FORM-14159 R000*

Periodic Safety Review - Final Document Review Traveler

Bruce Power™

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NK29-SFR-09701-00015	R000	Internal Use Only	Information
Bruce Power Document Title: Safety Factor 15 - Radiation Protection			
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Supplier's Name: CANDESCO	Supplier Document #: K-421231-00215	Revision: R00	
Supplier Document Title: Safety Factor 15 - Radiation Protection			

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candesco
Division of Kinectrics Inc.

NK29-SFR-09701-00015

Title: Safety Factor 15 - Radiation Protection

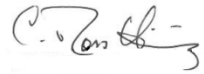
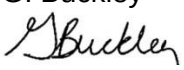
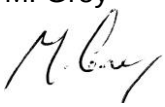
File: K-421231-00215-R00

A Report Submitted to Bruce Power

September 20, 2016

Issue R00D0	**Reason for Issue:** For harmonization				
	Author: R. Hirning K. McBlain	Verifier:	Reviewer: L. Watt	Approver:	Date: May 17, 2016
Issue R00D1	**Reason for Issue:** For internal review				
	Author: R. Hirning K. McBlain	Verifier:	Reviewer: M. Grey G. Archinoff	Approver:	Date: May 26, 2016
Issue R00D2	**Reason for Issue:** For Bruce Power review				
	Author: R. Hirning K. McBlain	Verifier: G. Buckley	Reviewer: M. Grey G. Archinoff	Approver:	Date: June 13, 2016
Issue R00D3	**Reason for Issue:** Addresses Bruce Power review comments and internal verification comments.				
	Author: K. McBlain R. Hirning	Verifier: G. Buckley	Reviewer: M. Grey G. Archinoff	Approver:	Date: August 24, 2016

candesco Division of Kinectrics Inc.	Rev Date: September 20, 2016	Status: Issued
	Subject: Safety Factor 15 - Radiation Protection	File: K-421231-00215-R00

Issue R00	**Reason for Issue:** For use				
	Author: K. McBlain  R. Hirning 	Verifier: G. Buckley 	Reviewer: M. Grey  G. Archinoff 	Approver: L. Watt 	Date: Sept 20, 2016
Document Classification: Report			Security Classification: Client Proprietary		

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Acronyms and Abbreviations

ADL	Administrative Dose Limits
AHP	Authorized Health Physicists
ALARA	As Low As Reasonably Achievable
AMP	Area Monitor Probe
AR	Action Request
AVTS	Audio-Visual Teledosimetry System
BIA	Business Impact Analysis
BP	Bruce Power
BWR	Boiling Water Reactor
CAP	Corrective Action Plan
CANDU	Canada Deuterium Uranium
CATS	Contain At The Source
CCA	Contamination Control Area
CFAM	Corporate Functional Area Manager
CMLF	Central Maintenance and Laundry Facility
CNO	Chief Nuclear Officer
CNSC	Canadian Nuclear Safety Commission
COG	CANDU Owners Group
CRC	Curriculum Review Committee
CRE	Collective Radiation Exposure
CSA	Canadian Standards Association
DCR	Document Change Request
DISN	Dosimetry Information System Number
DM	Department Manager
DRP	Discrete Radioactive Particle
DSL	Dosimetry Service Licence
ECL	Exposure Control Level
EPD	Electronic Personal Dosimeter
EPRI	Electric Power Research Institute

FAGM	Fixed Area Gamma Monitor
FASA	Focus Area Self-Assessment
FCO	Field Checkouts
FTB	Fuel Transfer Bays
GET	General Employee Training
HEPA	High Efficiency Particulate Air
HP	Health Physicist
HU	Human Performance
IAEA	International Atomic Energy Agency
IFB	Irradiated Fuel Bays
IHP	Instrumentation Health Physicist
INPO	Institute of Nuclear Power Operations
ISR	Integrated Safety Review
LAN	Local Area Network
LCE	Loose Contamination Event
LCH	Licence Conditions Handbook
LHRA	Locked High Radiation Area
LTEP	Long Term Energy Plan
MCR	Major Component Replacement
MLM	Morning Leadership Meeting
MSM	Management System Manual
NEW	Nuclear Energy Worker
NPP	Nuclear Power Plant
NSCA	Nuclear Safety and Control Act
NSRD	Nuclear Substance and Radiation Device
O.MOL	Ontario Ministry of Labour
OPEX	Operating Experience
OPG	Ontario Power Generation
OSART	Operational Safety Review Team
PA	Protection Assistants
PAGM	Portable Area Gamma Monitor

PCE	Personnel Contamination Event
PDS	Problem Development Sheet
PHWR	Pressurized Heavy Water Reactor
PM	Portal Monitor
PMC	Project Management and Construction
PRI	Portable Radiation Instrumentation
PROL	Power Reactor Operating Licence
PSR	Periodic Safety Review
PWR	Pressurized Water Reactor
R&D	Research and Development
RCA	Radiologically Controlled Area
REP	Radiation Exposure Permit
RHIS	Radiation Hazard Information System
RMSA	Radioactive Material Storage Area
RP	Radiation Protection
RPM	Radiation Protection Manager
RPP	Radiation Protection Procedure
RPPE	Radiological Personal Protection Equipment
RPS	Radiation Protection Services
RSO	Radiation Safety Officer
RWP	Radiation Work Plan
SAM	Small Article Monitor
SAT	Systematic Approach to Training
SBR	Safety Basis Report
SCA	Safety and Control Area
SCR	Station Condition Record
SFAM	Site Functional Area Manager
SFR	Safety Factor Report
SME	Subject Matter Expert
SOFA	State of the Functional Area
SSC	Systems, Structures and Components

TLD	Thermoluminescent Dosimeter
TMS	Tool Management System
TOM	Tool and Object Monitor
TOR	Terms of Reference
TQD	Training and Qualification Description
URP	Unconditional Release Permit
WANO	World Association of Nuclear Operators
WBM	Whole Body Monitor
WNSL	Waste Nuclear Substances Licence

1. Objective and Description

Bruce Power (BP), as an essential part of its operating strategy, is planning to continue operation of Bruce B as part of its contribution to the Long Term Energy Plan (LTEP) (http://www.energy.gov.on.ca/en/ltep/). Bruce Power has developed integrated plant life management plans in support of operation to 247,000 Equivalent Full Power Hours in accordance with the Bruce Power Reactor Operating Licence (PROL) [1] and Licence Conditions Handbook (LCH) [2]. A more intensive Asset Management program is under development, which includes a Major Component Replacement (MCR) approach to replacing 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 regular maintenance outage will be scheduled concurrently with MCR. In accordance with Licence Condition 15.2 of the PROL [1], Bruce Power is required to inform the Canadian Nuclear Safety Commission (CNSC) of any plan to refurbish a reactor or replace a major component at the nuclear facilities, and Bruce Power shall:

(i) Prepare and conduct a periodic safety review;

(ii) Implement and maintain a return-to-service plan; and

(iii) Provide periodic updates on progress and proposed changes.

The fifteen reports prepared as part of the Periodic Safety Review (PSR), including this Safety Factor Report (SFR), are intended to satisfy Licence Condition 15.2 (i) as a comprehensive evaluation of the design, condition and operation of the nuclear power plant (NPP). In accordance with Regulatory Document REGDOC-2.3.3 [3], a PSR is an effective way to obtain an overall view of actual plant safety and the quality of safety documentation and determine reasonable and practicable improvements to ensure safety until the next PSR.

Bruce Power has well-established PSR requirements and processes for the conduct of a PSR for the purpose of life-cycle management, which are documented in the procedure Periodic Safety Reviews [4]. This procedure, in combination with the Bruce B Periodic Safety Review Basis Document [5], governs the conduct of the PSR and facilitates its regulatory review to ensure that Bruce Power and the CNSC have the same expectations for scope, methodology and outcome of the PSR.

This PSR supersedes the Bruce B portion of the interim PSR that was conducted in support of the ongoing operation of the Bruce A and Bruce B units until 2019 [6]. Per REGDOC-2.3.3 [3], subsequent PSRs will focus on changes in requirements, facility conditions, operating experience and new information rather than repeating activities of previous reviews.

1.1. Objective

The overall objectives of the Bruce B PSR are to conduct a review of Bruce B against modern codes and standards and international safety expectations, and to provide input to a practicable

set of improvements to be conducted during the MCR in Units 5 to 8, and during asset management activities to support ongoing operation of all four units, as well as U0B, that will enhance safety to support long term operation. 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.

The specific objective of the review of this Safety Factor is defined in Appendix A of CNSC REGDOC-2.3.3 [3] and in the PSR Basis document [5] as follows:

"The objective of the review of RP [Radiation Protection] is to determine:

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

This specific objective is further defined through the review tasks presented in Section 1.2.

1.2. Description

The review is conducted in accordance with the Bruce B PSR Basis Document [5], which states that the review tasks are as follows:

1. Reactor design features for RP;
2. RP equipment and instrumentation for radiation monitoring;
3. RP aspects during nuclear emergencies;
4. RP operating experience.

As required by the PSR Basis Document, preparation of this Safety Factor Report included an assessment of the review tasks to determine if modifications were appropriate. Any changes to the review tasks described in this section are documented and justified in Section 5.

