision of situational awareness information,
- Coordination of site response and support,
- Understanding of the status of plant equipment outside the plant, and,
- Provincial and municipal emergency response.

Prior to 2011, site communication capabilities included several options, but all options depended, at least in part, on local infrastructure in order to be successful. One of the lessons learned from the Fukushima Daiichi event was that local infrastructure may be severely impaired as a result of an extreme natural event. With this knowledge, Bruce Power worked to initiate a multi-staged project that focused on a sustainable approach to interoperability communication enhancements on site, as well as with external agencies at all times, even during large scale infrastructure outages. This work was designed to meet the following requirements:

- Provide timely, accurate information;
- Maintain communication capability in the absence of local power and communications infrastructure;
- Minimize complexity by providing a single system suitable for all events, including the provisions for back-up capability;
- Provide the same information and data shared internally among all site emergency facilities and to all external agencies; and,
- Minimize time required by operations and emergency response staff to support communication of information and data.

15.15.2 Facilities

Bruce Power maintains a number of emergency response facilities to enable effective response to any and all emergencies. Facilities range from Emergency Operations Centers located within the nuclear generating stations to the Emergency Management Center located off-site. Appropriate back-up facilities are also in place to provide continuity in managing a response, if for any reason the primary facility is unavailable for use.

Bruce Power maintains VSAT technology and back-up power to ensure a back-up communication system is in place and operable at all times. VSAT provides satellite connectivity to ensure multiple phone hubs and internet connectivity are in place and operable when primary systems are not available.

Emergency Management Centre

Bruce Power maintains the Emergency Management Centre (EMC), which is located approximately 1 km from the Bruce site. The primary purpose of the EMC is to provide emergency response support to the stations. This includes communication with external agencies and additional support or resources, such that the stations are able to focus solely on plant response. The EMC is geographically separate from the site and maintains a VSAT satellite uplink for phone, fax, and internet, as well as radio, servers for software operation, and back-up power to support sustained operations during infrastructure outages.

Emergency Operations Centre

Bruce Power maintains an Emergency Operations Centre (EOC) within each nuclear generating station next to the control room. The primary purpose of the EOC is to focus on plant response requirements, such as initial notifications, deployment of Emergency Mitigating Equipment, and other response requirements within the station.

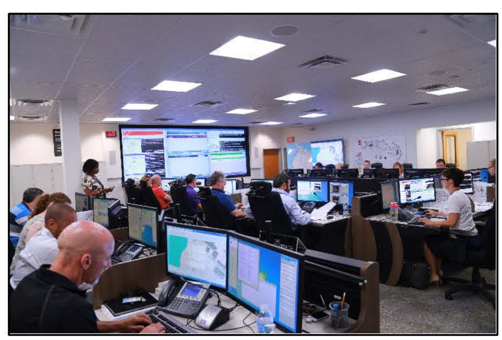


Figure 28. Bruce Power Emergency Management Centre

Once the EMC is activated and becomes operational, it supports the EOC by assuming activities such as communication with external agencies and providing additional support to the plant such that the EOC is able to solely focus on plant response.

In 2017-2018, implementation of a VSAT satellite uplink for phone, fax, and internet within the station EOCs will be completed. Additional considerations for secondary control areas located within the nuclear generating facilities are also being investigated. This work is following a staged approach so that each enhancement is planned, installed, and tested prior to moving to the next phase. The EOC communications upgrades will provide a solid foundation to support a new, robust data transfer process, ensuring its availability even during large-scale events when plant systems and environments could be challenged, as discussed further below.

Mobile and Alternate Emergency Management Centers

Bruce Power maintains a Mobile EMC, as well as Alternate EMC locations in both the Town of Saugeen Shores and the Municipality of Kincardine. The Mobile EMC provides a back-up to the EMC or the EOC, or may be used to augment command requirements depending on the situation. The mobile EMC is also equipped with back-up power, VSAT capability, and phone, fax and radio capabilities.

Bruce Power currently has one mobile EMC in place and in 2018 will enhance this with a second, larger Mobile Command Unit that will provide greater capability in supporting connectivity to the site and alternate command locations. This will further enhance the primary and back-up communication processes by ensuring that a robust interoperable system is established.

15.15.3 Communication Systems

Web EOC

In 2012, Bruce Power implemented WebEOC, an emergency management software application, as the primary means to effectively manage an emergency response to any or all hazards. The application is used by all Emergency Response Organization Command staff to ensure interoperability and management of strategic objectives, strategies, and tactics. The application also provides a forum for situational awareness through sharing of emergency response information. This system is operated within the Bruce Power EMC, which maintains back-up power and communications capabilities at all times to ensure sustained operation when local infrastructure is challenged.

