FORM-14159 R000*

Periodic Safety Review - Final Document Review Traveler

Bruce Power

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Bruce Power Document Title: Safety Factor 14 – Radiological Impact on the Environment			
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candesco
Division of Kinectrics Inc.

Title: Safety Factor 14 - Radiological Impact on the Environment

File: K-421231-00024-R01

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A Report Submitted to Bruce Power

February 29, 2016

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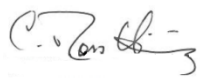
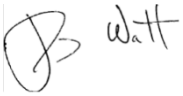
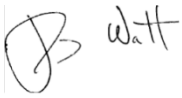
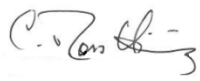
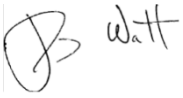
Issue R00	**Reason for Issue:** For use				
	Author: R. Hirning  N. Fajurally 	Verifier: G. Aldev  B. Rzentkowski 	Reviewer: G. Archinoff  L. Watt 	Approver: L. Watt 	Date: June 30, 2015
Issue R01	**Reason for Issue:** High-Level assessments of CNSC G-228 and CSA N288.3.4-13 provided in Appendices A.9 and A.10, respectively. Sections 3.2, 3.6, 5.2, 5.6, 5.8, 8.0, and 9.0 updated based on these new assessments.				
	Author: R. Hirning  N. Fajurally 	Verifier: H. Semeralul 	Reviewer: L. Watt 	Approver: L. Watt 	Date: February 29, 2016
Document Classification: Report			Security Classification: Client Proprietary		

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Acronyms and Abbreviations

AL	Action Level
ALARA	As Low As Reasonably Achievable
BP	Bruce Power
CALA	Canadian Association for Laboratory Accreditation
CNSC	Canadian Nuclear Safety Commission
CSA	Canadian Standards Association
DRL	Derived Release Limit
EA	Environmental Assessment
EED	Emission Effective Dose
EFADS	Emergency Filter Air Discharge System
EFPH	Equivalent Full Power Hours
EIW	Environmental Impact Worksheet
EMP	Environmental Monitoring Program
EMS	Environmental Management System
EPI	Environmental Performance Index
ERA	Environmental Risk Assessment
HEPA	High Efficiency Particulate Air
IAEA	International Atomic Energy Agency
IFB	Irradiated Fuel Bay
IIL	Internal Investigation Level
ISO	International Organization for Standardization
ISR	Integrated Safety Review
LCH	Licence Conditions Handbook
LTEP	Long Term Energy Plan
MCR	Major Component Replacement
MPER	Maximum Probable Emission Rate
NSCA	Nuclear Safety and Control Act
OBT	Organically-bound Tritium
OFI	Opportunities for Improvements

PROL	Power Reactor Operating Licence
PSR	Periodic Safety Review
QA/QC	Quality Assurance/Quality Control
RD/GD	Regulatory Document/Guidance Document
REMP	Radiological Environmental Monitoring Program
SBR	Safety Basis Report
SCR	Station Condition Record
SFR	Safety Factor Report
TAM	Task Analysis Meeting

1. Objective and Description

Bruce Power (BP), as an essential part of its operating strategy, is planning to continue operation of Units 3 and 4 as part of its contribution to the Long Term Energy Plan (LTEP) (http://www.energy.gov.on.ca/en/ltep/). Bruce Power has developed plant life integration management plans in support of operation to 247,000 Equivalent Full Power Hours (EFPH). A more intensive Asset Management program is under development, which includes a Major Component Replacement (MCR) approach to replace pressure tubes, feeders and steam generators, so that the units are maintained in a fit for service state over their lifetime. However, due to the unusually long outage and de-fuelled state during pressure tube replacement, there is an opportunity to conduct other work, and some component replacements that could not be done reasonably in a maintenance outage will be scheduled concurrently.

To support the definition and timing of practicable opportunities for enhancing the safety of Units 3 and 4, and the ongoing operation of Units 1 and 2, which have already been refurbished, Bruce Power is conducting a station-wide review of safety for Units 0A and 1-4, to be termed an Integrated Safety Review (ISR) [1]. This ISR supersedes the Bruce A portion of the interim Periodic Safety Review (PSR) that was conducted for the ongoing operation of the Bruce A and B units until 2019 [2]. This ISR is conducted in accordance with the Bruce A ISR Basis Document [1], which states that the ISR will meet or exceed the international guidelines given in International Atomic Energy Agency (IAEA) Guide SSG-25, Periodic Safety Review for Nuclear Power Plants [3]. The ISR envelops the guidelines in Canadian Nuclear Safety Commission (CNSC) Regulatory Document RD-360 [4], Life Extension for Nuclear Power Plants, with the exception of those related to the Environmental Assessment (EA), which has already been completed for Bruce A [5][1].

1.1. Objective

The overall objective of the Bruce A ISR is to conduct a review of Bruce A against modern codes and standards and international safety expectations and provide input to a practicable set of improvements to be conducted during the Major Component Replacement in Units 3 and 4, and during asset management activities to support ongoing operation of all four units, including U0A, that will enhance safety to support long term operation. The look-ahead period will be longer than that in the interim PSR performed for Units 1-8 [2]. It will cover a 10-year period, since there is an expectation that a PSR will be performed on approximately a 10-year cycle, given that all units are expected to be operated well into the future. Nuclear Safety is a primary

[1] RD-360 [4] was superseded by CNSC REGDOC-2.3.3 [6] in April 2015. CNSC REGDOC-2.3.3 was in draft at the time that the ISR Basis Document [1] was prepared. The draft version of CNSC REGDOC-2.3.3 stated that it was consistent with SSG-25, and the assessments in the Safety Factor Reports were performed on that basis. The issued version of CNSC REGDOC-2.3.3 also states that it is consistent with SSG-25, and therefore it is considered that the ISR envelops the guidelines in CNSC REGDOC-2.3.3.

consideration for Bruce Power and the management system must support the enhancement and improvement of safety culture and the achievement of high levels of safety, as well as reliable and economic performance.

The specific objective of the review of this Safety Factor is to determine whether the operating organization has an adequate program for surveillance of the radiological impact of the plant on the environment, which ensures that emissions are properly controlled and are as low as reasonably achievable (ALARA).

1.2. Description

The review is conducted in accordance with the Bruce A ISR Basis Document [1], which states that the review tasks are as follows:

Verification whether the monitoring program is appropriate and sufficiently comprehensive. In particular, the review should verify that the radiological impact of the plant on the environment is not significant compared with that due to other sources of radiation.

Additionally, as part of this review it should be verified that:

1. Concentrations of radionuclides in air, water (including river water, sea water and groundwater), soil, agricultural and marine products and animals are being monitored by the operating organization or by an independent public organization and are trended, and appropriate corrective actions are taken in the event that action levels are exceeded;
2. Potential new sources of radiological impact have been recognized by the operating organization;
3. Sampling and measurement methods are consistent with current standards;
4. Records of discharges of effluents are being monitored and trended and appropriate actions are taken to remain within established limits and to keep such discharges as low as reasonably achievable;
5. On-site monitoring is undertaken at locations and using methods that have a high probability of the prompt detection of a release of radioactive material to the environment;
6. Off-site monitoring for contamination levels and radiation levels is adequate and corrective actions are taken to keep such levels as low as reasonably achievable;
7. Actions have been taken to clean up contamination where reasonable and practicable;
8. Alarm systems to respond to unplanned releases of radioactive material from on-site facilities are suitably designed and available and will remain available in the future;
9. Appropriate data have been published on the environmental impact of the plant; and
10. Changes in the use of areas around the site have been taken into account in the development of monitoring programs.

2. Methodology of Review

As discussed in the Bruce A ISR Basis Document [1], the methodology for an ISR should include making use of safety reviews that have already been performed for other reasons. Accordingly, the Bruce A ISR makes use of previous reviews that were conducted for the following purposes:

- Return to service of Bruce Units 3 and 4 (circa 2001) [7];
- Life extension of Bruce Units 1 and 2 (circa 2006) [8] [9];
- Proposed refurbishments of Bruce Units 3 and 4 (circa 2008) [10] [11] [12]; and
- Safety Basis Report (SBR) and Periodic Safety Review (PSR) for Bruce Units 1 to 8 (2013) [2].

These reviews covered many, if not all, of the same Safety Factors that are reviewed in the current ISR. A full chronology of Bruce Power safety reviews is provided in Appendix F of [13].

The Bruce A ISR Safety Factor review process comprises the following steps:

1. **Interpret and confirm review tasks:** As a first step in the Safety Factor review, the Safety Factor Report author(s) confirm the review tasks identified in the ISR Basis and repeated in Section 1.2 to ensure a common understanding of the intent and scope of each task. In some cases, this may lead to elaboration of the review tasks to ensure that the focus is precise and specific. Any changes to the review tasks are identified in Section 5 of the Safety Factor Report (SFR) and a rationale provided.
2. **Confirm the codes and standards to be considered for assessment:** The Safety Factor Report author(s) validates the list of codes and standards presented in the ISR Basis Document against the defined review tasks to ensure that the assessment of each standard will yield sufficient information to complete the review tasks. Additional codes and standards are added if deemed necessary. If no standard can be found that covers the review task, the assessor may have to identify criteria on which the assessment of the review task will be based. The final list of codes and standards considered for this Safety Factor is provided in Section 3.
3. **Determine the type and scope of assessment to be performed:** This step involves confirming or modifying the assessment type for each of the codes and standards and guidance documents identified for consideration. The ISR Basis Document provides an initial assignment for the assessment type, selecting one of the following review types:
    - Programmatic Clause-by-Clause Assessments;
    - Plant Clause-by-Clause Assessments;
    - High-Level Programmatic Assessments;
    - High-Level Plant Assessments;
    - Code-to-Code Assessments; or

- Confirm Validity of Previous Assessment.

The final assessment types are identified in Section 3, along with the rationale for any changes relative to the assignment types listed in the ISR Basis Document.

4. **Perform gap assessment against codes and standards:** This step comprises the actual assessment of the Bruce Power programs and the Bruce A plant against the identified codes and standards. In general, this involves determining from available design or programmatic documentation whether the plant's design or programs meet the provisions of the specific clause of the standard or of some other criterion, such as a summary of related clauses. Each individual deviation from the provisions of codes and standards is referred to as a Safety Factor "micro-gap". The assessments, performed in Appendix A and Appendix B, include assessor's arguments conveying reasons why the clause is considered to be met or not met, while citing appropriate references that support this contention.
5. **Assess alignment with the provisions of the review tasks:** The results of the gap assessment against codes and standards are interpreted in the context of the review tasks of the Safety Factor. To this end, each assessment, whether clause-by-clause, high-level or code-to-code, is assigned to one or more of the review tasks (Section 5). Assessment against the provision of the review task involves formulating a summary assessment of the degree to which the plant or program meets the objective and provisions of the particular review task. This assessment may involve consolidation and interpretation of the various compliance assessments to arrive at a single compliance indicator for the objective of the review task as a whole.
6. **Perform program assessments:** The most pertinent self-assessments, audits and regulatory evaluations are assessed, and performance indicators relevant to the Safety Factor identified. The former illustrates that Bruce Power has a comprehensive process of reviewing compliance with Bruce Power processes, identifying gaps, committing to corrective actions, and following up to confirm completion and effectiveness of these actions. The latter demonstrates that there is a metric by which Bruce Power assesses the effectiveness of the programs relevant to the Safety Factor in Section 7. Taken as a whole, these provide a cross section, intended to demonstrate that the processes associated with this Safety Factor are implemented effectively (individual findings notwithstanding). Thus, program effectiveness, if not demonstrated explicitly in the review task assessments in Step 5, can be inferred if Step 5 shows that Bruce Power processes meet the Safety Factor requirements and if this step shows there are ongoing processes to ensure compliance with Bruce Power processes.
7. **Identification of findings:** This step involves the consolidation of the findings of the assessment against codes and standards and the results of executing the review tasks into a number of definitive statements regarding positive and negative findings of the assessment of the Safety Factor. Positive findings or strengths are only identified if there is clear evidence that the Bruce A plant or programs exceed compliance with the provision of codes and standards or review task objectives. Each individual negative finding or deviation is designated as a Safety Factor micro-gap for tracking purposes. Identical or similar micro-gaps are consolidated into comprehensive statements that describe the

deviation known as Safety Factor macro-gaps, which are listed in Section 8 of the Safety Factor Reports, as applicable.

3. Applicable Codes and Standards

This section lists the applicable regulatory requirements, codes and standards considered in the review of this Safety Factor. The list also includes any new codes or standards that came into effect after the completion of the 2013 PSR, as well as those that supersede codes or standards previously assessed. Regulatory codes and standards issued after the code effective date of August 31, 2014 were not part of the detailed review.