2. Methodology of Review

As discussed in the Bruce B PSR Basis Document [5], the methodology for a PSR should include making use of safety reviews that have already been performed for other reasons. Accordingly, the Bruce B PSR 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] [10];
- Proposed refurbishments of Bruce Units 3 and 4 (circa 2008) [11] [12] [13] [14] [15];

- Safety Basis Report (SBR) and PSR for Bruce Units 1 to 8 (2013) [6]; and
- Bruce A ISR to enhance safety and support long term operation (2015) [16] [17].

These reviews covered many, if not all, of the same Safety Factors that are reviewed in the current PSR. A full chronology of Bruce Power safety reviews up to 2013 is provided in Appendix F of [18].

The Bruce B PSR 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 PSR Basis Document [5] 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 PSR 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 the assessor confirming that the assessment type identified in Appendix C of the Bruce B PSR Basis Document [5] for each of the codes, standards and guidance documents selected for this factor is appropriate based on the guidance provided. The PSR 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 PSR Basis Document.
4. **Perform gap assessment against codes and standards:** This step comprises the actual assessment of the Bruce Power programs and the Bruce B plant against the identified codes and standards. In general, this involves determining from available design or programmatic documentation whether the plant or program 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 the 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 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. The results of this step are documented in Section 5 of each SFR.
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 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 B 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. Table C-1 of the Bruce B PSR Basis Document [5] identifies the codes, standards and guides that are relevant to this PSR. Modern revisions of some codes and standards listed in Table C-1 of the PSR Basis Document [5] have been identified in the

licence renewal application and supplementary submissions for the current PROL [19] [20] [21]. Codes, standards and guides issued after the freeze date of December 31, 2015 were not considered in the review [5].

3.1. Acts and Regulations

The *Nuclear Safety and Control Act* (NSCA) [22] establishes the Canadian Nuclear Safety Commission and its authority to regulate nuclear activities in Canada. Bruce Power has a process to ensure compliance with the NSCA [22] and its Regulations. Therefore, the NSCA and Regulations were not considered further in this review.

The Radiation Protection Regulations [23], made under the NSCA are relevant to this review and set requirements for Radiation Protection Programs and practices that are directly incorporated into Bruce Power governance. The CNSC has proposed amendments to the RP Regulations, and revised regulations and/or new regulatory documents are anticipated by the end of 2016. These amended RP Regulations and/or new regulatory documents are outside the scope of this review.

3.2. CNSC Licences

3.2.1. Power Reactor Operating Licence

The list of codes and standards related to probabilistic safety analysis that are referenced in the PROL [1] and LCH [2], and noted in Table C-1 of the Bruce B PSR Basis Document [5], are identified in Table 1. The edition dates referenced in the third column of the table are the modern versions used for comparison.

The PROL contains three licence conditions that are directly relevant to this review:

- Licence Condition G.2 – requires the licensee to “give written notification of changes to the facilities or their operation, including deviation from design, operating conditions, policies, programs and methods referred to in the licensing basis.”
- Licence Condition 3.3 – requires the licensee to “notify and report in accordance with CNSC regulatory document REGDOC 3.1.1, Reporting requirements: nuclear power plants.” [24]
- Licence Condition 7.1 – requires the licensee to “implement and maintain a radiation protection program, which includes a set of action levels. When the licensee becomes aware that an action level has been reached, the licensee shall notify the Commission within seven days.”

The LCH lists Bruce Power documents that require written notification of change to the CNSC:

- Radiation Protection Program, BP-PROG-12.05 [25]
- Action Levels, SEC-RPR-00022 [26]

- ALARA Program, BP-RPP-00044 [27]
- Dosimetry Requirements, BP-PROC-00280 [28]
- Dose Limits and Exposure Control, BP-RPP-00009 [29]
- Responsibilities of an Authorized Health Physicist, SEC-RPR-00040 [30]

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

Document Number	Document Title	Modern Version Used for PSR Comparison	Type of Review
CNSC G-129 (2004)	Keeping Radiation Exposures and Doses 'As Low As Reasonably Achievable (ALARA)'	[31]	HL
CNSC G-228 (2001)	Developing and Using Action Levels	[32]	HL
CNSC REGDOC-2.3.3	Periodic Safety Reviews	[3]	NA
CNSC REGDOC-3.1.1 (2014)	Reporting Requirements for Operating Nuclear Power Plants	[24]	NA
CNSC S-106 Rev 1 (2006)	Technical and Quality Assurance Requirements for Dosimetry Services	[33]	NA
CSA-N286-05 [34]	Management System Requirements for Nuclear Facilities	CSA-N286-12 [35]	NA
Assessment type: **NA**: Not Assessed; **CBC**: Clause-by-Clause; **PCBC**: Partial Clause-by-Clause; **CTC**: Code-to-Code; **HL**: High Level; **2SF**: Assessment performed in another SFR; **CV**: Confirm Validity of Previous Assessments			

CNSC G-129: G-129 provides guidance on keeping the effective dose and equivalent dose received by and committed to persons as low as reasonably achievable (ALARA). Table C-1 of the PSR Basis Document [5] indicates that a high level review is being performed as part of Safety Factor 14 – Radiological Impact on the Environment and that an assessment is not required for Safety Factor 15. However, most of the content of G-129 deals with occupational exposure, and so a high level review is included in the present Safety Factor Report, in Appendix A, Section A.1.

CNSC G-228: Table C-1 of the PSR Basis Document [5] calls for a high level review of CNSC G-228. Licence Condition 7.1 of the LCH [2] summarizes the RP action levels. These action levels have been defined through the Bruce Power RP Action Level procedure [26]. According to the procedure, Action Levels have been developed for each Bruce Power CNSC Licence by the Department Manager (DM), RP Programs using the guidance provided in CNSC Regulatory Guide G-228: Developing and Using Action Levels [32]. CNSC acceptance of the proposed Operational Radiation Protection and Environmental Action Levels for Bruce Power has been received [36]. As documented in Section 4.2 of the Action Level procedure [26] any requested changes to Action Levels for Radiation Protection of Workers, "shall demonstrate compliance with CNSC Regulatory Guide G-228". A high-level assessment of G-228 is provided in Appendix A, Section A.2.

CNSC REGDOC-2.3.3: This PSR is being conducted in accordance with CNSC REGDOC-2.3.3 per Licence Condition 15.2 (i) [1], and associated compliance verification criteria [2]. Therefore, REGDOC-2.3.3 is not reviewed further in this document.

CNSC REGDOC-3.1.1: Table C-1 of the PSR Basis Document [5] does not call for review of CNSC REGDOC-3.1.1 [24]. Compliance with this regulatory document is explicitly required under PROL Licence Condition 3.3 (see Section 3.2), and therefore and assessment is not required.

CNSC S-106: Table C-1 of the PSR Basis Document [5] does not call for an assessment of CNSC S-106. As discussed in Section 3.2.2, it is not assessed in this report.

CSA N286-12: CSA N286-05 is noted in the PROL (Licence Condition 1.1 [1]). Per the LCH [2], an implementation strategy for the 2012 version is in progress to be submitted to the CNSC by the end of January 2016. 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" [37].

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 current licensing period [38]. This 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 [39]. Bruce Power further stated CSA N286-12 does not establish any significant or immediate new safety requirements that would merit a more accelerated implementation. The gap analysis and the resulting transition plan were submitted to the CNSC [40]. Per [40], the major milestones of the transition plan to N286-12 are as follows:

- 22 January 2016: Discuss all the regulatory actions and the transition plan at the Corporate Functional Area Manager (CFAM) meeting
- 31 December 2016: Revision of CFAM Program Document(s) [with LCH notification requirements to the CNSC] to comply with CSA N286-12 requirements completed.

- 31 March 2017: Revision of CFAM Program Document(s) [that do not have LCH notification requirements to the CNSC] to comply with CSA N286-12 requirements completed
- 31 December 2017: Confirmation that that all impacted documents in the program suite comply with the requirements of CSA N286-12
- 15 September 2018: Verification via a Focus Area Self Assessment (FASA) that previously identified transition Gaps to meeting the requirements of CSA N286-12 have been addressed and effectively implemented
- 14 December 2018: issue notification to the CNSC regarding state of CSA N286-12 readiness, and, implementation date

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 and there is a transition plan in effect.

3.2.2. Dosimetry Service Licence

Section 8 of the Radiation Protection Regulations [23] requires a licensee to use a licensed dosimetry service to measure and monitor the doses of radiation received by and committed to nuclear energy workers who have a reasonable probability of receiving an effective dose greater than 5 mSv in a one-year dosimetry period.

The Bruce Power Dosimetry Service Licence (DSL) 13152-6-16.6[1] [41] references CNSC Technical Standard S-106 Rev 1 [33] and several CNSC dosimetry methodology documents. Compliance with these requirements is reviewed by the CNSC as part of the DSL compliance process. Consequently the dosimetry requirements are not reviewed as part of this assessment.