Radio Network

In March 2017, Bruce Power initiated a project to upgrade the 35-year-old site radio system from UHF to a new digital radio system, along with the installation of a new radio tower and backup power (planned to be complete by 2019). The scope of work will include replacement of systems that support site-wide Bruce A and Bruce B operations as well as Emergency and Protective Services (EPS) emergency response and security systems and infrastructure.

Replacement of the current radio tower will provide the capability to reach a distance of 30 km, enabling communication from site to both Bruce Power Alternate EMCs. The new system will provide appropriate enhancements to assist with greater interoperability communications both on-site and also with off-site external response agencies, as part of the broader interoperability approach in the Bruce-Grey-Huron region (interoperability is discussed further below).

Figure 29. Bruce Power radio tower

Public Alerting/Alert FM™

In addition to the new municipal siren system and public notification software in use by the Municipality of Kincardine, Bruce Power has collaborated with 3 local radio stations to implement the Alert FM™ notification system in 2016. This system utilizes the FM radio subcarrier system in order to send a message to a mobile receiver with an audible alarm and text message in the event of major infrastructure challenges.

Bruce Power provided receivers to all Category A staff to ensure an additional layer of redundancy is in place when primary and secondary communication systems are challenged. Bruce Power has deployed Alert FM™ technology to local municipality to support public alert efforts, with the capability to send public alert messages within 10 km of the site (primary zone). The system is connected to the National Public Alerting System (Alert Ready) and receives all Threat to Life Alerts distributed through that system.

Figure 30. Alert FM™ receiver

In addition to supporting the local municipality, Bruce Power has worked to further Wireless Public Alerting in Canada through participation in the Public Consultation process that has resulted in the Canadian Radio-Television and Telecommunication Commission mandating Wireless Service Providers participate in the National Public Alerting System by April 2018.

In an effort to increase the robustness of the communication system, Bruce Power worked with local radio stations to ensure appropriate back-up power was in place to ensure system operations in the event of infrastructure outage. This system is also operated within the EMC where back-up power and communication systems are in place at all times.

Notification of response workers

Prior to 2011, Bruce Power implemented MIR3 to provide an effective means of notifying response workers in the event of an event. The system is a mass notification tool, which uses an escalating process for contacting response workers through a variety of means, from landline to cell phone to email to paging systems. This system has been very effective in managing notifications to response workers and in activating response to any or all hazards. This system is operated within the Bruce Power EMC which maintains back-up power and communications at all times, to ensure sustained operation when local infrastructure is challenged.

MASIS

Bruce Power maintains account access to the CanOps Multi-Agency Situational Awareness System (MASIS). This system provides the ability to monitor and track greater situational awareness in the surrounding region. Although it is not used for Bruce Power site-specific mapping of events and equipment, it does provide a greater understanding of activity and events taking place in the broader region surrounding the Bruce site. This was demonstrated during the Huron Challenge Exercise in October 2012. The system is also used within the EMC, which is outfitted with back-up power and communications systems to ensure this capability is maintained during infrastructure outages.

On-site/off-site communications project

In 2017, Bruce Power moved forward with efforts to implement enhancements to emergency communications within the Bruce A and Bruce B EOCs and Secondary Control Areas. Currently, work to install VSAT technology and back-up power is underway, in order to provide multiple phone hubs and internet connectivity to emergency cloud applications for station EOCs. VSAT technology uses satellite connectivity to support multiple phone hubs and internet connectivity in both a stationary and mobile setting, allowing for versatility and ease in maintaining uninterrupted connectivity. This approach will allow for continued, uninterrupted information and data transmission to off-site and mobile EMCs and external agencies in the event of primary communications infrastructure challenges.

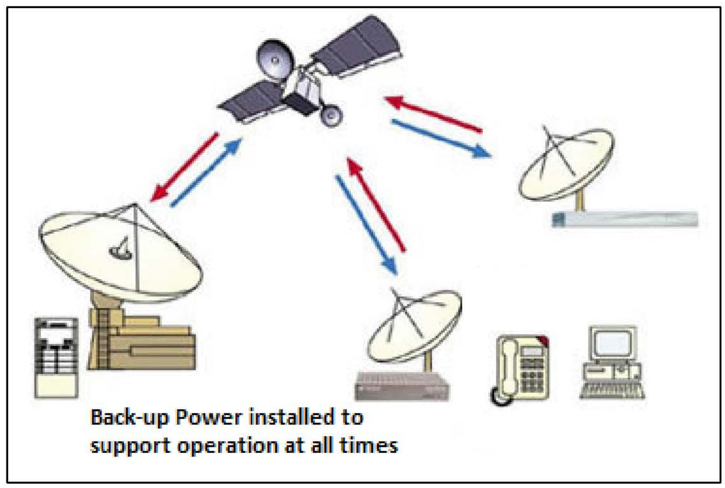


Figure 31. VSAT architecture

As part of this effort, appropriate back-up power and enhanced back-up communications will be provided to ensure appropriate Secondary Control Area and alternate EOC communications back-up capabilities. This effort is planned to be complete in 2018 and is a key step in providing the appropriate infrastructure to support automatic data sharing connectivity of critical system parameters and enable sustained operation during severe events.