3.1. Acts and Regulations

The *Nuclear Safety and Control Act* (NSCA) [14] establishes the Canadian Nuclear Safety Commission and its authority to regulate nuclear activities in Canada. The NSCA has been amended on July 3, 2013 to provide the CNSC with the authority to establish an administrative monetary penalty system. The Administrative Monetary Penalties Regulations were introduced in 2013, and set out the list of violations that are subject to administrative monetary penalties, as well as the method and criteria for penalties administration. However, these changes do not impact this Safety Factor. Furthermore, following the Fukushima nuclear events of March 2011, the Fukushima Omnibus Amendment Project was undertaken and completed in 2012, and resulted in amendments to regulatory documents to reflect lessons learned from these events. Bruce Power has a process to ensure compliance with the NSCA [14] and its Regulations. Therefore, the NSCA and Regulations were not considered further in this review.

3.2. Power Reactor Operating Licence

The list of codes and standards related to radiological impact on the environment that are referenced in the Bruce Power Reactor Operating Licence (PROL) [15] and Licence Conditions Handbook (LCH) [16], and noted in Table C-1 of the ISR Basis Document [1], are identified in Table 1.[2] The document numbers and edition dates referenced in the third column of the table are the modern versions used for comparison. The PROL contains six licence conditions which are directly relevant to this review:

- Licence Condition 1.5 – “The licensee shall give written notification to the Commission, or a person authorized by the Commission, prior to implementation of any policy and program changes to the Bruce Power Management System Manual and its attachments related to Section 9 of the *Nuclear Safety and Control Act* [14].”

[2] PROL 18.00/2020 [17] and LCH-BNGS-R000 [18] came into effect on June 1, 2015. However, PROL 15.00/2015 [15] and LCH-BNGSA-R8 [16] are the versions referred to in this ISR, as these were in force when the assessments in the Safety Factor Reports were performed.

- Licence Condition 1.6 – "The licensee shall control land use and occupation such that no permanent dwelling is permitted within a radius of 914 metres of the reactor buildings [the exclusion zone]".
- Licence Condition 1.7 – "The licensee shall notify and report in accordance with CNSC regulatory document S-99 …" And, "The licensee shall implement and maintain a public information and disclosure program in accordance with CNSC regulatory document RD/GD-99.3 …"
- Licence Condition 8.1 – "The licensee shall implement and maintain an environmental protection program for the nuclear facility in accordance with the requirements of CNSC regulatory document S-296 …"
- Licence Condition 8.2 – "The licensee shall control, monitor and record releases of nuclear substances to the environment from the nuclear facility such that releases do not exceed the derived release limits specified in Appendix C [of the licence]."
- Licence Condition 8.3 – "The licensee shall notify the Commission, or a person authorized by the Commission, within 7 days of becoming aware that an action level has been reached."

Table 1: Codes, Standards, and Regulatory Documents Referenced in Bruce A PROL and LCH

Document Number	Document Title	Modern Version Used for ISR Comparison	Type of Review
CNSC G-129	Keeping Radiation Exposures and Doses 'AS Low As Reasonably Achievable (ALARA)'	CNSC G-129 (2004) [19]	HL
CNSC G-228 (2001)	Developing and Using Action Levels	CNSC G-228 (2001) [20]	HL
CNSC RD/GD-99.3	Public Information and Disclosure	CNSC RD/GD-99.3, 2012 [21]	NR
CNSC RD-360	Life Extension of Nuclear Power Plants	CNSC RD-360 (2008) [4]	NR

Document Number	Document Title	Modern Version Used for ISR Comparison	Type of Review
CNSC S-296 (2006)	Environmental Protection, Policies, Programs and Procedures at Class I Nuclear Facilities and Uranium Mines and Mills	CNSC REGDOC-2.9.1 (2013) [22]	CTC
CNSC S-99 (2003)	Reporting Requirements for Operating Nuclear Power Plants	CNSC REGDOC-3.1.1 [23]	NR
CSA N286-05 [24]	Management System Requirements for Nuclear Power Plants	CSA N286-12 [25]	NR
CSA N292.3	Management of low- and intermediate-level radioactive waste	CSA N292.3-14 [26]	NR
Assessment type: Clause-by-Clause (CBC); Code-to-Code (CTC); High Level (HL); No Assessment Required (NR); Confirm Validity of Previous Assessments (CV)			

CNSC G-129: Table C-1 of the ISR Basis Document [1] did not identify CNSC G-129, keeping radiation exposures and doses 'as low as reasonably achievable' (ALARA). Licence Condition 9.1 of the LCH [16] notes that CNSC regulatory document G-129 provides guidance for developing, implementing and maintaining a radiation protection program to ensure exposures will be ALARA. While this Regulatory Guide applies primarily to radiation protection of workers, some clauses are applicable to environmental releases and so it is included here. A high-level assessment of the document is included in Appendix A (A.7).

CNSC G-228: Table C-1 of the ISR Basis Document [1] did not identify CNSC G-228, however G-228 was further considered. Licence Condition 8.3 of the LCH [16] notes the action levels (ALs) which have been set for the purpose of radiation protection of members of the public. Calculation of these ALs is described in the procedure, Radiological Emissions Monitoring: Limits, Action Levels [27]. Neither of these documents refers to G-228. However, the CNSC has asked that a review of this Standard be included in the ISR, so Bruce Power has committed to conduct a high-level assessment of the document [101]; the assessment is included in Appendix A (A.9).

CNSC RD/GD-99.3: Table C-1 of the ISR Basis Document [1] calls for a clause-by-clause assessment of CNSC RD/GD-99.3 Public Information and disclosure which establishes regulatory requirements for public information and disclosure for licensees. This regulatory

document is included in the current licence and accordingly no further assessment of RD/GD-99.3 requirements is performed for this ISR.

CNSC RD-360: This ISR is being conducted as part of ongoing operation for Units 1 and 2 and to support Major Component Replacement of Units 3 and 4, so it also envelops the guidelines in RD-360, Life Extension for Nuclear Power Plants, issued February 2008. Therefore, RD-360 [4] *de facto* continues to provide guidance on how this review should be conducted. However, RD-360 [4] was superseded by CNSC REGDOC-2.3.3 [6] in April 2015, which was in draft at the time that the ISR Basis Document [1] was prepared. The draft version of CNSC REGDOC-2.3.3 stated that it was consistent with SSG-25, and the assessments in the Safety Factor Reports were performed on that basis. The issued version of CNSC REGDOC-2.3.3 also states that it is consistent with SSG-25, and therefore it is considered that the ISR envelops the guidelines in CNSC REGDOC-2.3.3.

CNSC REGDOC-2.9.1: Table C-1 of [1] calls for a code-to-code comparison of CNSC REGDOC-2.9.1 to its predecessor documents S-296 and G-296. While the ISR Basis Document does not identify S-296 as part of the current licence, compliance with S-296 is identified in Licence Condition 8.1. The code-to-code comparison showed no significant changes regarding routine releases to the environment. The results of the comparison and a high-level assessment of this Regulatory Guide are given in Appendix A (A.1).

CNSC REGDOC-3.1.1: Table C-1 of the ISR Basis Document [1] calls for a code-to-code assessment of CNSC REGDOC-3.1.1 to CNSC S-99. CNSC S-99 (2003) [28], "Reporting Requirements for Operating Nuclear Power Plants", was included in PROL 15.00/2015 and was the basis document the CNSC used to assess past refurbishments at Bruce A, as Bruce Power has had an obligation to meet this Regulatory Document since before 2008. CNSC REGDOC-3.1.1 [23], Reporting Requirements for Nuclear Power Plants, which replaced S-99 [28] in May 2014, is listed as condition 1.7 in PROL 18.00/2020 [17] and sets reporting requirements for nuclear power plants. Bruce Power switched over to CNSC REGDOC-3.1.1 at the beginning of 2015[3], as committed in a letter submitted to the CNSC [29]. Line-by-line compliance with this regulatory document is verified on an ongoing basis to ensure compliance with the PROL, and therefore it was not assessed as part of this Safety Factor.

CSA N286-12: Table C-1 of the ISR Basis Document [1] calls for a code-to-code review against Canadian Standards Association (CSA) standard CSA N286-05. CNSC staff have stated that in their view the CSA N286-12 version of CSA N286 "does not represent a fundamental change to the current Bruce Power Management System" and have acknowledged that "the new requirements in CSA N286-12 are already addressed in Bruce Power's program and procedure documentation" [30].

Bruce Power had agreed to perform a Gap Analysis and to prepare a detailed Transition Plan, and to subsequently implement the necessary changes in moving from the CSA N286-05 version of the code to the CSA N286-12 version, during the next licensing period [29]. This

[3] Reporting is performed under S-99 up to the end of 2014, and under CNSC REGDOC-3.1.1 for periods thereafter.

timeframe will facilitate the implementation of N286 changes to the management system, and enable the gap analysis results from the large number of new or revised Regulatory Documents or Standards committed in the 2015 operating licence renewal. Bruce Power has also proposed that in the interim, CSA N286-05 be retained in the PROL to enable it to plan the transition to CSA N286-12, and committed to develop the transition plan and communicate the plan to the CNSC by January 30, 2016 [31]. Bruce Power further stated CSA N286-12 does not establish any significant or immediate new safety requirements that would merit a more accelerated implementation. This Safety Factor therefore has not performed a code-to-code assessment between CSA N286-05 and CSA N286-12 and will not be performing a clause-by-clause assessment of CSA N286-05, since it is in the current licence.

CSA N292.3-14: Table C-1 of the ISR Basis Document [1] calls for a clause-by-clause assessment in this Safety Factor of CSA Standard N292.3. However, upon review, it was determined that CSA N292.3 does not address the release of radioactive waste to the environment. It has no clauses specifically related to Safety Factor 14, and is thus not assessed in this report. A clause-by-clause assessment is performed in Safety Factor 11.

3.3. Regulatory Documents

The Regulatory Documents in Table 2 were considered for application to review tasks of this Safety Factor.

Table 2: Regulatory Documents

Document Number	Document Title	Reference	Type of Review
CNSC RD-346	Site Evaluation for New Nuclear Power Plants	[32]	CV
Assessment type: Clause-by-Clause (CBC); Code-to-Code (CTC); High Level (HL); No Assessment Required (NR); Confirm Validity of Previous Assessments (CV)			

CNSC RD-346: CNSC RD-346 came into effect after the Bruce 1 and 2 ISR. It represents the CNSC staff's adoption, or where applicable, adaptation of the principles set forth by the IAEA in NS-R-3 "Site Evaluation for Nuclear Installations" [33]. The IAEA guides under NS-R-3 relate to siting which has been fully addressed as part of the Environmental Assessment conducted in 2005 [5]. The same argument applies to CNSC RD-346. Therefore, CNSC RD-346 is not reviewed for this Safety Factor.

3.4. CSA Standards

CSA standards identified in Table C-1 of the ISR Basis Document [1] considered for application to review tasks of this Safety Factor beyond those identified in the PROL [15] and LCH [16] are listed in Table 3.

Table 3: CSA Standards

Document Number	Document Title	Reference	Type of Review
CSA N288.1-14	Guidelines for Calculating Derived Release Limits for Radioactive Material in Airborne and Liquid Effluents for Normal Operation of Nuclear Facilities	[34]	HL
CSA N288.4-10	Environmental Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills	[35]	HL
CSA N288.5-11	Effluent Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills	[36]	HL
CSA N288.6-12	Environmental Risk Assessments at Class I Nuclear Facilities and Uranium Mines and Mills	[37]	HL
Assessment type: Clause-by-Clause (CBC); Code-to-Code (CTC); High Level (HL); No Assessment Required (NR); Confirm Validity of Previous Assessments (CV)			

CSA N288.1-14: Table C-1 of the ISR Basis Document [1] calls for a code-to-code assessment between the 2014 and 2008 versions of the standard. CSA N288.1 provides guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities, and thus it was determined that a high level assessment of CSA N288.1-14 is more appropriate. This is provided in Appendix A (A.2).

CSA N288.4-10: Table C-1 of the ISR Basis Document [1] calls for a clause-by-clause assessment of CSA N288.4-10. This document discusses environmental monitoring programs at Class I nuclear facilities and uranium mines and mills, and is currently in the process of being implemented at Bruce Power. It has been reviewed only with respect to progress towards Bruce Power's implementation. The review type was therefore changed from clause-by-clause to high level, and is provided in Appendix A (A.3).

CSA N288.5-11: Table C-1 of the ISR Basis Document [1] calls for a clause-by-clause assessment of CSA N288.5-11, effluent monitoring programs at class I nuclear facilities and uranium mines and mills addresses the design and operation of effluent monitoring programs for Class I nuclear facilities. CSA N288.5-11 is currently in the process of being implemented at Bruce Power, and so has been reviewed only with respect to progress towards its implementation. The review type was therefore changed from clause-by-clause to high level, and is provided in Appendix A (A.4).