Operators of licensed dosimetry services must comply with the requirements set out in Sections 18 and 19 of the Radiation Protection Regulations [23] and the performance standards set out in CNSC Technical Standard S-106 Rev 1 [33]. Consequently, for the purpose of this assessment, it will be assumed that any measurement of the effective or equivalent dose to a worker that is performed by the licensed Bruce Power dosimetry service, or any licensed commercial dosimetry service, complies with the performance requirements (effectiveness) of the code or standard that calls for that measurement.

3.2.3. Class II Nuclear Facility and Prescribed Equipment (Irradiator Facility) Licence

CNSC Class II Nuclear Facility and Prescribed Equipment Licence 13152-2-16.6 [42] authorizes the licensee to operate an irradiator facility at Bruce B (Building B05). Similarly, CNSC Class II Nuclear Facility and Prescribed Equipment Licence 13152-5-17.4 [43] authorizes the licensee to construct an irradiator facility at Central Maintenance and Laundry Facility (CMLF) (Building B12). For the purpose of this assessment, it will be assumed that any activities performed using

[1] Here and in following instances the last three digits of the licence number refer to the revision/amendment number of the licence.

or in support of the prescribed equipment possessed under these licences are performed in accordance with the terms and conditions of this licence and this work or activity will not be considered within the scope of this Safety Factor.

3.2.4. Waste Nuclear Substance Licence (WNSL) (Central Maintenance and Laundry Facility)

CNSC Waste Nuclear Substance Licence WNSL-W2-323.05/2017 [44] "authorizes the licensee to possess, transfer, use, process, manage, and store, the nuclear substances, except Category I, II and Ill nuclear material as defined in section 1 of the Nuclear Security Regulations, that are required for, associated with or arise from the operation of the Central Maintenance Facility". Consequently, for the purpose of this assessment, it will be assumed that any work or activity involving radioactive materials performed at the Central Maintenance and Laundry Facility is performed in accordance with the terms and conditions of this licence and this work or activity will not be considered within the scope of this Safety Factor.

3.2.5. Nuclear Substances & Radiation Devices (Consolidated Uses of Nuclear Substances) Licence

CNSC Nuclear Substances & Radiation Devices Licence 13152-1-20.1 [45] authorizes the licensee to possess, transfer, import, export, use and store nuclear substances (both sealed and unsealed) and prescribed equipment for the "consolidated uses of nuclear substances" throughout the Bruce Power site, including Bruce B. For the purpose of this assessment, it will be assumed that any activities performed using or in support of the nuclear substances and prescribed equipment possessed under this licence are performed in accordance with the terms and conditions of this licence and CNSC Regulatory Document REGDOC-1.6.1 [46] and this work or activity will not be considered within the scope of this Safety Factor.

3.2.6. Nuclear Substances & Radiation Devices (Industrial Radiography) Licence

CNSC Nuclear Substances & Radiation Devices licence 13152-3-20.0 [47] authorizes the licensee to possess transfer, import, export, use and store nuclear substances and prescribed equipment for the purposes of "industrial radiography throughout the Bruce Power site". For the purpose of this assessment, it will be assumed that any activities performed using or in support of the nuclear substances and prescribed equipment possessed under this licence are performed in accordance with the terms and conditions of this licence and CNSC Regulatory Document REGDOC-1.6.1 [46] and this work or activity will not be considered within the scope of this Safety Factor.

3.3. Regulatory Documents

In addition to those listed in the PROL [1] and the LCH [2], the Regulatory Documents identified in Table C-1 of the PSR Basis Document [5] considered for application to review tasks of this Safety Factor are included in Table 2.

Table 2: Regulatory Documents

Document Number	Document Title	Reference	Type of Review
CNSC R-116 (1995)	Requirements for Leak Testing Selected Sealed Radiation Sources	N/A	NA
CNSC REGDOC-1.6.1 (2015)	Licence Application Guide: Nuclear Substances and Radiation Devices	[46]	NA
Assessment type: **NA**: Not Assessed; **CBC**: Clause-by-Clause; **PCBC**: Partial Clause-by-Clause; **CTC**: Code-to-Code; **HL**: High Level; **2SF**: Assessment performed in another SFR; **CV**: Confirm Validity of Previous Assessments			

CNSC R-116: Table C-1 of the PSR Basis Document [5] does not call for assessment of CNSC R-116, which has been superseded by REGDOC-1.6.1 [46].

CNSC REGDOC-1.6.1: Table C-1 of the PSR Basis Document [5] does not call for an assessment of CNSC REGDOC-1.6.1 [46]. As discussed in Sections 3.2.5 and 3.2.6, it is not assessed in this report.

3.4. CSA Standards

Per Table C-1 of the PSR Basis Document [5], there are no other Canadian Standards Association (CSA) standards identified in the Bruce Power PROL [1] and LCH [2] for inclusion in this Safety Factor review.

3.5. International Standards

As applicable international guidance considered for application to review tasks of this Safety Factor are included in Table 3.

Table 3: International Standards

Document Number	Document Title	Reference	Type of Review
IAEA SSG-25 (2013)	Periodic Safety Review For Nuclear Power Plants	[48]	NA
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	[49]	NA
IAEA NS-G-2.7 (2002)	Radiation Protection and Radioactive Waste Management in the Operation of Nuclear Power Plants	[50]	NA
IAEA RS-G-1.1 (1999)	Occupational Radiation Protection	[51]	NA
Assessment type: **NA**: Not Assessed; **CBC**: Clause-by-Clause; **PCBC**: Partial Clause-by-Clause; **CTC**: Code-to-Code; **HL**: High Level; **2SF**: Assessment performed in another SFR; **CV**: Confirm Validity of Previous Assessments			

IAEA SSG-25: IAEA SSG-25 [48] addresses the periodic safety review of nuclear power plants. Per the PSR Basis Document [5], this PSR is being conducted in accordance with REGDOC-2.3.3. As stated in REGDOC-2.3.3 [3], this regulatory document is consistent with IAEA SSG-25. The combination of IAEA SSG-25 and REGDOC-2.3.3, define the review tasks that should be considered for the Safety Factor Reports. However, no assessment is performed specifically on IAEA SSG-25.

IAEA NS-G-3.2: Table C-1 of the PSR Basis Document [5] does not call for review of IAEA NS-G-3.2 [49]. This Safety Guide does not contain any requirements relevant to radiation protection during operations. Rather, it provides guidance on the assessment of potential future environmental impacts of the proposed facility and it is intended for use during the evaluations of potential sites for proposed nuclear facilities rather than during operation of an existing facility. As such, IAEA NS-G-3.2 has not been considered in this assessment.

IAEA NS-G-2.7: IAEA NS-G-2.7 [50] "…gives general recommendations for the development of radiation protection programmes at nuclear power plants" (Section 1.7). This safety guide is directed primarily at the regulatory body, and contains very high-level recommendations. Therefore, it was not considered useful to assess the Bruce Power RP Program against the recommendations of this document.

IAEA RS-G-1.1: IAEA RS-G-1.1 [51] "…gives general advice on the exposure conditions for which monitoring programmes should be set up to assess radiation doses arising from external radiation and from intakes of radionuclides by workers" (Section 1.3) Again, recommendations in this safety guide are intended primarily for regulatory authorities and are very high level.

Therefore, it was not considered useful to assess the Bruce Power RP Program against the recommendations of this document.

3.6. Other Applicable Codes and Standards

Two additional guidelines were considered for this review and are listed in Table 4.

Table 4: Other Applicable Codes and Standards

Document Number	Document Title	Reference	Type of Review
INPO 91-014 (1995)	Guideline for Radiological Protection at Nuclear Power Stations	[52]	NA
INPO 05-008 (2016)	Guidelines for Radiological Protection at Nuclear Power Stations	[53]	NA
WANO GL 2004-01 (Rev-01) (2012)	Guideline for Radiological Protection at Nuclear Power Stations	[54]	CBC
Assessment type: **NA**: Not Assessed; **CBC**: Clause-by-Clause; **PCBC**: Partial Clause-by-Clause; **CTC**: Code-to-Code; **HL**: High Level; **2SF**: Assessment performed in another SFR; **CV**: Confirm Validity of Previous Assessments			

INPO 91-014: Table C-1 of the PSR Basis Document [5] does not call for review of INPO 91-014, which has been superseded by INPO 05-008.

INPO 05-008: Table C-1 of the ISR Basis Document [5] does not call for review of INPO 05-008. The World Association of Nuclear Operators (WANO) Guideline for Radiological Protection at Nuclear Power Stations GL 2004-01 (Rev-1) [54], provides essentially the same information as the Institute of Nuclear Power Operations (INPO) document, and consistent with the Bruce A ISR, a clause-by-clause assessment is performed for WANO GL 2004-01 (Rev-1). INPO 05-008 was re-affirmed and re-issued in March 2016 based on the latest industry Radiation Protection experience. For example, it includes updated alpha monitoring requirements, refinements on the performance indicators and the addition of references to more recently issued Electric Power Research Institute documents. Safety Factor Report 8 addresses INPO 05-008, but it is not assessed in the current Safety Factor Report.