Plant data sharing and DLAN dashboard

Bruce Power understands the importance of sharing key plant data in a timely manner to support effective and timely decision making. Ensuring continuity of operations in an event is a key consideration when developing a data sharing communication process. As a first step Bruce Power conducted an assessment to determine if the Plant Information (PI) system, primarily established as a daily plant and system data storage tool, could also be used to reliably and accurately transmit data to those requiring this information during an event. Bruce Power determined that, since the PI system depends on the business Information Technology infrastructure and is not supported by robust back-up power supplies, the PI system would likely be unavailable for extended periods of time for events involving a simple loss of Class IV power supply and potentially even from a loss of grid supply.

Additionally, the PI system and its in-plant components have not been seismically or environmentally qualified for the design basis or beyond design basis conditions expected during accident scenarios. As such, there is a high likelihood that the PI system will either not be available to provide data at all during an event, or, even if available, the data provided could be inaccurate and potentially misleading. As a result, it was concluded that the PI system could not be viewed as a reliable tool for decision making.

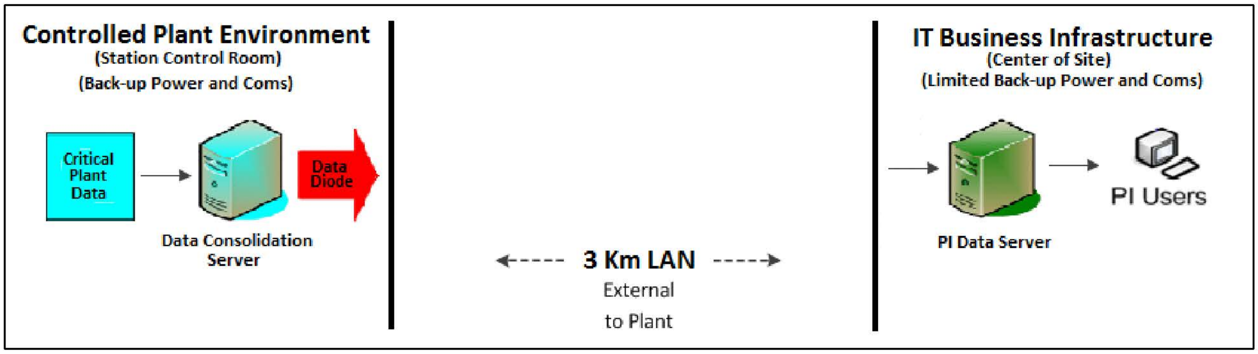


Figure 32. Plant Information (PI) system architecture

While it may be physically possible to retrofit the PI system to the extent where it can be considered robust enough for use in communicating the state of critical plant systems and parameters, the high costs and the time associated with extensive modifications to the current system architecture cannot be justified.

To meet the requirement to reliably and accurately communicate the status of critical plant systems and parameters under any circumstance, Bruce Power has worked with a software developer to create a software program that manages plant data (DLAN) and transmits it electronically in an organized and easily accessed format. When used in combination with VSAT technology, this new system will address the challenges for continuity of operations, as well as provide the following features:

- A dashboard to show all emergency response data, including plant data to external agencies;
- Reduction of operator burden, with an easier process that does not rely on a fax system;
- Automatic trending of plant data for ease in understanding event progression and to allow for quicker decision making protocols;
- Ability to download data to support further analysis;
- Housed within a secure cloud with appropriate back-up systems to ensure 24/7 availability even during large scale infrastructure outages; and,
- Availability in the station EOCs within the station Main Control Room area where most of the required data is located in close proximity.

Figure 33. DLAN interface.

initially tested DLAN as a method of sharing plant data with external agencies. The initial testing utilized a manual data verification process to ensure data correctness and availability in the event of plant system challenges. Based on the successful test, further work was undertaken in 2017 to implement DLAN as the primary methodology for sharing plant data and emergency response information.