CSA N288.6-12: Table C-1 of the ISR Basis Document [1] calls for a clause-by-clause assessment of CSA N288.6-12 [37], environmental risk assessments at Class I nuclear facilities and uranium mines and mills which provides guidance on designing, implementing and managing environmental risk assessments for nuclear facilities, uranium mines and mills. CSA N288.6-12 is currently in the process of being implemented at Bruce Power, and so has been reviewed only with respect to progress towards its implementation. The review type was therefore changed from clause-by-clause to high level, and is provided in Appendix A (A.5).

3.5. International Standards

Applicable international guidance considered for application to review tasks of this Safety Factor is included in Table 4.

Table 4: International Standards

Document Number	Document Title	Reference	Type of Review
IAEA NS-G-3.2 (2002)	Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluation for Nuclear Power Plants	[38]	HL
IAEA SSG-25 (2013)	Periodic Safety Review for Nuclear Power Plants	[3]	NR
Assessment type: Clause-by-Clause (CBC); Code-to-Code (CTC); High Level (HL); No Assessment Required (NR); Confirm Validity of Previous Assessments (CV)			

IAEA NS-G-3.2: IAEA NS-G-3.2 [38], dispersion of radioactive material in air and water and consideration of population distribution in site evaluation for nuclear power plants, is reviewed at a high level in Appendix A (A.6).

IAEA SSG-25: IAEA SSG-25 [3] addresses the periodic safety review of nuclear power plants and is the governing document for the review of the ISR, as identified in the Bruce A ISR Basis

Document [1]. It defines the review tasks that should be considered for this Safety Factor. However, no assessment is performed specifically on IAEA SSG-25.

3.6. Other Applicable Codes and Standards

One additional standard considered for application to review tasks of this Safety Factor is listed in Table 5.

Table 5: Other Applicable Codes and Standards

Document Number	Document Title	Reference	Type of Review
ANSI/HPS N13.1-1999	Sampling and Monitoring Releases of Airborne Radioactive Substances From the Stacks and Duct of Nuclear Facilities	[39]	HL
CSA N288.3.4-13	Performance testing of nuclear air-cleaning systems at nuclear facilities	[96]	HL
Assessment type: Clause-by-Clause (CBC); Code-to-Code (CTC); High Level (HL); No Assessment Required (NR); Confirm Validity of Previous Assessments (CV)			

ANSI/HPS N13.1: Table C-1 of the ISR Basis Document [1] did not identify ANSI/HPS N13.1-1999; however this Standard provides guidance on automatic alarms for airborne radioactive releases, which was not found in the other standards and codes listed above and therefore was assessed at a high-level in Appendix A (A.8).

CSA N288.3.4-13: Table C-1 of the ISR Basis Document [1] did not identify CSA N288.3.4-13. However, the CNSC has asked that a review of this Standard be included in the ISR and Bruce Power has committed to do so [101]. This Standard sets requirements and provides guidance for the performance testing of air-cleaning systems at nuclear facilities. Its scope is limited to systems that remove radioactive particulate matter and iodine species from airborne effluent streams. A high-level assessment of this Standard is provided in Appendix A (A.10)

4. Overview of Applicable Bruce A Station Programs and Processes

This section provides a brief overview of the key Bruce Power programs, procedures and practices related to this Safety Factor.

Bruce Power's Management System [40] provides the overall framework for integration of safety, environment, quality, economic and other requirements. With respect to the management of environmental safety, Bruce Power has implemented an Environmental Safety Management Program, BP-PROG-00.02 [41], which meets the requirements of an environmental management system (EMS) as required by ISO 14001 [42]. BP-PROG-00.02 [41] defines the overall scope, business need, functional requirements, constituent elements and key responsibilities associated with the management of environmental safety. BP-PROG-00.02 takes its authority from the Bruce Power Management System, BP-MSM-1 [40], which expresses Bruce Power's policy on environmental management. The key implementing documents are listed in Table 6.[4]

Table 6: Key Implementing Documents

First Tier Documents	Second Tier Documents	Third Tier Documents	Fourth Tier Documents
BP-MSM-1: Management System Manual [40]	BP-PROG-00.02: Environmental Safety Management [41]	BP-PROC-00076: Management of the Off-Site Radiological Environmental Monitoring Program [43]	
		BP-PROC-00080: Effluent Monitoring Program [44]	
		DPT-ENV-00016: Environmental Risk Assessment - Aspect/Impact [45]	

According to BP-PROG-00.02,

"The purpose of the Environmental Safety Management Program is to define the requirements and elements of environmental protection and to oversee the planning, implementation and control of activities associated with minimizing potential adverse impacts of Bruce Power operations on the natural environment. The Bruce Power Environmental Safety Management

[4] Table 6 lists the key governance documents used to support the assessments of the review tasks for this Safety Factor Report. There is a continual process to update the governance documents; document versions may differ amongst individual Safety Factor Reports depending on the actual assessment review date. A full set of current sub-tier documents is provided within each current PROG document.

Program conforms to the Canadian Nuclear Safety Commission (CNSC) regulatory standards S-296 [46], Canadian Standards Association (CSA) N286-05 (2007) [24], Clauses 6.28 and 6.29 as well as the International Organization for Standardization (ISO) 14001 for Environmental Management Systems [42]. Programs, processes, and procedures will, at a minimum, assure compliance with regulatory and statutory requirements and facilitate continual improvement in environmental performance."

BP-PROG-00.02 describes:

- Establishing, implementing and maintaining the requirements of an EMS per ISO 14001:2004;
- Bruce Power's approach to ensure compliance with S-296 [46]; and
- Bruce Power's approach to ensuring compliance with all applicable statutory, regulatory and other requirements.

Section 4 and Appendix C of BP-PROG-00.02 map the programs and procedures that form the Bruce Power EMS onto the required elements of an EMS as set out in ISO 14001. The ISO 14001 elements that are most directly relevant to the scope of this review are:

- Section 4.5.1, Monitoring and Measurements,
- Section 4.5.3, Nonconformance and Corrective Action and Preventive Action,
- Section 4.5.4, Control of Records,
- Section 4.7.1, Emissions Management, and
- Section 4.7.3, Land Assessment and Remediation Management.

BP-PROG-00.02 identifies three Level 2 documents that are directly relevant to this review:

- BP-PROC-00076, Management of the Off-Site Radiological Environmental Monitoring Program [43];
- BP-PROC-00080, Effluent Monitoring Program [44]; and
- DPT-ENV-00016, Environmental Risk Assessment - Aspect/Impact [45].

BP-PROC-00076, Management of the Off-Site Radiological Environmental Monitoring Program [43], describes Bruce Power's Radiological Environmental Monitoring Program (REMP), which is designed to meet the requirements of CSA N288.4-10, "Guidelines for the Radiological Monitoring of the Environment" [35]. Bruce Power's REMP provides the following:

- Data to estimate actual or potential doses to critical groups and populations from the presence of radiation fields or radioactive materials in the environment as a result of operations on the Bruce Power site.
- Data to confirm compliance of the facility or source with release guidelines and regulations and to provide public assurance of compliance.
- A check, independent of effluent monitoring, on the effectiveness of containment and effluent control.

- A database to facilitate the detection of trends.
- Verification or refinement of the predictions of environmental models.
- Determination of the fate of released radioactive materials to show whether any significant pathway to man has been overlooked.

Bruce Power's Effluent Monitoring Program is described in BP-PROC-00080 [44]. This procedure provides information on the design, implementation, and management of an effluent monitoring program that meets legal and business requirements and incorporates current best practices and technologies used internationally. This procedure also describes specific details on the airborne and liquid effluents monitoring program under normal and abnormal operating conditions.

DPT-ENV-00016, Environmental Risk Assessment - Aspect/Impact [45], outlines the methodology for identifying and determining the significance of Environmental Aspects, environmental risks, environmental impacts and environmental flagging of equipment at Bruce Power. Environmental Aspects are identified and ranked in order to ensure that those aspects that have, or can have, a significant impact on the environment are managed to achieve the desired environmental performance. Identification of Environmental Aspects, their associated environmental impacts, and those Environmental Aspects that are determined to be Significant Environmental Aspects (SEAs) is a fundamental part of an EMS under ISO 14001 and CNSC Regulatory Standard S-296 [46].

Additional Level 2 and lower-level documents related to this Safety Factor are identified in BP-PROC-00076 [43], BP-PROC-00080 [44] and DPT-ENV-00016 [45].

5. Results of the Review Tasks

The results of the review of this Safety Factor are documented below under headings that correspond to the review tasks listed in Section 1.2 of this document. The review tasks assessed in this section have not changed from those listed in Section 1.2.

5.1. Appropriateness of Monitoring Program

The review task is to verify that:

> The monitoring program is appropriate and sufficiently comprehensive. In particular, verify that the radiological impact of the plant on the environment is not significant compared with that due to other sources of radiation.

PROL Condition 8.1 requires that an environmental protection program for the nuclear facility be implemented and maintained in accordance with the requirements of CNSC regulatory standard S-296 [46]. This document and the associated regulatory guide G-296 [47] have been superseded by CNSC REGDOC-2.9.1 [22]. A code-to-code comparison of CNSC REGDOC-2.9.1 to its two predecessor documents showed no significant differences with respect to routine environmental monitoring (Appendix A.1).

CNSC REGDOC-2.9.1, requires that the licensee "Establish, implement and maintain an EMS that meets the requirements set by CSA ISO 14001:2004, *Environmental Management Systems—Requirements with Guidance for Use*" [42]. Conformance with this requirement is documented in the environmental program document BP-PROG-00.02 [41], and is demonstrated by Bruce Power being certified to the ISO standard. The program document also states that the program complies with the requirements of CNSC Standard S-296 [46].

CSA Standard N288.4-10, Environmental Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills [35], provides guidance on the design and operation of an environmental monitoring program. Conformance to this standard (or to its predecessor, N288.4-M90) is not currently a condition of the PROL, but the CNSC has notified Bruce Power that they expect implementation and transition plans to be submitted for it [48]. More details on implementation are provided in Appendix A.3.

Results of the environmental monitoring program are published annually in a report that is submitted to the CNSC. The report includes data on trends of the annual calculated radiation doses to the most exposed members of the public due to release of radiation and radioactivity from the Bruce site (which includes Bruce A, Bruce B, Ontario Power Generation's Western Waste Management Facility, and Atomic Energy of Canada Limited's Douglas Point Waste Management Facility.) According to the 2013 report [49], annual doses have been lower in the last three years (2011-2013) than in the previous ten years (2001-2010). In that more recent time period, annual doses have been less than 0.16% of the public dose limit of 1000 μSv/year, and far below the typical natural background dose of about 2100 μSv/year. Ontario Power Generation operates a background radiological monitoring program and provides the resulting data to Bruce Power for inclusion in the annual report.

It is concluded that Bruce Power meets the requirements of this review task.

5.2. Concentrations of Radionuclides and Corrective Actions

The review task is to verify that:

> Concentrations of radionuclides in air, water (including river water, sea water and groundwater), soil, agricultural and marine products and animals are being monitored by the operating organization or by an independent public organization and are trended, and appropriate corrective actions are taken in the event that action levels are exceeded.

According to CNSC Regulatory Guide G-228 [20], Section 8.0, when an AL is reached, an investigation should be conducted to determine the cause, identify and take action to restore the effectiveness of the radiation protection program and notify the CNSC within the time period specified in the licence. These actions should be appropriate to the circumstances and commensurate with the level of risk associated with reaching the AL.

PROL Conditions 8.2 and 8.3 require monitoring and control of radiological releases to the environment, and notification of the CNSC within seven days of an AL being exceeded. Detailed requirements for environmental monitoring are given in CSA Standard N288.4-10 [35].

According to BP-PROC-00076 [43], the media that are being monitored for radionuclide concentrations are air, water (drinking, surface, well, precipitation, ground), agricultural plants (fruits, vegetables, grains), animal products (meat, milk, honey), fish, sediment and soil. The results are published in the annual Environmental Monitoring Program Report, and compared with historical trends. The 2013 report is Reference [49].

The calculation of ALs and the response required when one is exceeded are described in BP-PROC-00171 [27]. A review of the action tracking database for S-99 reports showed that no AL for effluent or environmental release has been exceeded in the last five years, and consequently no corrective actions have been needed.

Section 5.8 also describes the actions to be taken if an AL is exceeded, but further states that no ALs related to environmental radiological releases have been exceeded in the last five years.

It is concluded that Bruce Power meets the requirements of this review task.

5.3. Potential New Sources of Radiological Impact

The review task is to verify that:

> Potential new sources of radiological impact have been recognized by the operating organization.