WANO GL 2004-01 (Rev-1): A clause-by-clause assessment of WANO GL 2004-01 (Rev-1) [54] is called for by the PSR Basis Document [5] and provided in Appendix B. Since WANO GL 2004-01 is specifically intended for Pressurized Water Reactors (PWRs) or Boiling Water Reactors (BWRs) reactors, some specific items of guidance may not be relevant to a Canada Deuterium Uranium (CANDU) reactor. In these cases the guidance has either been:

- interpreted to include issues relevant to CANDU reactors (e.g., control of airborne contamination has been interpreted to include control of airborne tritiated water vapour); or
- not considered if there was no relevance to a CANDU reactor (e.g., the specific guidance on control of BWR coolant chemistry given in the guideline clause V.C3c).

4. Overview of Applicable Bruce B Station Programs and Processes

Bruce Power has created a radiation protection program and a radiation protection organization to manage that program. The RP Program and organization faced a series of challenges during the period 2009 through 2012 and significant deficiencies in the RP Program and organization were identified at that time. Actions were taken in 2013 to address these deficiencies, which included:

- Providing greater RP resources support to station operations, which involved restructuring reporting lines, increasing headcount and assigning RP technicians to all shifts;
- Health Physicists (HPs) were moved from the RP Programs and Dosimetry sections to increase HP capability in the stations, and were assigned to provide ALARA support for major outage programs.
- Establishing an initiative to upgrade RP equipment and processes; and
- Revising program documentation to address deficiencies that had been identified and describe changes made in the RP organization.

These changes have completely reshaped the RP Program, organization and approach to such an extent that evaluations of the program and its effectiveness (including audits, inspections and self-assessments) that were conducted prior to the changes are not believed to be representative of the current RP Program and organization.

The remainder of this section describes the RP Program that is currently in place at Bruce B.

4.1. Bruce Power Radiation Protection Program

The Bruce Power Management System Manual (BP-MSM-1, Appendix A) [55] defines the objectives of the Bruce Power Radiation Protection Management Policy as:

- Bruce Power shall strictly control occupational and public exposure below regulatory limits and As Low As Reasonably Achievable (ALARA).
- Bruce Power shall manage and control the movement of people and materials to prevent the release of contamination from site in accordance with Canadian regulations and standards associated with contamination control and radiation protection.
- Bruce Power shall strive to achieve high standards of radiation protection performance as compared to industry leading practices and WANO GL 2004-01 [54].

The Bruce Power Radiation Protection Program (BP-PROG-12.05) [25] defines the fundamental business needs, constituent elements, functional requirements, implementing approaches and key responsibilities associated with implementing the Bruce Power Radiation Protection Management Policy as defined in the Bruce Power Management System Manual (BP-MSM-1, Appendix A). Section 4 of BP-PROG-12.05 defines the elements of the Radiation Protection Program and Appendix B of BP-PROG-12.05 identifies the implementing Procedures applicable to each of those elements. The elements of the Radiation Protection Program and the associated Level 2 and 3 Procedures are shown in Table 5[2].

Table 5: Elements of the Radiation Protection Program and Key Implementing Documents

Level 0	Level 1	Level 2	Level 3
Section 4.1 of BP-PROG-12.05: RP Management Roles, Responsibilities & Expectations			
BP-MSM-1: Management System Manual [55]	BP-PROG-12.05: Radiation Protection Program [25][3]	BP-PROC-00581: Radiation Protection Department Fundamentals [56]	
		BP-PROC-00819: Radiation Protection Worker Fundamentals [57]	
		SEC-RPR-00012: RP Performance Indicators [58]	

[2] Table 5 lists the key governance documents used to support the assessments of the review tasks for this Safety Factor Report. A full set of current sub-tier documents is provided within each current PROG document. In the list of references, the revision number for the governance documents is the key, unambiguous identifier; the date shown is an indicator of when the document was last updated, and is taken either from PassPort, the header field, or the “Master Created” date in the footer.

[3] Written notification to the CNSC required prior to change.

Level 0	Level 1	Level 2	Level 3
		SEC-RPR-00013: Radiation Protection Process Quality Management [59]	SEC-RPR-00045: Radiation Protection Records Retention [Obsolete]
			SEC-RPR-00061: Management of Radiation Protection Website [60]
		SEC-RPR-00023: Certification of Authorized Health Physicists [61]	
		SEC-RPR-00040: Responsibilities of an Authorized Health Physicist[4] [30]	
Section 4.2 of BP-PROG-12.05: RP Qualifications & Training			
BP-MSM-1: Management System Manual [55]	BP-PROG-12.05: Radiation Protection Program [25]	BP-RPP-00006: Radiation Protection Qualifications [Obsolete]	BP-RPP-00018: Facility Access and Working Rights[5] [62]
			BP-RPP-00026: Designation of the Nuclear Energy Worker [63]
Section 4.3 of BP-PROG-12.05: Facilities and Equipment			
BP-MSM-1: Management System Manual [55]	BP-PROG-12.05: Radiation Protection Program [25]	BP-PROC-00858: Radiation Protection Personal Protective Equipment (RPPE) Life Cycle Management [64]	BP-RPP-00014: Selection of Radiation Personal Protective Equipment [65]

[4] Written notification of change required to the CNSC.
[5] Ontario Power Generation (OPG) interface document

Level 0	Level 1	Level 2	Level 3
		BP-PROC-00908: Radiation Protection Equipment and Material Management [66]	
		BP-PROC-00917: Tritium Air Monitoring Program [67]	
		BP-RPP-00008: Access Control [68]	
		BP-RPP-00015: Zoning [69]	
		BP-PROC-00192: Radiation Instrumentation Management [70]	BP-PROC-00037: Calibration and Maintenance of Fixed Contamination Monitors [71]
			BP-RPP-00035: Use of Fixed Radiation Protection Instrumentation [72]
			BP-PROC-00370: Calibration and Maintenance of Portable Radiation Instrumentation [73]
			BP-RPP-00012: Use of Portable Radiation Instrumentation [74]
Section 4.4 of BP-PROG-12.05: Radiological Work Planning & ALARA Program			
BP-MSM-1: Management System Manual [55]	BP-PROG-12.05: Radiation Protection Program [25]	BP-RPP-00044: ALARA Program [27][6]	BP-RPP-00009: Dose Limits and Exposure Control [29][7]

[6] Written notification of change required to the CNSC.

Level 0	Level 1	Level 2	Level 3
			BP-RPP-00011: Requirements for Planning Radiological Work [75]
			BP-RPP-00049: Source Term Management [76]
			SEC-RPR-00041: Responsibilities of an ALARA Health Physicist [77]
		SEC-RPR-00022: Action Levels [26][8]	
Section 4.5 of BP-PROG-12.05: Executing Radiological Work to Control Contamination and Dose			
BP-MSM-1: Management System Manual [55]	BP-PROG-12.05: Radiation Protection Program [25]	BP-PROC-00188: Radioactive Material Transportation[9] [78]	BP-PROC-00097: Vehicle Radiation Monitoring[10] [79]
			BP-RPP-00013: Radioactive Shipments [80]
			BP-RPP-00033: Unconditional Releases and Conditional Transfers of Material [81]
			BP-PROC-00941: Radioactive Material Container Life Cycle Management [82]

[7] Written notification to the CNSC required prior to change.
[8] Written notification to the CNSC required prior to change.
[9] Radioactive material transport is outside the scope of this review (see Section 6).
[10] OPG interface document.

Level 0	Level 1	Level 2	Level 3
		BP-RPP-00041: Executing Radiological Work [83]	BP-RPP-00007: Decontamination [84]
			BP-RPP-00019: Greenmanning, Protection Assistants [85]
			BP-RPP-00021: Use of Facility Change Rooms [86]
			BP-RPP-00022: Contamination Control [87]
			BP-RPP-00023: Hazards Surveys, Posting, Response and Recording [88]
			BP-RPP-00027: Contaminated Tools and Equipment [89]
			BP-RPP-00048: Large Area Containments (Tents), Specification, Fabrication and Use of [90]
			SEC-RPR-00043: Radiological Controls for Diving Operations [91]
			SEC-RPR-00069: Airborne Radioactive Particulate Surveys [92]

Level 0	Level 1	Level 2	Level 3
		BP-PROC-00878: Radioactive Waste Management[11] [93]	Implementing procedures[12]
		BP-RPP-00043: Management of Nuclear Substances and Radiation Generating Equipment[13] [94]	Implementing procedures[14]
Section 4.6 of BP-PROG-12.05: Verification of Radiological Work			
BP-MSM-1: Management System Manual [55]	BP-PROG-12.05: Radiation Protection Program [25]	BP-PROC-00913: Health Physics Laboratory [95]	Implementing procedures[15]
		BP-PROC-00914: Radiological Analysis [96]	Implementing procedures[16]
		BP-PROC-00280: Dosimetry Requirements [28][17]	BP-RPP-00020: Dosimetry and Dose Reporting [97]
			Implementing procedures[18]

[11] Radioactive waste management is outside the scope of this review (see Section 6).
[12] The RP Program identifies 4 Level 3 implementing procedures under BP-PROC-00878. Since these are not in the scope of this review they have not been specifically listed here (see Section 6).
[13] This Level 2 procedure and the implementing Level 3 procedures listed are outside the scope of this review.
[14] The RP Program identifies 7 Level 3 implementing procedures (along with several lower level procedures) under BP-RPP-00043. Since these are not in the scope of this review they have not been specifically listed here (see Sections 3.2.3, 3.2.5, and 3.2.6).
[15] The RP Program identifies 2 Level 3 implementing procedures (along with several lower level procedures) under BP-PROC-00913. Since these are not in the scope of this review they have not been specifically listed here (see Section 3.2.2).
[16] The RP Program identifies 3 Level 3 implementing procedures (along with several lower level procedures) under BP-PROC-00914. Since these are not in the scope of this review they have not been specifically listed here (see Section 3.2.2).
[17] Written notification to the CNSC required prior to change.