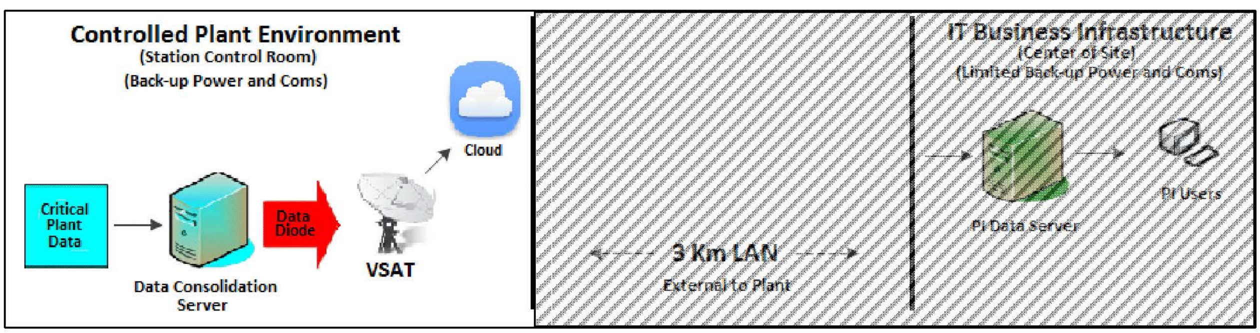


Figure 34. Emergency plant information system architecture. Greyed-out boxes represent elements which will not be included, in comparison with Figure 32.

Once this phase has been successfully implemented, Bruce Power plans to begin a feasibility assessment in 2018 to investigate options for automated connectivity to station and site data systems in order to further reduce operator burden, to support automated sharing of data, and to simplify dose and plume modeling. Initial steps will include auto-connectivity to DLAN with systems that currently meet CISC criteria, such as off-site remote monitoring data and URI plume modelling data.

This approach will ensure a sustainable system, that supports continuity of operation from end to end, is put in place to provide, as much as possible, automated transfer of critical plant data, from qualified and/or reliable plant instrumentation to external agencies. This will involve testing capabilities to feed data from these critical plant systems directly into DLAN, utilizing the more secure environment and back-up power and communications provided to the control rooms of each station. As part of this effort, system security will be reviewed to ensure cloud providers and third-party vendors meet all security requirements.

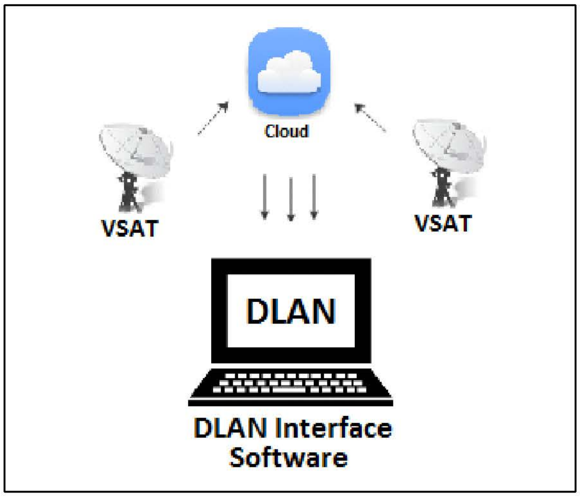


Figure 35. Auto-connectivity to DLAN

Shown below is a full overview of Bruce Power's emergency communications approach and information flow to internal emergency management centres and external agencies (see Figure 36).