Section 5.3.1 of CSA Standard N288.4-10 [35] defines the types of change that may result in the need for a revised Environmental Risk Assessment (ERA) and a change to the environmental monitoring program (EMP). This Standard goes on in Section 5.3.3 to require a periodic review of the EMP and in Section 5.3.4 to require revisions to the EMP where there has been a change in the environmental risks. In addition, CSA Standard N288.6-12 [37] requires in Section 11 that an ERA be reviewed "on a five-year cycle or more frequently if major facility changes are proposed that would trigger a predictive assessment..."

The process at Bruce Power for identifying radiological impacts (referred to as Environmental Aspects) is described in DPT-ENV-00016 [45]. There is a database that is used to track Environmental Aspects, which may be identified in a wide variety of ways, listed in Section 4.3 of the document.

The screening level (Tier 1) risk assessment required by N288.6-12 was completed in March 2013 [50]. A Tier 1 assessment applies screening criteria to identify environmental issues (receptors and stressors) that require further quantitative evaluation at a higher level (Tier 2 or Tier 3). However, radiological stressors require higher-level evaluation even though they meet the screening criteria, to satisfy CNSC reporting requirements and to address public concerns. The higher-level risk assessment was completed and issued in January 2015 [51].

A recent example of Bruce Power recognizing potential new (or additional) sources of radiological impact is a study that calculated the potential public dose due to routine releases of gaseous tritium (HT) [52]. The study concluded that, "HT could be emitted from Units at Bruce A in negligible quantities, when compared to emission of HTO. … Compared with public dose resulting from the total emissions from Bruce Power site, the dose to public due to the emission of gaseous tritium is expected to be four orders of magnitude less. Accordingly, HT

emission does not require regular monitoring and the calculation of [DRL] for HT is not required."

It is concluded that Bruce Power meets the requirements of this review task.

5.4. Sampling and Measurement Methods

The review task is to verify that:

> Sampling and measurement methods are consistent with current standards.

For environmental sampling, this review task is not explicitly addressed in any of the codes and standards that were assessed for this Safety Factor. Section 8.4 of CSA Standard N288.4-10 [35] is a list of references that provide guidance on sampling and analysis techniques, and this standard is currently being implemented at Bruce Power. For effluent sampling, guidance is provided in CSA Standard N288.5-11 [36], also currently being implemented.

The sampling and measurement procedures for radiological monitoring are referenced in B-PROC-00076 [43]. Most of the sampling and analyses are conducted by the Bruce Power Health Physics Laboratory, which has been accredited to the analytical laboratory standard ISO/IEC 17025 [53] by the Canadian Association for Laboratory Accreditation (CALA). The exception is environmental gamma-ray monitoring, which is performed with thermoluminescent dosimeters supplied and analyzed by the Ontario Power Generation Health Physics Laboratory. This laboratory is also accredited by CALA.

A recent audit [54] found some deficiencies in sampling and the reporting of results (see Section 7.2.1 for details.) These deficiencies are being corrected through three Action Requests (28456566, 28456570, and 28456573) and therefore this does not constitute a gap.

For effluent sampling and measurement, there is no corresponding list of procedures in either the program document, BP-PROC-00080 [44], or in the document Radionuclide Effluent Monitoring System Requirements, B-ST-03480-10000 [55]. The latter document states that "Procedure for the calculations of emissions must be documented. (These are currently found in Chemistry Laboratory Procedures.)", but does not reference those procedures. A self assessment of Chemistry Lab compliance with the requirements of ISO/IEC 17025 conducted at the end of 2013 (SA-CHEM-2013-01 [56]) identified many gaps, and actions are in progress to close them by the end of 2016 (see Section 7.1 for details.)

It is concluded that Bruce Power meets the requirements of this review task.

5.5. Effluent Discharge Records: Monitoring, Trending and Responding

The review task is to verify that:

> Records of discharges of effluents are being monitored and trended and appropriate actions are taken to remain within established limits and to keep such discharges as low as reasonably achievable.

PROL Condition 8.2 requires that releases of nuclear substances to the environment be controlled, monitored and recorded, such that releases do not exceed the Derived Release Limits (DRLs). The CSA Standard N288.5-11 [36] provides guidance on the design and operation of effluent monitoring programs at Class I nuclear facilities. Bruce Power has committed to the full implementation of this standard by December 2018 [55].

The Bruce Power effluent monitoring program and the requirements for recordkeeping are described in BP-PROC-00080 [44]. Results of effluent monitoring are reported in quarterly operations reports to the CNSC, as required by CNSC Standard S-99 [28] (recently superseded by CNSC REGDOC-3.1.1; see Section 5.10.) In addition, effluent monitoring results are included in the annual EMP Report.

Emission limits and ALs are given in BP-PROC-00171 [27]. The calculation of DRLs and ALs is described in NK21-REP-03482-00002 [57], which uses the methodology of CSA Standard N288.1-08, Update No. 1 [58]. There has been a recent revision of this standard, N288.1-14 [34], which updates some of the model parameters it prescribes for use in the calculations and refines some of the models. A high-level review of this standard is given in Appendix A.2. Bruce Power is participating in a CANDU Owners Group project to revise the DRL calculation program IMPACT to include the changes in N288.1-14 as described in COG Work Package# 30495 [59]. Once this is done, calculations will be based on the revised standard. This is considered to be indirect compliance.

Any exceedance of ALs must also be reported to the CNSC under S-99. The reporting process is described in BP-PROC-00165 [60]. According to BP-PROC-00171 [27], radiological emissions to the environment are kept ALARA by:

- Keeping radiological emissions below Internal Investigation Limits for each radionuclide group.
- Ensuring ALs are not exceeded.
- Ensuring that airborne and waterborne emissions are kept reasonably constant.
- Identify opportunities and taking action to reduce airborne and waterborne emissions during normal station operations.

The effectiveness of these measures is shown by the results described in Section 5.1.

It is concluded that the Bruce Power meets the requirements of this review task.

5.6. On-Site Monitoring and Prompt Detection

The review task is to verify that:

> On-site monitoring is undertaken at locations and using methods that have a high probability of the prompt detection of a release of radioactive material to the environment.

PROL Condition 8.2 requires that the licensee “control, monitor and record releases of nuclear substances to the environment from the nuclear facility such that the releases do not exceed the derived release limits …” The control aspect of this condition implies the need for prompt

detection of an unusually high release that could result in the DRL being exceeded. CSA Standard N288.5-11 [36] includes guidance on process monitoring, which "is intended to allow operators to take timely action to ensure that effluent releases remain under control."

CNSC G-228 also requires that an AL be supported by a monitoring program that can accurately detect when the AL is reached. This program should consist of an appropriate methodology and frequency of sampling or measurement [20].

Bruce Power's Effluent Monitoring Program, BP-PROC-00080 [44], describes the requirements for on-site monitoring of effluents. It includes references to the requirements of N288.5-11, and Bruce Power has committed to be in full compliance with this standard by December 2018 [55]. Among the objectives of the program are, "Confirm control at the source" and "Provide an indication of unusual conditions that might require corrective action." The program is implemented by BP-PROC-00171 [27], which defines ALs at 10% of the release limits that could lead to a public dose limit being reached, and Internal Investigation Levels (IILs) at still lower values to "provide the earliest possible warning of abnormal system behavior and allow remedial action to be taken should a radionuclide emission show a steady upward trend over time." Actions to be taken when an IIL has been exceeded are prescribed in this document. ALs and IILs are defined for reporting periods of one week for airborne contaminants and of one month for waterborne contaminants. In addition, there are limits on the concentration of specific radionuclides in the condenser cooling water outfall and in unit stacks. Calculations of Maximum Probable Emission Rates (MPERs) are used to "determine whether there is a need to regularly monitor a potential emission source and the type of monitoring that may be required." Values of the calculated MPERs are documented in the Site Emission Monitoring Plan [61].

The Bruce Power Design Standard, Radionuclide Effluent Monitoring System Requirements, B-ST-03480-10000 [55], provides detailed guidance on the requirements for performance and control monitoring of airborne and waterborne effluent streams. In this document, "performance monitoring" is defined as "the monitoring of an emission source that potentially could emit an amount of radioactivity equivalent to a significant proportion of any Derived Release Limit. Performance monitoring is required to demonstrate compliance with regulatory limits, measure emissions performance, calculate the potential dose impact to a critical group." Control monitoring is defined as, "the monitoring of an emission source to provide adequate warning to ensure automatic or operator action can be taken so targets and regulatory limits are not exceeded," and is equivalent to the process monitoring defined in N288.5-11. Control monitoring sampling frequencies for continuous streams are specified to ensure that no more than 5% of the applicable weekly DRLs could be released without detection and alarm.

It is concluded that the Bruce Power meets the requirements of this review task.

5.7. Off-Site Monitoring and Corrective Actions

The review task is to verify that:

> Off-site monitoring for contamination levels and radiation levels is adequate and corrective actions are taken to keep such levels as low as reasonably achievable.

Off-site monitoring must be adequate to demonstrate compliance with public dose limits, DRLs and ALs, all of which are regulatory or licence requirements. In addition, Regulatory Guide G-129 [19] requires in Clause 7.3.3 that "radionuclide emissions to the environment are kept ALARA." Detailed guidance for an environmental monitoring program is provided in CSA Standard N288.4-10 [35].

Management of the off-site Radiological Environmental Monitoring Program (REMP) is governed by BP-PROC-00076 [43]. The Bruce Power REMP states that it satisfies the requirements of CSA N288.4-10, although the company has not committed to full implementation of the standard until December 2018 [55]. Data presented in the 2013 EMP Report [49] and reproduced in Figure 1 show that dose to the public due to releases from the station have remained low and quite constant since 2001. The dose in 2009 was somewhat elevated relative to other years due to tritium emission from the vacuum building and unit outages occurring at the same time as the annual produce sampling. This resulted in an overly conservative estimate of the public dose, and no corrective actions were considered to be required. As described in Section 5.1, public doses have been far below applicable limits and background levels leaving very limited opportunity for further reductions on the basis of ALARA.

It is concluded that Bruce Power meets the requirements of this review task.

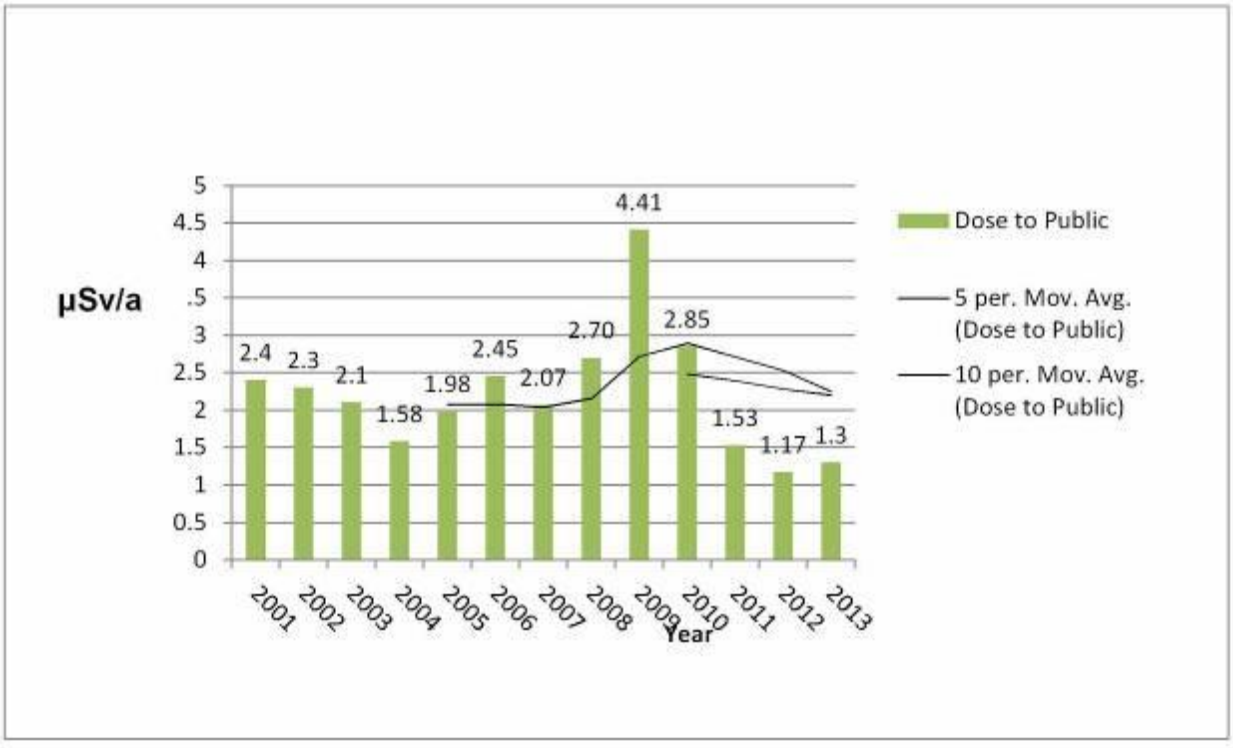

Figure 1: Historical Dose to Public Trend

5.8. Contamination Levels

The review task is to verify that:

> Actions have been taken to clean up contamination where reasonable and practicable.