Level 0	Level 1	Level 2	Level 3
		BP-RPP-00005: Routine Radiological Survey [98]	SEC-RPR-00016: Alpha Monitoring Procedure [99]
			SEC-RPR-00032: Routine and Outage Surveys Performed by Radiation Protection Technicians [100]
			SEC-RPR-00046: Routine Surveys Outside the Protected Area [101]
		BP-RPP-00040: Oversight of Radiological Work [102]	SEC-RPR-00025: Radiation Protection Field Inspection Oversight [103]
Section 4.7 of BP-PROG-12.05: Radiological Incident Response			
BP-MSM-1: Management System Manual [55]	BP-PROG-12.05: Radiation Protection Program [25]	BP-RPP-00047: Station Response to an Abnormal Radiological Condition [104]	
		BP-PROC-00517: Health Physics Response to a Radiological Overexposure [105]	
		SEC-RPR-00026: Health Physics Response to a Personnel Contamination Incident [106]	

[18] The RP Program identifies 18 Level 3 implementing SEC-DOS-XXXXX procedures (along with several lower level procedures) under BP-PROC-00280. Since these are not in the scope of this review they have not been specifically listed here (see Section 3.2.2).

Level 0	Level 1	Level 2	Level 3
		SEC-RPR-00038: Radiation Protection Response to a Radiological Event [107]	

4.1.1. RP Management Roles, Responsibilities and Expectations

Section 4.1 of BP-PROG-12.05 "defines the organization framework for the management of radiation protection at Bruce Power and defines radiation protection responsibilities and expectations for individuals. It also includes the management of radiation protection documentation and special projects." [25]

BP-PROC-00581, Radiation Protection Department Fundamentals "sets forth the expectations for performing, assessing, and reinforcing the RP fundamentals to ensure RP activities achieve industry best performance. These fundamentals constitute a set of standards and behaviours for the Radiation Protection Department at Bruce Power facilities" (Section 1.0) [56]

BP-PROC-00819, Radiation Protection Worker Fundamentals "sets forth the expectations for performing, assessing, and reinforcing the RP fundamentals to ensure RP activities achieve industry best performance. These fundamentals constitute a set of standards and behaviours for RP qualified workers at Bruce Power facilities" (Section 1.0) [57]

SEC-RPR-00012, Radiation Protection Performance Indicators "outlines the performance indicators (metrics) used to measure the effectiveness of BP-PROG-12.05, Radiation Protection Program, through the application of this program, in the operation of the Bruce Power Site" (Section 1.0) [58].

SEC-RPR-00013, Radiation Protection Process Quality Management "provides instruction for the RP Staff, when applying the Management System Manual in accordance with BP-PROG-12.05" [59] by defining: the requirements for: screening RP Operating Experience (OPEX); managing the creation, revision, issuance and implementation of BP-PROG-12.05; managing the creation and issuance of reports and technical documents; RP approvals, Authorized Health Physicist (AHP) exemptions and Radiation Safety Officer (RSO) exemptions; managing records produced through the implementation of the RP Program; and sharing information with non-Bruce Power personnel (Section 1.0).

SEC-RPR-00045, Radiation Protection Records Retention appears as an implementing, Level 3 procedure under SEC-RPR-00013 in the RP Program document [25]. This procedure is obsolete. [AR 28449635] states that the procedure was made obsolete following the issue of SEC-RPR-00013 R002 which incorporates the relevant content from SEC-RPR-00045 (see completed [DCR 28449633]).

SEC-RPR-00061, Management of Radiation Protection Website defines "the process for maintaining, updating, deleting content or adding new content to the RP web page" (Section 1.0) [60].

SEC-RPR-00023, Certification of Authorized Health Physicists defines "the process for obtaining and maintaining CNSC Certification of Authorized Health Physicists" (Section 1.0) [61].

SEC-RPR-00040, Responsibilities of an Authorized Health Physicist "describes the responsibilities of the Authorized Health Physicist (formerly known as the Responsible Health Physicist) to satisfy the requirements of the Bruce A and B PROLs and to meet the objectives of the Radiation Protection Program, BP-PROG-12.05" (Section 1.0) [30].

4.1.2. Radiation Protection Qualifications and Training

Section 4.2 of BP-PROG-12.05 "defines the training requirements for workers to perform radiological work, requirements for NEWs [Nuclear Energy Workers], and radiation protection qualification requirements for individuals to access and work at Bruce Power facilities." [25]

BP-RPP-00006, Radiation Protection Qualification appears as an implementing, Level 2 procedure with implementing documents beneath it in the RP Program document [25]. This procedure is obsolete; superseded by BP-PROG-12.05 [25].

BP-RPP-00018, Facility Access and Working Rights "defines the RP Qualification requirements for workers accessing and performing work at Bruce Power Facilities" (Section 1.0) [62].

BP-RPP-00026, Designation of the Nuclear Energy Worker "defines the criteria to be applied and process to be followed in the administration of NEW designation" (Section 1.0) [63].

4.1.3. Facilities and Equipment

Section 4.3 of BP-PROG-12.05 "defines the facilities, equipment, and processes used to support the safe execution of radiological work execution at Bruce Power and maintain doses ALARA." [25]

BP-PROC-00858, Radiation Protection Personal Protective Equipment (RPPE) Life Cycle Management defines "the process by which Radiation Personal Protective Equipment (provided to personnel in order to maintain doses As Low As Reasonably Achievable [ALARA] and to prevent the spread of radioactive contamination) is approved for use at Bruce Power" (Section 1.0) [64].

BP-RPP-00014, Selection of Radiation Personal Protective Equipment "details the requirements to be used to select and use RPPE when required to perform radiological work at Bruce Power" (Section 1.0) [65].

BP-PROC-00908, Radiation Protection Equipment and Material Management defines "the process for obtaining approval to use new RP Equipment and/or Material at Bruce Power" (Section 1.0) [66].

BP-PROC-00917, Tritium Air Monitoring Program provides "guidance on the placement of tritium air monitors for the purpose of continuous tritium monitoring of generally accessible areas of the station, monitoring for work in progress, and monitoring of areas with potential for leaks. This procedure addresses the use of radiation instrumentation to avoid unplanned exposures, specifically tritium" (Section 1.0) [67].

BP-RPP-00008, Access Control "outlines the requirements to access areas of the plant where high radiation fields may exist" (Section 1.0) [68].

BP-RPP-00015, Zoning "details the requirements for movement of personnel, equipment and material around the Zoned Areas of Bruce Power facilities" (Section 1.0) [69].

BP-PROC-00192, Radiation Instrumentation Management "sets the expected standards for all RP Instrumentation… used at Bruce Power for the purpose of detecting and measuring radiation hazards and radioactive contamination in support of the RP Program" (Section 1.0) [70].

BP-PROC-00037, Calibration and Maintenance of Fixed Contamination Monitors sets out "the minimum requirements for the maintenance and calibration of fixed radiation protection instrumentation" (Section 1.0) [71].

BP-RPP-00035, Use of Fixed Radiation Protection Instrumentation "details the fixed radiation protection instruments currently in use at Bruce Power for measurement of external and internal radiological hazards to personnel. Operating instructions, flow charts and pictures of each instrument are provided in order to clearly illustrate the instructions for use" (Section 1.0) [72].

BP-PROC-00370, Calibration and Maintenance of Portable Radiation Protection Instrumentation sets out "the minimum requirements for the maintenance and calibration of portable RP instrumentation" (Section 1.0) [73].

BP-RPP-00012, Use of Portable Radiation Protection Instrumentation "defines the PRI [Portable Radiation Instrumentation] approved for use at Bruce Power to measure radiological dose, contamination and airborne hazards. This procedure also provides instruction on selection, pre-operational checks and the use of these instruments" (Section 1.0) [74].

4.1.4. Radiological Work Planning and ALARA Program

Section 4.4 of BP-PROG-12.05 introduces the Bruce Power ALARA Program, BP-RPP-00044, which "identifies planning strategies to control dose and minimize exposure As Low As Reasonably Achievable at Bruce Power to meet the requirements outlined in CNSC Regulatory Guide G-129, Keeping Radiation Exposures and Doses 'As Low as Reasonably Achievable (ALARA).'" [25]

BP-RPP-00044, ALARA Program aims to "ensure that occupational radiation exposures, both individually and collectively are maintained ALARA. The ALARA Program establishes the requirements and responsibilities for the effective implementation of the ALARA Program" (Section 1.0) [27].

BP-RPP-00009, Dose Limits and Exposure Control specifies "the requirements at Bruce Power facilities for the use of Exposure Control Levels (ECLs) and Administrative Dose Limits (ADLs) and to ensure the doses to the individuals do not exceed regulatory limits" (Section 1.0) [29].