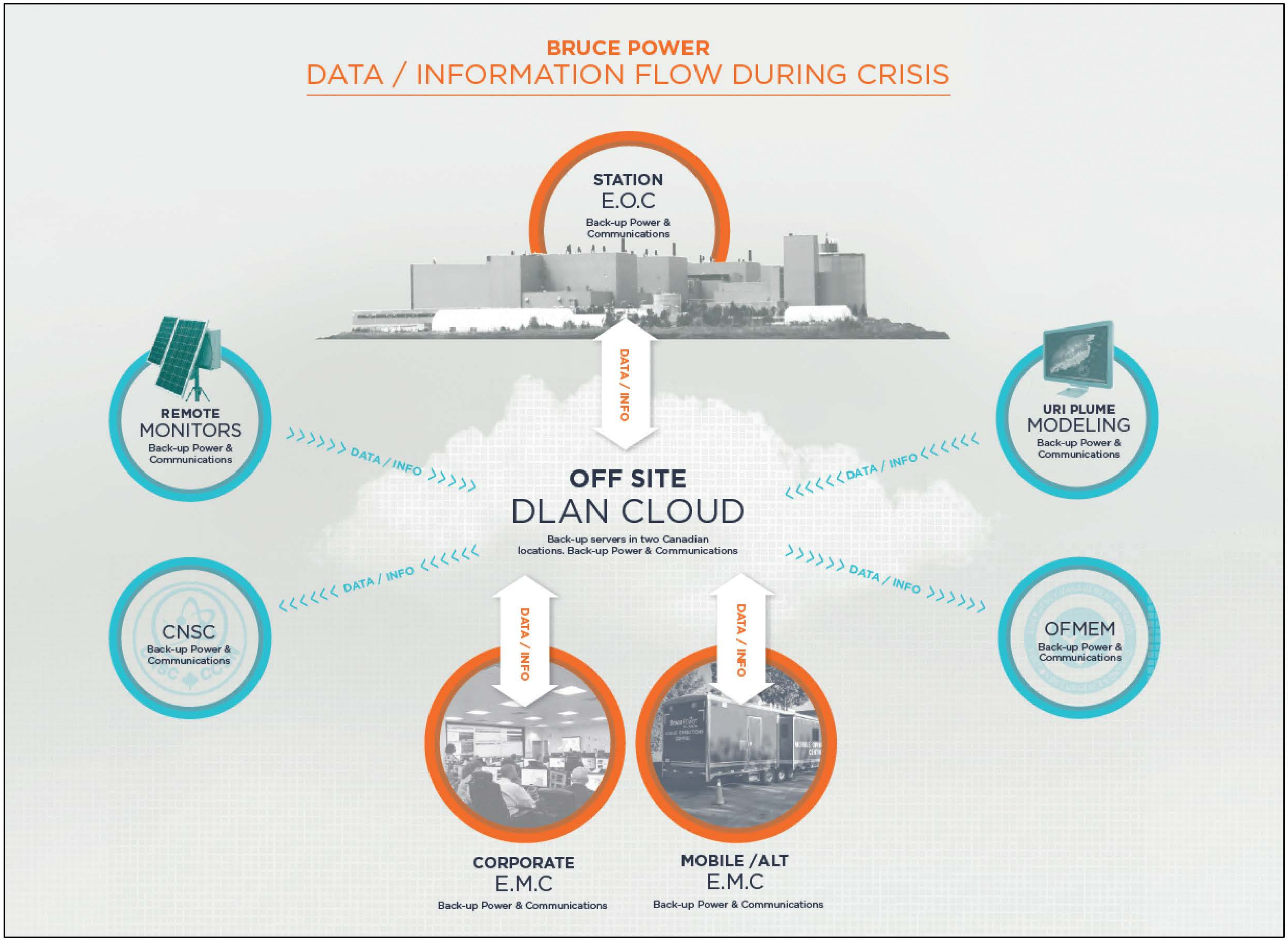


Figure 36. Bruce Power data / information flow during crisis

Off-site Radiation Monitor Network

In 2012, Bruce Power implemented a real-time Radiation Monitoring System within 10 km (primary zone) of the Bruce site. This system provides the capability to support enhanced monitoring and reporting of gamma-emitting radionuclides. Designed to operate independently of local infrastructure, the system feeds emergency response data to the EMC, which also is capable of operating independently of local infrastructure, ensuring full operation at any time.

Bruce Power has in place 44 gamma spectrometers and 10 back-up deployable units that can be used to augment the current system. Primary data transmission is via the cellular network, with back-up satellite capability. Data storage and external data access is provided through a remote off-site third party data storage network with appropriate cloud security and backup power and storage facilities in two separate locations within Canada.

Figure 37. Off-site radiation monitor

URI plume modelling

The current plume modelling software, known as the Bruce Emergency Response Projection (BERP) code, is effective for accidents in which containment pressure is maintained sub-atmospheric so that effectively all of the containment releases occur via the Emergency Filtered Air Discharge System (EFADS) stack.

For beyond design basis accidents (for example, multi-unit accidents), in which positive containment pressures are possible, releases can occur via unmonitored pathways in the containment structure. However, the current code cannot readily account for releases via unmonitored pathways.

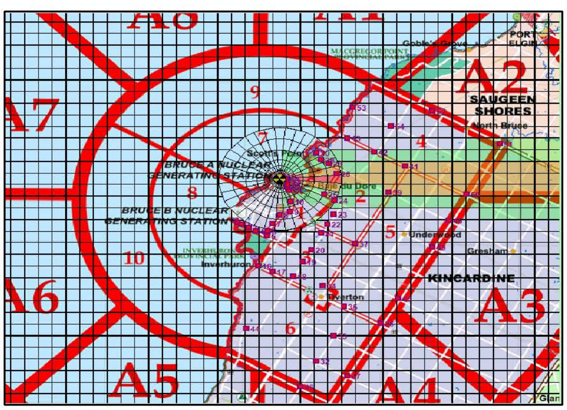


Figure 38. URI dashboard map

As a result, in 2015 Bruce Power partnered with Ontario Power Generation to begin developing an enhanced approach to plume dispersion modelling to support provincial decision making during events. Shortly thereafter, a decision was made to adapt and modify the Unified RASCAL Interface (URI)/RASCAL code. This work is being completed by Radiation Safety and Control Services (RSCS) in collaboration with Kinectrics, a Canadian testing, inspection, and consulting company. RSCS has provided URI to over 60 nuclear units in the USA and has adapted its use for the state of Illinois as part of its emergency planning initiatives.