Given that there have been no incidents where significant releases to the environment have occurred, this review task is interpreted to mean that actions have been taken to reduce radiological releases to the environment to levels that are below ALs and ALARA. One of these actions is to ensure that airstreams from contaminated areas are adequately cleaned of radioactive contamination before being released to the atmosphere. Effectiveness of the filters used for this is demonstrated by periodically testing their performance. A recent CSA Standard, N288.3.4-13 [96], establishes requirements and provides guidance for such testing.

If an AL is exceeded, Section 4.3.1 of BP-PROC-00171 [27] specifies the required actions, which include "Promptly identify source of emission (utilizing Task Analysis Meeting (TAM)) and mobilize prompt corrective action to reduce emissions to normal operating levels, including unit shut down if the source cannot be mitigated with the unit on-line." Similar actions are required when an IIL is exceeded at more than 25% of an AL. Adoption of the ALARA principle is demonstrated by the actions listed in Section 5.5, above. In addition, Section 4.10 of BP-PROC-00171 requires that, to ensure the proper persons are notified and the appropriate level of response achieved when a spill or release is occurring, reference be made to BP-PROC-00059, Event Response and Reporting [62], and that initial sampling requirements be identified according to BP-PROC-00093, Spills to the Environment [63].

Based on a search for S-99 reportable events in the Station Condition Record (SCR) database, no ALs related to environmental radiological releases have been exceeded in the last five years.

In addition, there is a Bruce Power procedure on the management of soil and groundwater contamination, BP-PROC-00241 [64]. While it applies to contamination on-site, appropriate management of such contamination should prevent its spread off-site. The procedure describes how environmental site assessments are conducted, and the process for remediating any contaminated sites that are identified. Although radioactive contamination is not explicitly excluded from the procedure, the emphasis is clearly on chemical contamination.

Regarding the performance testing of air-cleaning systems, BP-PROC-00171 [27] in Section 4.14.2.1 states that, "Performance Requirements for Contamination Exhaust Control Filters shall follow DPT-PE-00005, and should comply with CSA N288.3.4 Performance testing of nuclear air-cleaning systems at nuclear facilities." Testing of air-cleaning systems at the Bruce site is currently contracted to Kinectrics. The contract [97], in effect for 2012-2016, notes that, "In the absence of a Canadian Standard being available at this time CSA N288.3.4 Performance testing of air cleaning systems at Nuclear Mines and Mills, best practices shall be used." It is further stated, under Quality Assurance Requirements, "Work to be done in compliance to CSA N288.3.4." An assessment of N288.3.4 [96] revealed a number of gaps in the Bruce Power program for filter performance testing. These are described in detail in Appendix A (A.10).

It is concluded that Bruce Power does not fully meet the requirements of this review task.

5.9. Alarm Systems Responding to Unplanned Releases of Radioactive Material

The review task is to verify that:

> Alarm systems to respond to unplanned releases of radioactive material from on-site facilities are suitably designed and available and will remain available in the future.

Licence Condition 8.2 of the PROL [15] requires the licensee to control, monitor and record releases of nuclear substances to the environment so that releases do not exceed DRLs. In CSA Standard N288.5-11 [36], Clause 0.2.2.3 describes process monitoring as a means "to allow operators to take timely action to ensure that effluent releases remain in control. As such, it generally requires the real-time (or near real-time) measurement of the instantaneous or short-term value of selected effluent parameters." There is no discussion in the standard of automatic alarms. The American National Standard ANSI/HPS N13.1-1999 [39] contains guidance on determining the level at which an alarm for airborne contamination should be generated (which it refers to as an "action level") and on determining whether a sampling or monitoring system is sufficiently sensitive to detect such a level.

Section 4.13 of BP-PROC-00171 [27] provides guidance on the calculation of MPERs, upon which monitoring requirements are based, and on actions to be taken when a stack monitor alarm is exceeded. Appendix A of the site emission monitoring plan, NK21-PLAN-03480-0001 [61], shows stack alarms for high rates of release of noble gases, particulates and radioiodine. Table 1 of B-ST-03480-10000 [55] shows that alarms are required for monitoring airborne effluent streams, and a footnote says, "Alarms can be either physical devices or procedures which alert appropriate staff of monitor malfunction or emissions in excess of a set point or target. Justification for local or control room alarms and the type of alarm mechanism is at the discretion of the facility." Section 4.14 of B-PROC-00171 describes Quality Assurance/Quality Control (QA/QC) requirements, including specifications for instrument sensitivity and data uncertainty.

There is a Liquid Effluent Monitor in the discharge line to the condenser cooling water duct. According to the Bruce A 2012 Safety Report – Part 2 [65], discharge is automatically terminated "if high activity is detected in the discharge line. In such an event, the discharge line is drained and the waste undergoes further treatment, as necessary, before discharge is resumed." Table 2A of B-ST-03480-10000 [55] shows that alarms are required for liquid effluent batch streams from the Radioactive Liquid Waste Management System, and Table 2B provides the same information for liquid effluent batch streams from other systems. Table 3 of this standard specifies alarms for liquid effluent continuous streams. All three of these tables include the same footnote regarding alarms as quoted above for airborne emissions.

Radioactive solid wastes produced at Bruce A are not normally removed from the Bruce site. Instead, they are transferred to the Western Waste Management Facility, which is operated by Ontario Power Generation on the Bruce site, for long-term storage. Bruce Power has established a "likely clean" program for Zone 2 wastes that are anticipated to be free of radioactive contamination. These wastes are packaged and handled separately from other Zone 2 wastes [66]. After monitoring, these wastes are "cleared" for disposal as inactive waste. A portal radiation monitor at the main gate provides an indication of the presence of radioactive

material in (or on) any vehicle leaving the site. This would be sufficient to identify any unplanned release of solid radioactive wastes from the site. There are also contamination monitors for people and their possessions leaving potentially contaminated areas, which would alarm and prevent the spread of contamination to the environment.

It is concluded that Bruce Power meets the requirements of this review task.

5.10. Publication of Environmental Data

The review task is to verify that:

> Appropriate data have been published on the environmental impact of the plant.

PROL Condition 1.7 requires the licensee to notify and report in accordance with CNSC regulatory document S-99 [28], and to implement and maintain a public information and disclosure program in accordance with CNSC regulatory document RD/GD-99.3 [21]. CNSC REGDOC-3.1.1 [23], which replaced S-99 [28] in May 2014, is listed as Condition 1.7 in PROL 18.00/2020 [17] and sets reporting requirements for nuclear power plants. Bruce Power switched over to CNSC REGDOC-3.1.1 at the beginning of 2015[5], as committed in a letter submitted to the CNSC in November 2014 [29].

Bruce Power reports quarterly and annually according to the requirements of S-99. The quarterly reporting requirement is met by submitting to the CNSC Quarterly Operations Reports, which include a section on environmental monitoring. Specifically, data on airborne and waterborne radioactive emissions, unplanned monitoring and facility emissions effective dose are included in these reports. The annual Environmental Monitoring Program Report contains more complete and detailed information on the results of effluent and environmental monitoring, including historical trends for comparison. It is also submitted to the CNSC, and is subsequently posted on the Bruce Power website for public access.

Like S-99, CNSC REGDOC-3.1.1 specifies the type and frequency of reporting to the CNSC. It requires quarterly reporting of defined performance indicators, including radiological releases to the environment, and also annual reporting of information on environmental protection. It also regulates the issuing of event reports to the CNSC. The reporting done by Bruce Power exceeds the requirements of S-99 and satisfies the requirements of CNSC REGDOC-3.1.1.

In addition, CNSC RD/GD-99.3 [21] requires Class I facility operators to establish and operate a program for public information, including “routine and non-routine releases of radiological and hazardous materials to the environment.”

The objective of the Bruce Power Stakeholder Interaction Program, BP-PROG-09.02 [67], is “to ensure groups and individuals who have the potential to influence Bruce Power’s success are identified, their interests and requirements are understood and they receive the appropriate level of communication, according to a defined disclosure protocol.” The program is

[5] Reporting is performed under S-99 up to the end of 2014, and under CNSC REGDOC-3.1.1 for periods thereafter.

implemented, in part, by a procedure for responding to enquiries from the public, BP-PROC-00052 [68], and a procedure for disclosing information to stakeholders, BP-PROC-00919 [69].

These procedures aim to ensure open and transparent communication with the public, community, and stakeholders and organizations with an interest in Bruce Power's operations. For instance, Bruce Power's Website provides a user-friendly and accessible platform for members of the public to obtain information about Bruce Power's values and policies, environmental assessments, including publishing:

- an Annual assessment report on environmental and radiological data (http://www.brucepower.com/category/reports/environmental-reports/); and
- Licence Renewal activities (http://www.brucepower.com/licence-renewal-2015/).

The Website also offers other means for staying connected with the community, including social media, publishing:

- quarterly reports (http://www.brucepower.com/community/community-updates/), which are distributed to 50,000 people in Bruce, Grey and Huron Counties; and
- annual reports (http://www.brucepower.com/reports-archive/) available to all readers.

It is concluded that Bruce Power meets the requirements of this review task.

5.11. Changes in the Use of Areas Around the Site

The review task is to verify that:

> Changes in the use of areas around the site have been taken into account in the development of monitoring programs.

Section 5.3.1 of CSA Standard N288.4-10 [35] lists a number of events that should initiate a review of the EMP. One of these is "a change in the population or land use in the surrounding community."

Section 4.3 of DPT-ENV-00016 [45] presents a list of sources of information on changes that can result in a revision to the Environmental Aspects database, and potentially to the EMP. The Environmental Aspects database is a password protected spreadsheet that demonstrates how Environmental Aspects and Significant Environmental Aspects are managed at Bruce Power. One of the sources of information is "Changes in the surrounding community including new public interest or concerns." In addition, BP-PROC-00076 [43] requires in Section 4.5.6.1 an annual review of the EMP, including an assessment of "Any site-specific parameters that have changed such as land usage, population distribution, meteorology, hydrology, water uses, food sources, etc." There is also a requirement for a "systematic review of the REMP design" at least every five years, per Section 4.5.6.2 of BP-PROC-00076.

The site specific survey provides information regarding land usage, population distribution, water sources, water use and food sources in the vicinity of the Bruce Power site. The site specific survey is conducted every five years or prior to licence renewal unless a significant change in the community or site operations requires an earlier survey. The information from this survey is used to update potential critical groups, conduct pathways analysis and subsequently

update the DRLs for the nuclear facilities on the Bruce Power site. These changes may also result in changes to the environmental monitoring program. The most recent site specific survey was conducted in 2011 [70].

It is concluded that Bruce Power meets the requirements of this review task.

6. Interfaces with Other Safety Factors

There is some degree of interrelationship among most of the 15 Safety Factors that comprise the Bruce A ISR. The following identifies specific aspects of this Safety Factor that are addressed in, or where more detail is provided in, another Safety Factor Report.

- "Safety Factor 1: Plant Design" in Appendix B.2, assesses requirements and guidance regarding environmental protection considerations within the plant design.
- "Safety Factor 8: Safety Performance" in Section 4.6, discusses the Corrective Action Program which addresses issues identified through internal, independent audits of the EMS and REMP.
- "Safety Factor 10: Organization and Administration" in Section 5.4.8, discusses the prioritization of safety issues, with realistic objectives and timescales, that ensures that these issues receive proper resources.
- "Safety Factor 11: Procedures" in Appendix B.2, assesses requirements and guidance related to radioactive waste.

For the purposes of this assessment, the following scopes have been assumed for Safety Factors 13, 14 and 15:

- "Safety Factor 13: Emergency Planning" has been interpreted to include the preparations made for the protection of people and the environment from the adverse effects of exposure to ionizing radiation during abnormal operations;
- "Safety Factor 14 (this report): Radiological Impact on the Environment" has been interpreted to include the protection of people and the environment outside the Protected Area of the station from the adverse effects of exposure to ionizing radiation during normal operations which includes anticipated operational occurrences; and
- "Safety Factor 15: Radiation Protection" has been interpreted to include the protection of people inside the Protected Area of the station from the adverse effects of exposure to ionizing radiation during normal operations which includes anticipated operational occurrences (there are no natural areas of any significance inside the Protected Area of the station).

7. Program Assessments and Adequacy of Implementation

Section 7 supplements the assessments of the review tasks in Section 5, by providing information on four broad methods used to identify the effectiveness with which programs are implemented, as follows:

- Self-Assessments;
- Internal and External Audits and Reviews;
- Regulatory Evaluations; and
- Performance Indicators.