BP-RPP-00011, Requirements for Planning Radiological Work "outlines the requirements for planning radiological work at Bruce Power... so that radiation exposures are kept ALARA" (Section 1.0) [75].

BP-RPP-00049, Source Term Management "establishes the requirements and responsibilities for the effective implementation of the Source Term Management Program … to ensure that materials selection, plant operation, maintenance activities, and chemistry strategies during normal operations, shutdowns, and start-ups are managed to the extent practical to reduce the radiation source term" (Section 1.0) [76].

SEC-RPR-00041, Responsibilities of an ALARA Health Physicist "outlines the responsibilities of an ALARA Health Physicist and provides guidance on how to apply these ALARA responsibilities" (Section 1.0) [77].

SEC-RPR-00022, Action Levels "defines the Action Levels for radiation protection of workers for each of Bruce Power's CNSC Licences and the *[sic]* outlines the process to change an Action Level" (Section 1.0) [26].

4.1.5. Executing Radiological Work to Control Contamination and Dose

Section 4.5 of BP-PROG-12.05 "defines the process in place to ensure all radiological work is executed conscientiously and as planned, to minimize dose to workers and prevent the spread of contamination." [25]

BP-PROC-00188, Radioactive Material Transportation "defines the standards and processes established for the safe packaging and transport of radioactive material by Bruce Power" (Section 1.0) [78].

BP-PROC-00097, Vehicle Radiation Monitoring "describes the process … of monitoring vehicles exiting the Bruce Power site via the perimeter guardhouse in order to prevent the uncontrolled release of radioactive material and minimize the risk of radioactive contamination *[release]* into the Public Domain" (Section 1.0) [79].

BP-RPP-00013, Radioactive Shipments "specifies the requirements for the shipment of radioactive material from Bruce Power licensed facilities and the receipt of nuclear substances from off-site facilities" (Section 1.0) [80].

BP-RPP-00033, Unconditional Releases and Conditional Transfers of Material "specifies the requirements for the unconditional release of material into Zone 1 or the

public domain and conditional transfer of material between on-site licensed facilities" (Section 1.0) [81].

BP-PROC-00941, Radioactive Material Container Life Cycle Management "defines the standards and overall processes established for all the activities that are related to purchase, use, and maintenance of radioactive material packages and containers in Bruce Power" (Section 1.0) [82].

BP-RPP-00041, Executing Radiological Work "outlines the requirements for workers performing radiological work to control internal and external doses ALARA and minimize the spread of radioactive contamination" (Section 1.0) [83].

BP-RPP-00007, Decontamination specifies "requirements, actions, conditions and process for performing radiological decontamination at Bruce Power Nuclear Facilities" (Section 1.0) [84].

BP-RPP-00019, Greenmanning, Protection Assistants "specifies the requirements at Bruce Power facilities for providing: direct and indirect radiation protection to orange qualified workers through a green qualified person; direct radiation protection to red qualified workers through a green qualified person; radiation protection assistance to yellow and green qualified staff through a protection assistant" (Section 1.0) [85].

BP-RPP-00021, Use of Facility Change Rooms "details use of facility change rooms at Bruce Power" (Section 1.0) [86].

BP-RPP-00022, Contamination Control "describes the RP work practices, measures and techniques used to control radioactive contamination at the source, including Discrete Radioactive Particles (DRPs) to prevent contamination spreading to workers, equipment and areas between work locations and maintain exposures ALARA" (Section 1.0) [87].

BP-RPP-00023, Hazards Surveys, Posting, Response and Recording "details the requirements for surveying for radiation hazards, recording hazard details and the methods of communicating the results of these surveys to workers and management" (Section 1.0) [88].

BP-RPP-00027, Contaminated Tools and Equipment "specifies *[the]* requirements for identification, use and storage of contaminated tools, equipment and related materials at Bruce Power" (Section 1.0) [89].

BP-RPP-00048, Large Area Containments (Tents), Specification, Fabrication and Use of provides "guidelines for large area containment (tent) requirements, design, inspection, construction, and use of containments to control the spread of radioactive contamination" (Section 1.0) [90].

SEC-RPR-00043, Radiological Controls for Diving Operations provides "the radiation protection requirements for diving operations in the Irradiated Fuel Bays (IFB) or Fuel Transfer Bays (FTB). It defines the actions necessary to protect the health and safety of the worker and the methods required in order for internal and external radiation exposures to be maintained ALARA" (Section 1.0) [91].

SEC-RPR-00069, Airborne Radioactive Particulate Surveys establishes "the criteria to determine when airborne radioactivity surveys are required" and "the methods for performing particulate air sampling." The procedure also provides direction on "field screening and analysis of particulate air samples", "assessment and response to particulate air sample results" and "documentation of airborne particulate radioactivity surveys" (Section 1.0) [92].

BP-PROC-00878, Radioactive Waste Management "defines the fundamental business needs, constituent elements, functional requirements, implementing approaches and key responsibilities associated with implementing the Bruce Power Radiation Protection Waste Management Policy … for radioactive waste" (Section 1.0) [93].

BP-RPP-00043, Management of Nuclear Substances and Radiation Generating Equipment "defines the requirements for the management of the activities associated with… Bruce Power CNSC Licences and Ontario Ministry of Labour (O.MOL) Radiation Protection Services (RPS) Registrations" (Section 1.0) [94] The scope of this procedure includes the CNSC licences discussed in Sections 3.2.3, 3.2.4, 3.2.5 and 3.2.6.

4.1.6. Verification of Radiological Work

Section 4.6 of BP-PROG-12.05 describes the processes in place for "confirming by measurement or observation that planned results have been achieved" in radiological work. "Verification processes are integrated at all levels of radiation protection activities to ensure that the processes and systems established in this Program meet the objectives outlined" in the program. [25]

BP-PROC-00913, Health Physics Laboratory defines "the purpose of the Bruce Power Health Physics Laboratory, the major functional elements, and the organization arrangements of the Dosimetry Section" (Section 1.0) [95].

BP-PROC-00914, Radiological Analysis defines "the scope of the radiological analysis and environmental sampling carried out by the Health Physics Laboratory" (Section 1.0) [96].

BP-PROC-00280, Dosimetry Requirements documents the requirements for Bruce Power's Dosimetry Section which "provides radiation dosimetry services in support of the Radiation Protection Program, and in accordance with the Dosimetry Service Licence" (Section 1.0) [28].

BP-RPP-00020, Dosimetry and Dose Reporting documents "the processes for use of radiation dosimetry devices" (Section 1.0) [97].

BP-RPP-00005, Routine Radiological Survey defines Routine Radiological Survey Program Requirements. This procedure applies to routine radiological surveys inside the protected area, outside the protected area and in areas of the station impacted by alpha activity (Section 1.0) [98].

SEC-RPR-00016, Alpha Monitoring Procedure "establishes a standardized and graded approach to monitoring for alpha contamination based on the Electric Power Research

Institute (EPRI) Alpha Monitoring Guidelines for Operating Nuclear Power Stations (2009)" (Section 1.0) [99].

SEC-RPR-00032, Routine and Outage Surveys Performed by Radiation Protection Technicians provides "guidance to RP Technicians for performing routine and outage radiological surveys at Bruce Power" (Section 1.0) [100].

SEC-RPR-00046, Routine Surveys Outside the Protected Area "defines routine radiological survey requirements outside the protected area" (Section 1.0) [101].

BP-RPP-00040, Oversight of Radiological Work "defines the oversight required by managers of workers performing radiological work to ensure effective compliance with key planning and execution activities associated with the Bruce Power RP Program" (Section 1.0) [102].

SEC-RPR-00025, Radiation Protection Field Inspection Oversight sets "the expectations of the RP Departments at Bruce Power licensed facilities when providing oversight of radiological work" (Section 1.0) [103].

4.1.7. Radiological Incident Response

Section 4.7 of BP-PROG-12.05 "describes the procedures and processes in place to ensure radiological incidents are responded to promptly, and investigated to ensure the safety of all workers and the public." [25]

BP-RPP-00047, Station Response to an Abnormal Radiological Condition provides "guidance to station personnel on how to respond to abnormal radiological occurrences in accessible areas. This procedure is intended to be used in conjunction with Emergency Response Procedures" (Section 1.0) [104].

BP-PROC-00517, Health Physics Response to a Radiation Overexposure provides "Health Physics personnel with supporting information to be used when informed that a worker has received an acute dose or a committed dose from an uptake of radioactive material that has resulted in him/her exceeding a CNSC Radiation Protection Regulations annual effective dose limit" (Section 1.0) [105].

SEC-RPR-00026, Health Physics Response to a Personnel Contamination Incident provides "guidance to Health Physicists when responding to incidents involving the contamination of an individual at Bruce Power" (Section 1.0) [106].

SEC-RPR-00038, Radiation Protection Response to a Radiological Event provides "information to RP staff responsible for responding to and investigating a radiological event to ensure event response and follow-up actions to the event are performed consistently and in accordance with all regulatory and internal Bruce Power reporting requirements" (Section 1.0) [107].