The URI code will be operable within the Provincial Emergency Response Center (PEOC) and the Bruce Power EMC, both of which are supported with backup power and communications to sustain operation when local infrastructure is challenged. Bruce Power plans to finalize implementation by late 2017. As part of the overall communication approach, plans are in place to look at opportunities to automate data transfer from URI into DLAN to support enhanced decision making and situational awareness.

Command Bridge

Bruce plans to demonstrate the use of Command Bridge during the 2017 corporate exercise in Q4 2017. Command Bridge is a software application designed to provide capability to track on-site and off-site response equipment through real-time geolocation technology. This system will be operable within the EMC and is supported with backup power and communications to ensure continuity of operations if primary communication systems are challenged.

15.15.4 Training, Emergency Drills, and Exercise Support

Drills and exercises

To support a more detailed and comprehensive approach to drills and exercises, Bruce Power has expanded the scope of its Drill and Exercise Development Program and is now incorporating the use of more detailed station and off-site data to support greater situational awareness and decision making during events.

Bruce Power developed detailed plant data to test DLAN in an initial test of the concept in 2016. Although successful in testing the capabilities of the DLAN application, the testing has brought to light the complexities of developing full-scale data exercises.

To ensure a robust approach is in place, Bruce Power is developing a more rigorous approach to data development for drills and exercises that will incorporate a detailed formal technical review prior to use and will allow scenarios to be preprogrammed, rather than depending entirely on exercise control injections during an exercise. This approach will also provide the ability for external agencies to conduct their own internal exercises that utilize this data separate from actual response activity during an emergency drill.

To support this initiative Bruce Power will develop additional exercise scenario data, allowing the conduct of varied data exercises for training purposes.

Simulation

Bruce Power is currently working with ARES to develop and implement simulation capability to support emergency response analytics and training. Since 2012, efforts have been moving forward with the creation of a 3D site model to support response analysis and to provide enhanced training capabilities to Bruce Power response crews. This will serve to enhance understanding and response capabilities to all hazard events.

Figure 39. ARES three-dimensional simulation

Efforts continue to finalize the tool in 2017, with full implementation of the simulation and analytic capabilities planned for 2018. The simulator will be operable within the EMC, which is supported with back-up power and communications. Efforts to fully realize the potential of simulation will be explored as the use of the tool progresses and fully integrated into the Emergency Response Program.

Regional Emergency Response Interoperability (CSSP-funded project)

In 2015, Bruce Power worked closely with response agencies in the Bruce-Grey-Huron region to develop an Interoperability Plan. As part of this plan, work was completed to create a Regional Emergency Response Interoperability Committee with representation from Bruce Power, the Municipality of Kincardine, the Town of Saugeen Shores, and Saugeen Ojibway First Nations, as well as Bruce, Grey, and Huron Counties.

As part of the Committee effort, Bruce Power worked closely with external partners to develop and submit an application to the Defence Research and Development Canada to secure $230,000 of government funding through the Canadian Safety and Security Program (CSSP) to conduct a two-year study on communications interoperability among response agencies located within the Bruce-Grey-Huron region.

The project was initiated in early 2017 and is currently scheduled to be complete in early 2019. The project will oversee the development of a strategic plan which follows the CSIC and is designed to enhance communication interoperability among response organizations within Bruce-Grey-Huron.

Summary

Bruce Power is progressing as planned to ensure a robust communication system is in place which can provide easy access through cloud architecture and which is operable at all times even when primary systems are challenged.

Significant enhancements have been achieved to date, utilizing a secure cloud approach to develop a robust, fully redundant system, that considers the CSIC and focuses on ensuring interoperability and continuity of operations in each and every aspect of the system.

In addition, Bruce Power understands the importance of timely, accurate data sharing with external agencies and is working towards this achievement in a staged approach to direct connectivity to critical plant system data.

The initial stage of this process focused on developing an emergency management dashboard that provides an interface for emergency management information and real-time data.

In the next stage, Bruce Power plans to implement VSAT capabilities in the Bruce A and Bruce B control rooms (planned for 2018). This will put in place the fully-redundant emergency communications infrastructure from which critical system plant data can be connected. Currently, Bruce Power's PI system is housed on business infrastructure and is not provided with the back-up support required to ensure continuity of operations during severe accidents.

The third and final stage is planned for 2018, with analysis of current critical system architecture within the control room protected environment and then development of a plan to ensure direct connectivity at that location to DLAN, the emergency management dashboard. This approach will ensure that data sharing of all critical plant data, as well as all other emergency response information, is supported by a system that follows the CSIC strategy and continually provides emergency response data at all times, even during severe accidents when primary systems could be challenged or may not be available.

Considerable effort has focused on ensuring a sound approach is taken to provide the redundancy required to meet the high-level standard required for a world-class emergency response program. This is key to an effective emergency communications approach and the basis of Bruce Power's approach. Efforts over the next two years will focus on plant data connectivity, ensuring a fully-redundant system that effectively shares real-time plant and emergency response data directly from plant systems outward to off-site emergency response centres as well as federal and provincial agencies.