For the first three methods, the most pertinent self-assessments, audits and regulatory evaluations are assessed. Bruce Power has a comprehensive process of reviewing compliance with Bruce Power processes, identifying gaps, committing to corrective actions, and following up to confirm completion and effectiveness of these actions. While there have been instances of non-compliance with Bruce Power processes, Bruce Power's commitment to continuous improvement is intended to correct any deficiencies.

For the fourth method, the performance indicators relevant to this Safety Factor are provided. These are intended to demonstrate that there is a metric by which Bruce Power assesses the effectiveness of the programs relevant to this Safety Factor.

Taken as a whole, these methods provide a cross section, intended to demonstrate that the processes associated with this Safety Factor are implemented effectively (individual findings notwithstanding). Thus, program effectiveness can be inferred if Bruce Power processes meet the Safety Factor requirements and if there are ongoing processes to ensure compliance with Bruce Power processes. This is the intent of Section 7.

7.1. Self-Assessments

Generally, self-assessments are used by functional areas to assess the adequacy and effective implementation of their programs. The results of the assessment are compared with business needs, the Bruce Power management system, industry standards of excellence and regulatory/statutory or other legal requirements.

The self-assessments:

- Identify internal strengths and best practices;
- Identify performance and/or programmatic gap(s) as compared to targets, governance standards and "best in class";
- Identify gaps in knowledge/skills of staff;
- Identify the extent of adherence to established processes and whether the desired level quality is being achieved;

- Identify adverse conditions and Opportunities for Improvements (OFI); and
- Identify the specific improvement corrective actions to close the performance/programmatic gap.

Focus Area Self-Assessment SA-ENV-2011-01, "Effluent Monitoring – Radiological", October 2011 [71]

This self-assessment reviewed Bruce Power's Radiological Effluent Monitoring Program against CSA Standard N288.5 [36], with the objective of identifying actions required to ensure compliance. Many gaps and deficiencies were found, both in program documentation and in execution. These led to numerous action assignments, documented in Action Requests 28266485 and 28238120. All assignments have been completed by their due date, with some outstanding and the last one due by February 15, 2016.

Focus Area Self-Assessment SA-ENV-2011-02, "Effectiveness Review on Environmental Impact Worksheets (EIW)", 30 September 2011 [72].

The objective of this self-assessment was to "Review the effectiveness of environmental impact worksheet and practices at Bruce Power in relation to top performers in the industry and provide areas for improvement." Four issues were identified:

#1: "Some activities that interact with the environment occurred because the process of assessing impacts on the environment was not followed or form 11422 (EIW) was not used."

#2: "... EIWs are not clearly understood by project proponent, environmental officers in field and environmental programs."

#3: "There are instances where follow-up actions are not tracked for completion and EIW forms cannot be retrieved for oversight and assessment purpose."

#4: "There is no effective oversight on EIWs to make sure if all environmental and waste management consideration are taken care of and EIW are managed to their completion."

While all of the examples given in this self-assessment were related to non-radiological environmental impacts, the issues identified would also have a negative effect on the identification of radiological environmental impacts. All of the 24 corrective actions arising from this self-assessment had been completed by 30 June 2013 (AR# 28266253).

Focus Area Self-Assessment SA-ENV-2012-01, "Environmental Monitoring – N288.4-10", December 2012 [73].

This self-assessment was performed to review Bruce Power's EMP against the requirements of CSA Standard N288.4-10 and to identify actions for implementation to ensure compliance. Many adverse conditions were identified related to inadequacy of current documentation relative to that required by the standard. One adverse condition was the absence of an implementation plan for N288.4-10, and another was the need to review and document the effectiveness of implementation of the standard. There were also three opportunities for improvement noted, one of which was to implement the use

of one software system for data management that minimized human intervention. The corrective action plan, documented under AR# 28335084, contains 26 assignments, of which 19 were completed by 31 October 2014 and the remaining 7 are due between 30 June 2015 and 15 December 2015. The assignment to prepare an implementation plan for N288.4-10 was closed as complete on 12 December 2013, with a note that it was done in Microsoft Project with multiple levels.

Focus Area Self-Assessment SA-ENV-2013-01, "Transition to CSA N288.6 Environmental Risk Assessments at Class I Nuclear Facilities and Uranium Mines and Mills", 1 December 2013 [74].

The purpose of this self-assessment was to review Bruce Power processes, policies and procedures against the requirements of CSA Standard N288.6-12. It looked at the high-level implementation plan that had been submitted to CNSC as part of the PROL licence renewal application, and assessed progress on that plan. The self-assessment identified five issues; four of these related to interfaces between Bruce Power and other users of the Bruce site, and CNSC. The one issue that is relevant to this Safety Factor was #5, which was that the Bruce Power Tier 2/Tier 3 risks had not yet been identified. The corrective action was to ensure that several of the steps in the Implementation Plan will be completed following the Tier 2/Tier 3 ERA, by adding additional activities to Action Tracking. This has been done under AR# 28405618, and the actions due so far have been either cancelled or completed. Several actions remain open for completion by dates in 2016-2018.

Focus Area Self-Assessment SA-CHEM-2013.01, "Chemistry Quality Assurance/Quality Control Management Standards", December 20, 2013 [56].

Station Chemistry Labs analyze effluent samples, and are therefore subject to the requirements of Standard CSA 288.5-11 [36]. The CSA Standard in turn requires analytical labs to establish and maintain QA/QC programs such as those described by the ISO/IEC Standard 17025 [53]. This self assessment looked at compliance of the Chemistry Program and Labs with the requirements of ISO/IEC 17025. It found numerous program gaps, infrastructure deficiencies and compliance gaps. Several Action Requests resulted: 28410002, 28410004, 28410009, 28410013 and 28410030. Many of the assignments have been completed, several are in progress, and the last one is due December 16, 2016. There is one assignment that was due May 13, 2015, and is now overdue, but it was intended to address an opportunity for improvement recommendation, rather than an issue.

7.2. Internal and External Audits and Reviews

The objective of the audit process as stated in BP-PROG-15.01 [75] is threefold:

- To assess the Management System and to determine if it is adequately established, implemented, and controlled;
- To confirm the effectiveness of the Management System in achieving the expected results and that risks are identified and managed; and
- To identify substandard conditions and enhancement opportunities.

The objective is achieved by providing a prescribed method for evaluating established requirements against plant documentation, field conditions and work practices. The process describes the activities associated with audit planning, conducting, reporting, and closing-out. The results of the independent assessments are documented and reported to the level of management having sufficient breadth of responsibility for resolving any identified problems (as stated in Section 5.14.2 of [24]).

7.2.1. Internal Audits

Seven recent audits performed by the Bruce Power Nuclear Oversight and Regulatory Affairs Division were reviewed. The bases for all of these audits were S-296 [46], ISO 14001:2004 [42], CSA N288.4-10 [35] and any applicable legal and internal requirements. The focus areas of each audit were as indicated below.

- Audit Report AU-2009-00001, “EMS and Environment Compliance Audit”, June 2009 [76].

  Focus was on water emissions, waste and PCBs.

- Audit Report AU-2010-00005, “EMS and Environment Compliance Audit”, June 2010 [77].

  Focus was on air emissions, ozone depleting substances and spills management.

- Audit Report AU-2010-00035, “Radiation Environmental Monitoring Program (REMP)”, October 2010 [78].

  Focus was on compliance with core element requirements defined in the following clauses of N288.4-10 [35]:
  - Clause 6 – Design of an EMP
  - Clause 8 – Sampling and analytical procedures
  - Clause 9 – Interpretation of Data
  - Clause 10 – Quality assurance (QA) and quality control (QC)
  - Clause 11 – Reporting, review and audit.

- Audit Report AU-2012-00003, “Environmental Safety Management”, May 2012 [79].

  Focus was on air emissions, waste management, PCBs and “other” requirements.

- Audit Report AU-2012-00004, “Radiation Environmental Monitoring (REMP) Audit”, December 2012 [80].

  Focus was on compliance with non-core element requirements defined in the following clauses of N288.4-10 [35]:
  - Clause 4 - Objectives of an EMP
  - Clause 5 - Criteria for establishing and revising an EMP
  - Clause 7 - Guidance for design elements of an EMP
  - Clause 12 - Staff qualifications and training
  - Clause 13 - Documentation.

- Audit Report AU-2013-00003, “Environmental Safety Management Audit”, June 2013 [81].

Focus was on conventional and radioactive water emissions, ozone depleting substances and spills management.

- Audit Report AU-2014-00004, "Radiation Environmental Monitoring – Essential Elements", August 2014 [54].

  Focus was on the same core element requirements as in the audit reported in AU-2010-00035, and so the results of this audit supersede those of the earlier audit.

In general all seven audits found that the Bruce Power EMS meets the requirements of ISO 14001 and in the vast majority of cases is compliant with legislation. However, weaknesses were noted in several areas that may affect control of radiological emissions:

- Poor corrective action completion and effectiveness, including corrective actions arising from previous audits - this was a repeat finding common to all audits;
- Environmental impacts of operational changes not effectively controlled;
- REMP not clearly and concisely documented (R004), and documentation not current;
- Environmental related documents not always adequately controlled;
- Environmental related records not always adequately managed;
- Quality Assurance/Quality Control (QA/QC) requirements of external service providers not clearly defined;
- Program reviews for REMP do not always ensure alignment with design basis document;
- Some procedures contain inconsistent and inadequate instructions;
- REMP training and qualifications not effectively implemented in areas of systematic approach to training and external service provider qualifications;
- Lack of fully qualified environmental staff.

These weaknesses relate to quality management issues, rather than technical deficiencies. Consequently, they are not directly related to the review tasks of this Safety Factor.

The most recent audit, in 2014, also found that some technical requirements of the REMP were not always met. Specifically:

- Sampling specifications and instructions were not adequate; and
- There was noncompliance with reporting of sample results and associated uncertainties.

These technical findings could have a negative impact on the reliability and credibility of the REMP results. Bruce Power management has accepted the findings, and corrective actions were due for completion by 1 December 2014 (AR# 28456570). Some new actions have been added, and are now due for completion by 28 April 2015.

The 2014 audit report also noted that there has been progress towards implementation of the requirements of CSA Standard N288.4-10 in anticipation of it becoming a licence requirement, but the REMP is not yet fully compliant with it.

7.2.2. External Audits and Reviews

CALA performed assessments of the Health Physics Laboratory in 2012 [82] and 2014 [83] to verify compliance with ISO/IEC 17025 [53], for purposes of accrediting the laboratory to that standard.

In the 2012 assessment, CALA identified four non-conformances, all related to quality assurance and documentation (AR# 28315267). The necessary changes to documents have been made.

In the 2014 assessment, there were eight findings (AR# 28450986). Most again were related to quality assurance and documentation, but two had technical implications:

- "No documentation for [sample] holding times was defined".
- "Verify all reagents are labeled with material concentration or purity, date of prep and expiry date."

The corrective action for the first of these has been completed. No corrective action was defined for the second finding, possibly because it was rated "Type C", meaning an optional recommendation.

7.3. Regulatory Evaluations and Reviews

After a licence is issued, the CNSC stringently evaluates compliance by the licensee on a regular basis. In addition to having a team of onsite inspectors, CNSC staff with specific technical expertise regularly visit plants to verify that operators are meeting the regulatory requirements and licence conditions. Compliance activities include inspections and other oversight functions that verify a licensee's activities are properly conducted, including planned Type I inspections (detailed audits), Type II inspections (routine inspections), assessments of information submitted by the licensee to demonstrate compliance, and other unplanned inspections in response to special circumstances or events.

Type I inspections are systematic, planned and documented processes to determine whether a licensee program, process or practice complies with regulatory requirements. Type II inspections are planned and documented activities to verify the results of licensee processes and not the processes themselves. They are typically routine inspections of specified equipment, facility material systems or of discrete records, products or outputs from licensee processes.

The CNSC carefully reviews any items of non-compliance and follows up to ensure all items are quickly corrected.

- Bruce A and B Radiological Environmental Monitoring Program Inspection Report BRPD-2010-AB-010 [84]

  This CNSC inspection resulted in a single recommendation: that the Bruce Power Laboratory present data as collected (average/single point) and that the numbers be

presented as such in the annual report as accurately as possible. Bruce Power responded by making the necessary document changes to implement the recommendation [85].

- Bruce A and Outside Bruce Power CNSC Compliance Inspection Report BRPD-A-2012-013 Environmental Monitoring Bruce A and Outside Bruce Power – Action Item 1207-3231 [86]

  The general conclusion of this inspection report was that "the effluence and environmental monitoring program at the Bruce Power site meets the CNSC requirements. However, one action notice has been raised as a result of this inspection." That Action Item was to actively review a number of Temporary Configuration Changes that had been in place longer than permitted by Bruce Power procedure. Bruce Power notified the CNSC of their compliance with the Action Item in November 2012 [87], and the CNSC closed the Action Item in December 2012 [88].