4.2. Radiation Protection Improvements

In 2012 a plan was developed to implement improvements in all areas of RP: dose control; contamination control; source term characterization and control; radiological material control; organization and staffing; and training. Improvements were to be established through evaluation and revision of standards and processes and bolstered by improved facilities and implementation of new technologies [108] [109].

In 2013 Bruce Power RP performed two large self-assessments intended to benchmark industry excellence and to identify gaps to excellence at Bruce Power and opportunities for RP improvement. The first was a gap analysis commissioned by Bruce Power to evaluate the RP Program against the findings of the CANDU Radiological Protection Benchmarking Project final report [110]. The second was a gap analysis of the RP Program and standards against the guidance contained in WANO GL 2004-1 (Rev-1) [111]. Following these assessments many improvement actions were initiated; one of the most significant being a reorganization of RP at Bruce Power.

A brief summary of improvement initiatives, current as of Q2 2015, is provided below [108]:

- **RP organization and staffing** – A significant reorganization of RP Programs, dosimetry, Bruce A and Bruce B sections took place in the fall of 2013. HPs were moved to increase HP capability in the stations and were assigned responsibility for ALARA support to major outage programs. The structure of RP technician staffing at the stations was also reorganized to provide RP support at all hours, every day.
- **Dose control** – Dose reduction projects were initiated, expected to result in an estimated dose savings of 10 person·Sv by the end of 2018. Specific examples include increased use of shielding, improved vault tritium management, improved execution of the boiler maintenance program and implementation of source term reduction initiatives.
- **Source term characterization and control** – Methods were established for characterizing and maintaining current records of the station source term. A source term database is now used to keep source term information up to date for all units.
- **RP training** – The Yellow badge qualification training was restructured to include a greater emphasis on practical aspects of RP practices. Annual requalification is now required for Yellow and Green badge qualifications. Enhanced RP fundamentals training was developed and delivered to supplementary RP Technicians.
- **Contamination control** – Twenty-five new whole-body monitors were put in place at Bruce B, with plans to replace other monitors by the end of 2015. Further planned initiatives included replacement of whole-body monitors at Bruce A and the CMLF, replacement of the site small-article monitors and a new large-article monitor to allow release of bulk items.

4.3. Impact of Changes on the Radiation Protection Program

Improvements of such a broad scope to the implementation of RP inevitably require extensive revision to the RP Program documentation (as described in Section 4.1). For example, the ALARA program was significantly revised to incorporate industry best practices. Throughout the course of this assessment of the RP Program at Bruce Power it has been determined that revision to the RP Program documentation is often lagging the implementation of improvements and reorganization. This gap in the RP Program documentation is discussed in further detail in Sections 5 and 8.

5. Results of the Review Tasks

The results of the assessment of Bruce Power Radiation Protection against the review tasks listed in Section 1.2 are presented in the following sections. The structure and interpretation of the review tasks identified in REGDOC-2.3.3 have been adapted to provide a comprehensive assessment of RP at Bruce Power. Three additional review tasks have been added to align with the contents of WANO GL-2004 (Rev-1) [54] for completeness and to increase the utility of the review:

- RP organization and administration
- RP training
- RP Program documentation

Two of the elements that are recommended in REGDOC-2.3.3 are covered under other safety factors (see Section 6):

- RP operating experience is covered under Safety Factor 9 – Use of experience from other NPPs and research findings. As a result, only a limited assessment of very specific guidance related to RP OPEX is included in this assessment under review task 3.
- The review of RP aspects for nuclear emergencies is described by REGDOC-2.3.3 as intended to demonstrate “the effectiveness of RP measures during a nuclear emergency. These measures may be significantly impacted by facility configuration and controls; or for example, the review should consider access controls, habitability controls, communications systems, adequate radiation monitoring capabilities, portable emergency response RP equipment, and radiation personnel protective equipment” (Section A.3.3). The programs and plans in place to address RP aspects for nuclear emergencies are included in the scope of Safety Factor 13 – Emergency planning, and are not included in this review (see Section 6).

In this section each of the review tasks is presented under a second-level heading as follows:

Section 5.1 – Reactor design features for RP

Section 5.2 – RP equipment and instrumentation

Section 5.3 – RP OPEX

Section 5.4 – RP organization and administration

Section 5.5 – RP training

Section 5.6 – RP Program documentation

5.1. Reactor Design Features for Radiation Protection

REGDOC-2.3.3 [3] elaborates on the first review task, stating that the assessment "should identify all sources of radiation and radiation exposure pathways, with an evaluation of radiation doses that could be received by workers at the facility with consideration of contained and fixed sources, and potential sources of airborne radioactive material. The review should demonstrate that the ALARA principle has been incorporated in the reactor design and operational programs and arrangements, in order to minimize the number and locations of radiation sources and the radiation fields associated with them" (Section A.3.1).

The first review task therefore involves reactor design features for RP along with assessment of the RP Program established in support of the operation of the reactors as designed.

REGDOC-2.3.3, Section A.3.1, goes on to state:

> The review should include RP principles, and how they are incorporated into the reactor design and are of sufficient depth to demonstrate the following:
>
> - Suitable provisions have been made in the design and layout of the reactor facility to keep occupational radiation doses below regulatory limits and ALARA, including:
> - classification of areas (zoning) and access control
> - aging of all materials and obsolescence of technology that could impair the radiological safety functions of SSCs [Systems, Structures and Components]
> - radiological hazard control
> - decontamination of personnel, equipment and structures
> - radiological monitoring (in-plant)
> - SSCs have been adequately designed so that radiation exposures during all activities are optimized and justified.

Each of the above items has been expanded upon in the following subsections, with the exception of ageing and obsolescence. There is no regulation, standard or guideline relating to ageing and obsolescence of the RP equipment and instrumentation listed in Section 5.2.1. However, based on REGDOC-2.3.3 it is apparent that there should be provisions made to ensure that ageing and obsolescence of equipment and instrumentation do not negatively impact radiation safety. Assessment of the Bruce Power RP Program documentation against guidance from WANO GL-2004 Revision 1 [54] related to the impact of ageing and obsolescence on RP equipment and instrumentation is considered under the second review task, RP equipment and instrumentation for radiation monitoring (see Section 5.2).

In this section each of the review elements identified under review task 1 is presented under a third-level heading as follows:

Section 5.1.1 – ALARA

Section 5.1.2 – Zoning and access control

Section 5.1.3 – Radiological hazard control (including decontamination)

Section 5.1.4 – Radiological monitoring

5.1.1. ALARA

5.1.1.1. Interpretation

The Bruce B reactor design features presented in support of the ALARA review task element include the general description of RP and the dose reduction program provided in the Bruce B Safety Report [112].

The review of the RP Program for this review task element is interpreted to include incorporation of the ALARA principle into Bruce Power operational programs and arrangements through the establishment of an ALARA program for the purpose of dose planning, dose management and dose reduction.

Assessment of radiation sources and potential doses to personnel is performed on an ongoing basis upon discovery of new sources and/or during work planning as part of the Bruce Power ALARA program [27]. The ALARA Program is assessed as part of this review task.

5.1.1.2. Design Features

Section 12.1 of the Bruce B Safety Report [112] provides a general description of RP:

> The goal of Radiation Protection is to limit the exposure of plant personnel to a level that is As Low As Reasonably Achievable (ALARA). This applies to all types of radiation generated by the reactors. A Radiation Protection Program is in place in support of this goal.
>
> Limiting personnel exposure is achieved by incorporating protective features into the initial station design, by controlling access to areas with elevated radiation levels, and by excluding personnel who are approaching certain administrative dose limits from further exposure.
>
> Requirements are in place that govern the use of Radiation Protection Protective Equipment (RPPE), which protect personnel from internal radiation resulting from the uptake of airborne and surface contamination. Decontamination facilities are provided to restrict the spread of contamination. Dosimetry and personnel monitoring devices are used extensively to monitor the doses that staff members receive, and to ensure that these doses are within allowable limits.

Section 12.2 of the Safety Report provides a description of how personnel dose reduction was considered during the original design phase prior to bringing the Bruce B Units 5-8 into service during the period from 1984 to 1987:

> All systems considered to have significant radiological implications for station personnel during operation or maintenance were reviewed in the design phase. The review process included a series of Man-Rem Audit meetings on a system-by-system basis. AECL design, operations, health physics, and physics and analysis groups were represented. Each system design was

examined with respect to reliability, maintainability, ease of handling, ease of access, shielding, etc. Radiation exposure was estimated for each system in man-rem per year, and the estimate compared with budgeted exposure figures prepared earlier as targets. Proposals to reduce radiation exposure by improving system design were analyzed and, wherever feasible, implemented.

Special attention was also directed to system chemistry, equipment simplicity, service intervals, and ease of component removal. In general, it was recognized that the fundamental approach of improving component reliability or system chemistry is more effective than secondary measures such as installation of additional shielding.

Improved station design has contributed significantly to the reduction of both collective and individual dose expenditures, and to the productivity of those dose expenditures which do take place.

5.1.1.3. Radiation Protection Program Review

Through a high-level assessment it was concluded that Bruce Power's RP Program documentation meets the requirements of CNSC Regulatory Guide G-129, Keeping Radiation Doses 'As Low As Reasonably Achievable' [30] (see Appendix A.1).