15.16 Elements of the licence application package

The licence renewal application package has been structured as two primary documents:

- Licence renewal application: a technical submission that addresses the requirements for an application, pursuant to the *Nuclear Safety and Control Act* (provided in Reference B10, Attachment A). This submission is intended to demonstrate compliance and has not been structured in accordance with the Safety and Control Areas. Some information is duplicated between the application and the Performance Review (this document);

- Performance review: a high-level, integrated review of licensee performance over the previous licensing period (this document). The review covers the Safety and Control Areas, which are defined by the CNSC and used by the CNSC to review and report on performance for all facilities and activities licensed by the CNSC. The performance review is written with the public and Commission as the intended audience, with relatively limited technical discussion—although some understanding of CANDU technology is assumed.

In addition, the following supplementary documents provide supporting information:

- Integrated Implementation Plan,
- Return to Service Plan (MCR in Unit 6),
- Project Execution Plan (MCR in Unit 6),
- Environmental Risk Assessment,
- Final report for the U12 Environmental Assessment follow-up monitoring program,
- Summary report of whitefish research activities,
- Summary report of low-dose radiation and environmental research activities, and,
- Security program description.

Each of these supplementary documents is described briefly below.

Additionally, Bruce Power committed to provide information on Indigenous engagement (see Section 15.12) and information on the Fisheries Act Authorization update (see Section 9.6).

15.16.1 Integrated Implementation Plan

Bruce Power conducted a Periodic Safety Review (PSR), in accordance with REGDOC-2.3.3, *Periodic Safety Reviews*. The purpose of the PSR is to review the facilities with respect to modern codes and standards and to implement practicable improvements to enhance safety. It is anticipated that the PSR will be updated approximately every 10 years.

The objectives of the PSR are the following:

- To determine the extent to which Bruce A and Bruce B meet modern codes and standards, as well as industry best practices;
- To determine the extent to which the licensing basis will remain valid over the operating life of Bruce A and Bruce B;
- To determine the adequacy of the Structures, Systems, and Components and programs that are in place to ensure safety for long-term operation; and,
- To determine practicable improvements to be implemented for resolution of findings.

The final output of the PSR is the Integrated Implementation Plan (IIP). All of the PSR findings were consolidated, classified, grouped, and ranked for inclusion within the IIP. Where practicable, Bruce Power has identified improvements to address the findings. No safety concerns requiring immediate action were identified. However, the IIP will enhance the current safety of Bruce A and Bruce B.

The final Integrated Implementation Plan will be submitted to the CNSC for acceptance under separate cover with record number NK21-CORR-00531-13543 / NK29-CORR-00531-14165, and the proposed improvements are intended to form part of the licensing basis for the next licensing period.

15.16.2 Return to Service Plan and Project Execution Plan for MCR in Unit 6

As discussed in Section 0.4, plans for MCR are subject to change. However, in support of this application, Bruce Power will provide formal notification of the intent to perform MCR in Unit 6 (Reference B19).

This notification will include a Return to Service Plan, which describes how the reactor will be returned to commercial operations. This includes key milestones and proposed regulatory hold points.

Additionally, this notification will include a Project Execution Plan, which describes the programs and processes used to complete the project, as well as to monitor the quality of the work activities.

15.16.3 Environmental Risk Assessment

Bruce Power will submit an updated ERA—one that includes the Major Component Replacement activities—to the CNSC. The updated ERA will be submitted at the same time as this licence renewal application, three years in advance of the next required update (Reference B20).

Additional information on the Environmental Risk Assessment is provided in Section 9.5.

15.16.4 Final report for the Unit 1 and 2 EA follow-up monitoring program

The final report for the Unit 1 and 2 Environmental Assessment Follow-up Monitoring Program was provided to the CNSC in Reference B21. A brief summary of the Environmental Assessment and the Follow-up Monitoring Program is provided below.

In 2004, Bruce Power proposed the refurbishment and restart of Units 1 and 2 at the Bruce A nuclear generating station. This project included the refurbishment of Units 3 and 4, as well as the potential use of Low Void Reactivity Fuel ("new fuel") at Bruce A. Under Canadian Environmental Assessment Act (CEAA), this project required an Environmental Assessment.

The "Bruce A Refurbishment for Life Extension and Continued Operations Environmental Assessment" was initiated to determine likely measurable changes in the environment. A detailed assessment was performed based on Valued Ecosystem Components, which are components of the environment that are valued based on scientific or cultural importance. As part of the EA process, adverse effects remaining after mitigation (residual adverse effects) were identified and assessed for significance.

The EA Study Report was completed in 2005 and concluded that the "Project is not likely to result in any significant adverse effects on the environment." The EA Study Report was accepted by the CNSC in 2006, and the refurbishment project was subsequently initiated.