- Bruce A and B Quarterly Field Inspection Report for Q4 of 2013-14 [89]

  The conclusion of this CNSC field inspection regarding environmental protection was that, "Bruce Power emissions were low and well below regulatory limits. Environmental monitoring equipment was observed to have no indications of impairments to functionality." There were no enforcement actions resulting from this inspection.

7.4. Performance Indicators

Performance indicators are defined as data that are sensitive to and/or signals changes in the performance of systems, components, or programs.

The Bruce Power Environmental Performance Index (EPI) is a composite report card which uses environmental events and regulatory infractions as a means to monitor and measure environmental performance. The following environmental performance indicators are reported in the EPI:

- Spills and releases
- Regulatory infractions
- Water emissions
- Air emissions

In compliance with CNSC REGDOC-3.1.1, Bruce Power submits an annual report on environmental protection. Quarterly reports on safety performance indicators include data on weekly airborne and monthly waterborne radiological emissions; the latest revision of the procedure for these reports [90] was issued to ensure compliance with CNSC REGDOC-3.1.1.

In addition, the CNSC produces an annual report on the safety performance of Canada's NPPs. The report for 2013, "CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants for 2013", issued in September 2014 [91], summarizes the 2013 ratings for Canada's NPPs in each of the 14 CNSC Safety and Control Areas (SCA), including environmental protection. For 2013, the Bruce A rating for the environmental protection SCA was "satisfactory".

8. Summary and Conclusions

The overall objective of the Bruce A ISR is to conduct a review of Bruce A against modern codes and standards and international safety expectations and provide input to a practicable set of improvements to be conducted during the Major Component Replacement in Units 3 and 4, and during asset management activities to support ongoing operation of all four units, that will enhance safety to support long term operation. The specific objective of the review of this Safety Factor is to determine whether the operating organization has an adequate program for surveillance of the radiological impact of the plant on the environment, which ensures that emissions are properly controlled and are ALARA. This specific objective has been met by the completion of the review tasks specific to radiological impact on the environment.

Bruce Power's Environmental Safety Management Program [41] and its procedures meet the requirements set out in the applicable regulations, Licence Conditions and regulatory documents. The program is consistent with the current best practices in the industry and work is underway towards implementation of the latest industry standards: CSA N 288.4-10, CSA N288.5-11 and CSA N288.6-12.

However, Bruce Power's program for performance testing of air-cleaning systems was found not to fully satisfy the requirements of the CSA Standard N288.3.4-2013 [96]. The key issue is summarized in Table 7.

Table 7: Key Issues

Issue Number	Gap Description	Source(s)
SF14-1	Performance testing of air-cleaning systems: documentation does not fully meet the requirements of CSA N288.3.4 [96].	Section 5.8 Micro-gaps against requirement clauses: CSA N288.3.4 Clauses 8.5, 8.9, 10, 11, 12, 13

9. References

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[2] NK21-CORR-00531-11005/NK29-CORR-00531-11397, Submission of Safety Basis Report, Bruce Power Letter, F. Saunders to R. Lojk, December 30, 2013.

[3] IAEA SSG-25, Periodic Safety Review of Nuclear Power Plants, IAEA, 2013.

[4] CNSC RD-360, Life Extension of Nuclear Power Plants, CNSC, 2008.

[5] NK21-CORR-00531-03839, Bruce A Environmental Assessment Study Report, Bruce Power, December 7, 2005.

[6] CNSC REGDOC-2.3.3, Operating Performance: Periodic Safety Reviews, CNSC, April 2015.

[7] NK21-CORR-00531-00514, Bruce A: CNSC approval to Restart Units 3 and 4 and Application to Amend PROL 15.01/2003, Bruce Power Letter, F. Saunders to J.H.M. Douglas, November 16, 2001.

[8] NK21-CORR-00531-04059, Bruce A Refurbishment for Life Extension – Systematic Review of Safety: Plant Design, Bruce Power Letter, F. Saunders to P. Webster, March 30, 2006.

[9] NK21-CORR-00531-04339, Bruce A Units 1 and 2 Return to Service – Systematic Review of Safety, Bruce Power Letter, F. Saunders to P. Webster, July 31, 2006.

[10] NK21-CORR-00531-05976, Bruce A Units 3 and 4 Refurbishment for Life Extension and Continued Operation: ISR Safety Factor Reports, Bruce Power Letter, F. Saunders to P. Elder, June 2, 2008.

[11] NK21-CORR-00531-06596, Bruce A Units 3 and 4 Refurbishment for Life Extension and Continued Operation: ISR Safety Factor Reports 1, 2, 3 and 4, Bruce Power Letter, F. Saunders to K. Lafrenière, December 18, 2008.

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[14] Nuclear Safety and Control Act, 1997, c. 9, N-28.3, Assented to March 20, 1997.

[15] NK21-CORR-00531-11272, Nuclear Power Reactor Operating Licence, Bruce Nuclear Generating Station A (PROL 15.00/201), May 1, 2014.

[16] NK21-CORR-00531-11391, Bruce Nuclear Generating Station A Nuclear Power Reactor Operating Licence: Licence Conditions Handbook (LCH-BNGSA-R8), June 4, 2014.

[17] PROL 18.00/2020, e-Doc 4723908, Nuclear Power Reactor Operating Licence, Bruce Nuclear Generating Station A and Bruce Nuclear Generating Station B, June 1, 2015.

[18] LCH-BNGS-R000, e-Doc 4659316, Bruce Nuclear Generating Station A and Bruce Nuclear Generating Station B Power Reactor Operating Licence, June 1, 2015.

[19] CNSC G-129 – R001, Keeping Radiation Exposures and Doses 'As Low As Reasonably Achievable (ALARA)', CNSC Regulatory Guide, October 2004.

[20] CNSC G-228, Developing and Using Action Levels, CNSC Regulatory Guide, March 2001.

[21] CAN/CSA RD/GD-99.3, Public Information and Disclosure, CNSC Regulatory Document, March 2012.

[22] CAN/CSA REGDOC-2.9.1, Environmental Protection: Policies, Programs and Procedures, CNSC Regulatory Document, September 2013.

[23] CNSC REGDOC-3.1.1, Reporting Requirements for Nuclear Power Plants, CNSC Regulatory Document, May 2014.

[24] CAN/CSA N286-05, Management System Requirements for Nuclear Facilities, 2007.

[25] CAN/CSA N286-12, Management System Requirements for Nuclear Facilities, 2012.

[26] CAN/CSA N292.3-14, Management of low- and intermediate-level radioactive waste, May 2014.

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[28] CNSC S-99, Reporting Requirements for Operating Nuclear Power Plants, CNSC Regulatory Standard, March 2003.

[29] NK21-CORR-00531-11189/NK29-CORR-00531-11593, Action Item 1307-4697: CSA N286-12 - Management System Requirements for Nuclear Facilities, Bruce Power Letter, F. Saunders to K. Lafrenière, May 16, 2014.

[30] NK21-CORR-00531-11494, CSA N286-12 - Management System Requirements for Nuclear Facilities, Action Item 1307-4697, CNSC Letter, Lafrenière to F. Saunders, July 24, 2014.

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[32] CNSC RD-346, Site Evaluation for New Nuclear Power Plants, CNSC Regulatory Document, November 2008.

[33] IAEA NS-R-3, Site Evaluation for Nuclear Installations, IAEA, November 2003.

[34] CAN/CSA N288.1-14, Guidelines for Calculating Derived Release Limits for Radioactive Material in Airborne and Liquid Effluents for Normal Operation of Nuclear Facilities, CSA Standard, March 2014.

[35] CAN/CSA N288.4-10, Environmental Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills, CSA Standard, May 2010.

[36] CAN/CSA N288.5-11, Effluent Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills, CSA Standard, April 2011.

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Appendix A – High-Level Assessments Against Relevant Codes and Standards

A.1. CNSC REGDOC-2.9.1, Environmental Protection Policies, Programs and Procedures

A comparison of CNSC REGDOC-2.9.1, Environmental Protection Policies, Programs, and Procedures [22], to the standard and guideline documents that it replaces, S-296 [46] and G-296 [47], showed no significant changes with respect to routine environmental releases. Clause 3.2 uses the word “should” rather than the word “can” that was used in G-296 in reference to using the regulatory document and ISO 14001 to develop an EMS, which makes the statement stronger. Since Bruce Power has developed their EMS to comply with ISO 14001, the change does not have any effect.

Full compliance with CNSC REGDOC-2.9.1 by Bruce Power will require [92]:

- Identification and adoption of industry “best practice” for the assessment of risks related to non-human biota; and
- Administrative documentation updates.

These actions will be completed in the course of implementing standards N288.4, N288.5 and N288.6, targeted for completion by December 2018.

A.2. CSA N288.1-14 Guidelines for Calculating Derived Release Limits for Radioactive Material in Airborne and Liquid Effluents for Normal Operation of Nuclear Facilities

Bruce Power is required by the CNSC to calculate DRLs and environmental ALs for radionuclide releases to the environment from its nuclear facilities. DRLs and ALs for Bruce NGS A are described in NK21-REP-03482-00002 Rev 002 [57], which uses the guidance and methodology specified in the CSA Standard N288.1-08, Update No. 1 [58]. NK21-REP-03482-00002 Rev 002 also took into account the results of 2011 site specific survey for the Bruce Power site [70] and used the most recent meteorological data. However, since this report was written, CSA N288.1-14 has been issued [34]. This standard is intended to provide guidance for DRL calculations and supersedes the previous editions published in 2008 and 1987. The major differences between this standard (CSA N288.1-14, March 2014 [34]) and the previous edition of this Guideline (CSA Standard N288.1-08, Update No. 1) include:

(a) updated energy expenditures and dietary intake rates for humans (e.g., as per Clauses in Section 6.15.1);

(b) updated half-lives (Annex E), gamma energies, and photon yields for all radionuclides (Table H.2);

(c) updated values for many parameters based largely on a new International Atomic Energy Agency handbook of parameter values for environmental transfers of radionuclides (IAEA, 2010) – E.g. as per Clauses in Sections 6.3.4.4, 6.9.1.4, 6.9.2.2, 6.9.3.2, 6.10.4.1, 7.7.2.4, 7.8.2, etc.;

(d) improved direction on when the Guideline can be used to calculate DRLs for intermittent releases (e.g., as per Clauses in Sections 8.2.2 and 8.2.3.1);

(e) updated wind direction and precipitation data for use in the wet deposition model (e.g., as per Clauses in Section 8.2.3.1);

(f) introduction of a model for wild waterfowl as an additional source of human exposure through ingestion (e.g., as per Clauses in Sections 6.9.1.5, 6.9.2.3, 6.10.1.4, 6.11.1.3, 7.9.1.1, 7.9.1.2, 7.9.2);

(g) extension of the carbon-14 (C-14) specific activity model to cover plant to animal transfer (e.g., as per Clauses in Sections 6.9.4, 6.10.4.2, 7.7.5.4 – 7.7.5.6);

(h) an improved specific activity model for tritium in animals, including an update and extension of the water intake source fractions for fresh and dry feed (e.g., as per Clauses in Sections 6.9.4, 7.7.4.2, 7.7.4.5, 6.9.1.1, 6.9.2.3, 6.10.1.1, 6.10.2.2, 6.10.2.3, 6.12.1.4); and

(i) provision of equations for explicit accounting of decay and progeny ingrowth in all physical media, as an alternative to the use of progeny-inclusive dose coefficients (e.g., as per Clauses in Sections 4.3.2, 4.3.3, 4.3.4, 4.3.9, 4.3.10, 4.3.11, Annex I).

Clauses for which there have been changes to parametric values (such as 6.2.7, 6.3.3.3, 6.3.3.4, 6.3.6.3, 6.4.4, 6.4.8.4, 6.4.9.3, 6.5.5.2, 6.6.2.2, 6.6.2.4, 6.9.1.3, 7.11.2) will have to reviewed again and taken into consideration when revising the DRLs.

There are also new clauses that provide guidance for calculating the transfer of radionuclides from pond water to pond sediment (see Clause 6.6.2.6). Section 6.9 has been revised to cover transfer from ponds and wells to plant produce (in addition to animal produce). Guidance related to organically-bound tritium (OBT) has also been updated as per clauses in Sections 6.10.3.1 and 6.10.3.2. In addition, CSA N288.1-14 indicates more conservative drinking water intake rates and recommends using the 95th percentiles in DRL calculations instead of 90th percentiles, as previously used in CSA N288.1-8, Update No. 1 (see Clause 6.15.3.1).

As such, updated guidance as provided in the latest version of CSA N288.1-14 should be factored in the revised DRL calculations.

A.3. CSA N288.4-10, Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills

This standard is a greatly expanded and revised version of the earlier standard N288.4-M90. In the licence renewal application of October 31, 2013 [93], Bruce Power provided implementation and transition measures, and committed to full implementation of N288.4-10 by December 2018. In subsequent correspondence with the CNSC [55], Bruce Power confirmed this completion date, and added that they expect to be in compliance with the companion CSA

Standards N288.5 [36] and N288.6 [37] by December 2018. Some Bruce Power documents, such as B-PROC-00076 [43], have already been revised to include reference to the requirements of N288.4-10 (issued May 2010).

A.4. CSA N288.5-11, Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills

This is a new standard issued April 2011. Bruce Power has committed to be in full compliance with it by December 2018 [55].

A.5. CSA N288.6-12, Environmental risk assessments at Class I nuclear facilities and uranium mines and mills

This is a new standard issued June 2012. The screening-level assessment report it requires was completed in March 2013 [50], and the higher-level assessment report was completed in January 2015 [51]. Bruce Power has committed to use these reports to develop and implement the compliance plans for N288.4 and N288.5, mentioned above [55].

A.6. IAEA NS-G-3.2, Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluation for Nuclear Power Plants

The scope of IAEA Safety Guide NS-G-3.2 (March 2002) is to provide guidance for the site evaluation stage of a nuclear power plant and to assess the effects of the proposed plant on the uses of land and water in the region of the site. Also, as stated in the safety requirements document: “Site Evaluation for Nuclear Installations” [33], the scope of this document is to perform a detailed evaluation of the candidate site as part of the siting process for a nuclear installation. As such, IAEA NS-G-3.2 is not applicable to this Safety Factor report, and in addition the site has already been selected and the Bruce A NGS has already been built.

Those clauses of NS-G-3.2 related to environmental pathway modeling that may also be applicable to operating nuclear power plants are fully addressed by the CSA Standard, N288.1-14 [34].

A.7. CNSC G-129, Keeping Radiation Exposures and Doses ‘As Low As Reasonably Achievable’, Revision 1

CNSC Regulatory Guide G-129, Revision 1, October 2014 is primarily concerned with maintaining worker doses ALARA, but it contains guidance related to maintaining public doses ALARA as well.

Clause 7.3.1, Resources, includes the statement, “resources for monitoring the environment beyond the workplace that is affected by operations should be identified and provided.”

Bruce Power provides the resources necessary to operate the REMP [43], which satisfies this recommendation.

Clause 7.3.3, Environmental Monitoring, recommends that management receive summary reviews of the results of environmental monitoring and ensure that radionuclide emissions to the environment be kept ALARA.

Clause 8.2, Substantiation, includes the considerations for deciding what is ALARA, analyses of trends of doses to workers and to the public, and of radioactive effluent releases and environmental monitoring results.

The recommendations of these two clauses are satisfied by the annual EMP Report (e.g., [49]), which includes both reviews of the results of environmental monitoring and analysis of trends of releases and environmental monitoring results.

A.8. ANSI/HPS N13.1-1999, Sampling and Monitoring Releases of Airborne Radioactive Substances Form the Stacks and Ducts of Nuclear Facilities

Most of the content of this American standard is addressed in CSA Standard N288.5-11 [36], but the latter document does not provide guidance on the setting of automatic alarm levels for airborne emissions. This topic is addressed in Section 4.4 of the American standard, and is referenced in Section 5.9 of the present report.

A.9. CNSC G-228, Developing and Using Action Levels

CNSC Regulatory Guide G-228, March 2001 [20], is primarily intended to provide high level guidance for developing, using and revising action levels (ALs) for radiation protection of workers and the public during the conduct of activities licensed by the CNSC.

Clause 5.0, Understanding Action Levels, includes the statement “An action level must be a meaningful indicator over a defined time period of the state of a radiation protection program. Accordingly, the action level must be measurable to accepted standards of accuracy”.

Further G-228 requires that an AL take into account the facility design and relevant operating experience. The AL should also be thoroughly and clearly explained and the rationale for the level and its planned use provided.

In BP-PROC-00171, it is stated that the Emission Effective Dose (EED) was applied to provide a public dose basis for defining ALs. The basis of the ALs for each airborne and waterborne radionuclide group was chosen to: “achieve an equitable implied level of protection of the public and environment across all radionuclide emissions and across all Bruce Power facilities”. Also, the AL set points are low enough such that a potential loss of control of emissions is identified and corrected well before any Regulatory limits are reached. ALs are also high enough to allow the facility to manage emissions beyond the normal range when a loss of control has not occurred [27].

BP-PROC-00171 discusses the changes to ALs that require CNSC approval and that are carried out as follows [27]:

- Calculate new ALs.
- Prepare and issue report detailing the methodology used and the results.
- Issue request to the CNSC for approval of revised ALs.

Bruce Power also has a commitment to review and if necessary revise the ALs specified in the LCH [16] at least once per licence period in order to validate their effectiveness.

CNSC has issued a discussion paper, "Process for Establishing Release Limits and Action Levels at Nuclear Facilities" [94], where it is acknowledged that G-228 "focuses on the use of ALs within the radiation protection program (predominantly for workers), rather than environmental protection in general" and that it "does not provide specific guidance for numerically deriving ALs." Therefore, although the BP procedures BP-PROC-00171 [27] and NK21-REP-03482-00002 [57] do not explicitly indicate that the AL was derived using guidance from G-228, CNSC has reviewed and accepted the proposed environmental ALs for Bruce Power [95].

As a result of the discussion paper DIS-12-02, a CSA standard is currently being prepared to provide guidance for establishing and implementing ALs to control emissions from nuclear facilities, and it is expected to support G-228. Compliance with the Standard will allow Bruce Power to demonstrate continuous improvement for revising its ALs.

A.10. CSA N288.3.4-13, Performance Testing of Nuclear Air-Cleaning Systems at Nuclear Facilities

Sections 4, 5, 6 and 7 of this Standard address the objectives, design criteria and design of an air-cleaning system testing program. The present assessment is focused on compliance with the subsequent sections of the Standard, which are relevant to the ongoing operation of the program at Bruce A.

Section 8 of this Standard lists the types of performance tests that should be documented (or referenced) and conducted. Some are given as recommendations ("should") and some as requirements ("shall"). These are listed below, with reference to the Bruce Power document in which they are mentioned, where applicable:

- Section 8.2 Visual inspection (recommendations only): Clause 4.2.4 of DPT-PE-00005 [98] requires that a, "Surveillance test of HEPA filter and carbon adsorber systems shall be made at regular intervals after installation to detect deterioration and leaks that may develop under normal service conditions." The intent of the standard is met.
- Section 8.3 In-place instrument calibration verification (recommendations): Clause 5(e) of B-ST-03480-10000 [55] requires that, "A stack flow measurement/velocity profile must be performed annually and calibrated/compared against a reference method." It goes on to specify that the stack flow measurement be within 20% of the measured air stream by the reference method. The intent of the standard is met.

- Section 8.4 Duct, damper, and housing leak tests: These tests are only required at commissioning and following upset or maintenance that may affect performance. Since commissioning and refurbishment preceded issuing of the Standard, this requirement does not apply.
- Section 8.5 Air flow and pressure measurements: Clause 4.7.2 of BP-PROC-00080 [44] requires, "Effluent flow rates shall be determined because they directly impact the accuracy of the emissions and emission estimates." In Table 1 of B-ST-03480-10000 [55], it is specified that a stack flow measurement be performed annually. In the document, "Bruce Power Stack Filter Testing" (Appendix A to the contract for testing of air cleaning systems by Kinectrics [97]), stack flow/monitor testing services are required annually for most stacks, and semi-annually for Emergency Filter Air Discharge Systems (EFADS) and Irradiated Fuel Bay (IFB) stacks. There is no discussion of air pressure measurements. The absence of ongoing air pressure measurements is assessed as a gap.
- Section 8.6 Air-aerosol mixing uniformity verification: This test is only required at commissioning and following system modification that may invalidate previous results. Since commissioning and refurbishment preceded issuing of the Standard, this requirement does not apply.
- Section 8.7 HEPA filter bank bypass test: The test frequency and leakage limits for HEPA filters are specified in DPT-PE-00005 [98], both for EFADS and for normal operation filters. The specific stacks whose filters require annual testing are listed in the document, "Bruce Power Stack Filter Testing" [97]. Detailed instructions on the performance of this test are given in a document prepared by the vendor of the test service, Kinectrics Technical Work Instruction, TWI-540-415-300 [99]. This Instruction is based on relevant ASME standards and U.S. Nuclear Regulatory Commission Regulatory Guides.
- Section 8.8 Adsorber bank bypass test: The test frequency and leakage limits for carbon filters are specified in DPT-PE-00005 [98], both for EFADS and for normal operation filters. The specific stacks whose filters require annual testing are listed in the document, "Bruce Power Stack Filter Testing" [97]. Detailed instructions on the performance of this test are given in a document prepared by the vendor of the test service, Kinectrics Technical Work Instruction, TWI-540-415-300 [99].
- Section 8.9 Laboratory testing of adsorbent media: This section requires both pre-service and in-service testing of adsorbent media (activated carbon). According to DPT-PE-00005 [98], there is no acceptance testing or in-service testing of filter carbon. Instead, it refers to an OPG purchase specification and an (obsolete) CSA standard (N288.3.2 [100]) as providing quality assurance of new carbon. In addition, it states that "Application-specific studies of the carbon that has been in service in safety system filters" provides quality assurance. Consequently, this requirement of the Standard is not met and is assessed as a gap.

- Section 8.10 Combined test for adsorber bank bypass and media adsorbency: This is described as an alternative test to Freon bypass and laboratory testing of the media, where consistent with facility operations.
- Section 8.11 Whole system bypass test: This test is required where air-cleaning systems include ducts and dampers to bypass the filters when they are not required. It is only required at commissioning, and should be conducted following upsets or maintenance that might have affected the condition or operation of the ducts and dampers. Since commissioning and refurbishment preceded issuing of the Standard, this requirement does not apply.
- Section 8.12 Air heater performance test: This test is done where there is an air heater in the air-cleaning system to reduce the relative humidity of air entering the adsorber banks, and is required only at commissioning and following maintenance or upset that may have affected its performance. Since commissioning and refurbishment preceded issuing of the Standard, this requirement does not apply.
- Section 8.13 Fan performance test: Fan testing is required only at commissioning and following upset or maintenance that may have affected its performance. Since commissioning and refurbishment preceded issuing of the Standard, this requirement does not apply.

Section 9 Interpretation of data: This section is mostly guidance, but it implies a requirement that sampling errors be kept to a minimum by the design of the testing program. It also implies a requirement that the number of significant figures quoted in monitoring test results not imply an unwarranted degree of accuracy. There is no discussion of uncertainties related to filter testing or flow rate measurement in the Bruce Power documents, and so this is assessed as a gap.

Section 10 Quality assurance and quality control: This section requires that all aspects of the testing program have appropriate QA/QC in accordance with CSA N286 [25]. There is no mention of QA/QC in DPT-PE-00005 [98], but “Bruce Power Stack Filter Testing” [97] says in Clause 3.1 (4) that a Kinectrics deliverable is to “Develop a QA/QC plan in collaboration with Bruce Power.” The Kinectrics document TWI-540-415-300 [99] includes aspects of QA/QC such as personnel qualification/experience, calibration/check standards and quality control measures. The absence of appropriate QA/QC guidance in Bruce Power governing documents is assessed as a gap.

Section 11 Reporting, review, and auditing: There is no requirement to report the results of filter testing to the CNSC. No record was found of reviews (such as self-assessments) or independent audits of the air-cleaning system performance testing program, and this is assessed as a gap.

Section 12 Staff qualification and training: The document “Bruce Power Stack Filter Testing” [97] says only that a Kinectrics deliverable is to “Deliver a team of full-time technical experts that are knowledgeable in all aspects of the program at the Bruce Site.” The Kinectrics document TWI-540-415-300 [99] in Section 2.0 describes in some detail the required qualifications of their personnel who conduct air filter performance testing. This does not meet the requirement of the Standard that the operator define the qualifications and that “If work is contracted out,

documentation shall be available to demonstrate that the contract personnel have equivalent requisite qualifications." Consequently, this is assessed as a gap.

Section 13 Documentation: This section contains a list of the documentation required of the program. While some of this documentation is provided in the documents mentioned above, much of it is missing, and so this is assessed as a gap.

Appendix B – Clause-By-Clause Assessments Against Relevant Codes and Standards

No codes or standards relevant to Safety Factor 14 were subjected to a clause-by-clause assessment. This Appendix is retained only for consistency with the Appendix numbering scheme in all other Safety Factor Reports.