Follow-up monitoring is a requirement of the EA process. The intent of follow-up monitoring is to verify the accuracy of EA predictions and to verify the effectiveness of mitigation (generally, mitigation was inherent in the development of the project).

The EA follow-up monitoring program was conducted from 2007-2015, including monitoring prior to, and following, 4-unit operations at Bruce A, which began in 2012 (Figure 40).

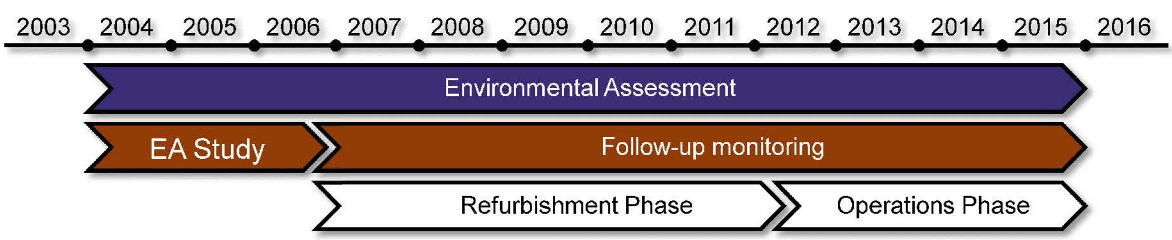


Figure 40. Timeline for U12 Environmental Assessment

The follow-up monitoring program included 23 elements. Several of these elements included monitoring with respect to potential effects on Lake Whitefish, including assessment of the levels of impingement and entrainment (two years of monitoring during 4-unit operations), as well as assessment of thermal effects on potential Lake Whitefish spawning habitat.

For all elements, the EA Study Report findings were verified, supporting the Study Report assessment that 4-unit operation at Bruce A has no significant adverse effect on the environment.

15.16.5 Summary report of whitefish research activities

Bruce Power has sponsored independent, university-led research that has examined the potential impacts of Bruce Power operations on Lake Whitefish and Round Whitefish.

The university-based research has conclusively demonstrated that spawning-condition Lake Whitefish near the Bruce Power site are members of a larger genetic and ecological group. This research supports the general understanding that the direct impact of the thermal discharge on the survival of Lake Whitefish embryos and juveniles is likely to be limited, with no additional effects caused by chemical and radiation exposure at the very low levels that result from Bruce Power operations.

A summary report, that includes an overview of historical research, population surveys, and monitoring, as well as the independent, university-based research, has been provided to supplement the licence application (Reference B22).

15.16.6 Summary report of low-dose radiation and environmental research activities

Bruce Power sponsors independent academic research with respect to:

- The effects of low-dose radiation in cellular, animal, and human models,
- Interactions between Bruce site operations and the aquatic environment, and,
- Indigenous health issues.

In many cases, Bruce Power's support has allowed researchers to be successful in receiving competitive, peer-reviewed funding from federal and provincial agencies. The receipt of these matching funding grants demonstrates the scientific rigor of the academic research that Bruce Power is supporting. Research findings continue to be published in peer reviewed academic journals and are available to all interested parties.

A summary report of this independent academic research has been provided to supplement the licence application (Reference B23).

15.16.7 Security program description

An updated security program description will be provided as a supplement to the licence application. This technical submission provides information required for a licence renewal application pursuant to the *Nuclear Safety and Control Act* and associated regulations.

This document contains prescribed information, pursuant to the *General Nuclear Safety and Control Regulations*, Section 21(c), and cannot be released to the public.

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B4. Letter, F. Saunders to K. Lafrenière, “Bruce Power Fisheries Act Authorization”, May 11, 2017,
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B5. Canadian Nuclear Safety Commission, “Record of Proceedings, Including Reasons for Decision, in the matter of Ontario Power Generation Inc., Financial Guarantee and Licence Amendments for OPG’s Class I Nuclear Facility Licences in Ontario”, October 24, 2012.

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NK21-CORR-00531-13229 / NK29-CORR-00531-13723.

B10. Letter, F. Saunders to K. Lafrenière, “Application for the Renewal of the Power Reactor Operating Licence”, June 30, 2017,
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B12. Letter, F. Saunders to K. Lafrenière, “Bruce A and Bruce B: Notification of a change to the Amended and Restated Lease Agreement”, October 20, 2016, NK21-CORR-00531-13144 / NK29-CORR-00531-13629 / NK37-CORR-00531-02633 (confidential).

B13. Hearing intervention, Saugeen Ojibway Nation, “Written Submissions of the Saugeen Ojibway Nation—Application to Renew the Power Reactor Operating Licence for the Bruce Nuclear Generating Stations A and B”, March 16, 2015, CMD 15-H2.118.

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