The Bruce Power RP Program documentation was also assessed against guidance from WANO GL-2004-01 (Rev-1) [54] related to the incorporation of the ALARA principle. Specific guidance related to dose reduction and the planning, execution and oversight of radiological work is provided primarily in the following clauses:

- Chapter I – Radiological
  - I.C5: Conservative Decision Making
- Chapter III – External Radiation Dose Control
  - III.C1: External Dose Controls
  - III.C2: Personnel Monitoring for External Radiation
  - III.C3: Identification and Control of Radiation Sources
- Chapter IV – Internal Radiation Dose Control
  - IV.C1: Internal Dose Controls
  - IV.C3: Monitoring for Internal Radioactivity
- Chapter V – Radiation Dose Reduction
  - V.C1: Preliminary Planning and Scheduling
  - V.C2: Work-in-Progress and Postwork Reviews
  - V.C3: Radiological Engineering
  - V.C4: Radiation Dose Goals
- Chapter VII – Radiological Protection Work Control

- VII.C1: Supervision and Monitoring of Radiological Work
- VII.C2: Radiation Work Permits and Procedures

Bruce Power has established an ALARA process, which is described in BP-RPP-00044, ALARA Program [27], but micro-gaps against the guidance given in WANO GL 2004-01 (Rev-1) were identified through the clause-by-clause assessment described in Appendix B. These micro-gaps are summarized as follows:

- Terms of Reference (TOR) for ALARA Committees do not meet all of the requirements of the ALARA Program, BP-RPP-00044 [27] and some TOR do not include a statement that the conduct of ALARA Committees will adhere to the requirements of BP-RPP-00044 [27], as committed by Bruce Power. Following an inspection focused on ALARA Planning and Controls [113] the CNSC issued the following Action Notice:

  > In order for Bruce Power to become fully compliant with BP-RPP-00044 sub-section 4.1, CNSC staff request Bruce Power to develop and implement a corrective action plan to ensure that the ALARA Committees' Terms of Reference are: clearly defined and documented, consistent with the requirements of BP-RPP-00044; and adhered to in the conduct of ALARA Committee Meetings. (Section 4.2.1 of BRPD-AB-2014-10, attachment of NK29-CORR-00531-12092 [113])

  In response to the Action Notice, Bruce Power committed that

  > a corrective action has been initiated to revise the Terms of Reference for all Site and Station ALARA Committees and Sub-Committees. This revision shall ensure that all Terms of Reference for the above named committees will adhere to BP-RPP-00044 and a statement is added that the conduct of such committees will adhere to the requirements of BP-RPP-00044. (Attachment A, [114])

  The Site ALARA Committee TOR [115] includes a statement that the TOR is in alignment with BP-RPP-00044 [27], and do align with the TOR requirements in that procedure with the exception that timelines for minute distribution are not provided. The Bruce B ALARA Committee TOR [116] does not include reference to BP-RPP-00044 [27], the required meeting agenda items, or timelines for minute distribution. The Bruce B ALARA Sub-committee TOR [117] does not include reference to BP-RPP-00044 [27] or timelines for minute distribution. Recommendations on how ALARA matters are discussed, addressed, decided upon and communicated are provided in Clause I.C5 of the WANO guideline.

- There is a misalignment between ALARA planning dates and outage planning dates making it difficult to comply with the related procedures. An internal assessment of the Bruce Power ALARA Program states that, “This review determined that the program is sound and meets the regulatory intent and industry guidelines. There are some challenges with execution, specifically the maintenance of the 5 Year Dose Reduction Plan has proven to be difficult given the dynamic nature of outage scope control and scheduling” (Section 4.0 [118]). Findings from this FASA identified that there is a misalignment between the ALARA planning dates provided in BP-RPP-00011 [75] and outage planning dates provided in BP-PROC-00342 Sheet 0001 [119]. A recommendation was made to revise the ALARA planning procedure to reference the outage planning procedure for dates in order to prevent the observed misalignment. The

required change was made and the revised procedure issued. A month later the change was revoked in another revision issued. Consequently, there remains a gap with respect to the required revision of BP-RPP-00011. This micro-gap was identified through assessment of Clause V.C1 of the WANO guideline [54].

- Clause V.C2 of the guideline recommends dose reduction suggestion programs as well as the programmatic inclusion of dose goals as part of incentive programs to help generate new ideas and provide focus on dose reduction. Section 4.7.1 of BP-RPP-00044 [27] describes how ALARA initiatives can be submitted by anyone through SCRs, Business Improvement Group Ideas (recently replaced by "Innovations at Work") or separate projects. However, there is no documented inclusion of dose goals as part of an incentive program at Bruce Power.
- Clause V.C4 recommends that stations "Formally provide station status weekly during normal operations and daily or per shift during outages." There is no specific requirement in the Bruce Power ALARA Program to provide station dose status weekly during normal operations and daily during outages. However, the following dose information is provided:
    - Via the RP web page - current year to date dose and dose per unit
    - Via the Radiation Information System - personal individual dose status
    - The Site ALARA Committee TOR [115] indicates that that committee reviews dose status monthly
    - The Bruce B ALARA Committee TOR [116] indicates that committee members are responsible for producing planned outage dose performance reports
    - Daily outage dose performance emails are sent to RP personnel
    - A detailed outage dose performance overview report is prepared and communicated following an outage
    - Dose status against the YTD target is reported daily in the Plant Condition Report

  RP practices that are not documented in RP Program governance have been identified as a programmatic gap, as discussed in Section 5.6.
- Clause VII.C2 of the guideline provides direction on conditions under which general REPs should be used for radiological work and those under which specific REPs should be used. While there seems to be two types of REPs (routine/general and unique/specific) in use at Bruce Power, the difference between them is not well explained or defined in the procedures.
- Within Clause VII.C2 is the recommendation, "When high radiation, discrete radioactive particle or airborne radioactivity conditions may be encountered, specify stop-work control levels (for example, dose rate or airborne radioactivity level) in the RWP [radiation work plan – equivalent of REP] at which all workers, including radiological protection personnel, are to leave the work area." The Radiation Exposure Permit (REP) procedure SEC-RPR-00015 [120] does not explicitly require that back-out criteria be specified in the REP for DRPs or airborne particulates; however, REPs do provide

control levels to stop-work if unanticipated hazards, such as DRPs and airborne activity, are encountered. As mentioned above, RP practices that are not documented in RP Program governance have been identified as a programmatic gap, as discussed in Section 5.6.

In general, it was concluded that Bruce Power has a comprehensive radiation dose limitation process, which is generally consistent with the guidance given in WANO GL 2004-01 Rev 1 [54]. Some specific micro-gaps pertaining to the ALARA program documentation were identified as described above. These micro-gaps are shown in Table 7 under SF15-1. Programmatic gaps identified where RP practices are not documented in RP Program governance are shown in Table 7 under SF15-5.

5.1.2. Zoning and Access Control

5.1.2.1. Interpretation

The Bruce B reactor design features presented in support of the zoning and access control review task element include the descriptions of these systems provided in the Bruce B Safety Report [112], along with drawings showing the plant zoning arrangement.

The review of the RP Program for this review task element is interpreted to include assessment of the RP operational programs and procedures to demonstrate that they provide suitable requirements for radiological zoning and access control to maintain occupational radiation doses ALARA.

Zoning is interpreted to include the permanent station zoning arrangement, temporary changes made to station zoning and the required process for making permanent changes to station zoning.

5.1.2.2. Design Features

Section 12.3.3 of the Bruce B Safety Report [112] discusses station zoning:

> The station is divided into three zones according to the potential for contamination and other radiological hazards ... The zones are defined as:
>
> - Zone 1
>
> Zone 1 is a clean area inside the Protected Area that is considered equivalent to Public Domain. This zone contains no radioactive sources other than those found in normal industrial establishments (or those approved for specific applications), and may be considered the equivalent of a normal public access area. Zone 1 includes the clerical offices in the administration area, the technical office on the 693 ft elevation, south entry, cloakroom, main lunch room, control centre lunchrooms, planning and training offices on the 663 ft elevation, conference rooms on the 615 ft elevation, and the Unit 8 office complex and Unit 0 Stores receiving area on the 591 ft elevation.
>
> - Zone 2

Zone 2 is an area that is normally free of contamination but is subject to infrequently cross-contamination due to the movement of personnel and equipment from contaminated areas. This zone may contain enclosed, sealed radioactive systems and sources (i.e. active ventilation ducts, radioactive monitoring pipelines, heavy water piping and constancy check sources. This zone contains a minimal amount of radioactive equipment. Certain enclosed radioactive systems may penetrate into Zone 2 from Zone 3, and some contamination is occasionally carried into Zone 2 from Zone 3 with the movement of personnel, equipment, and tools. Such contamination is cleaned up as soon as it is discovered. Zone 2 includes the turbine hall, stores area, mechanical maintenance shop, service and control maintenance shops, control centre, field work control rooms and selected instrument rooms, main access ways, offices, valve maintenance shop and the control maintenance monitoring shop on the 665 ft elevation.

- Zone 3

  Zone 3 is an area that contains systems and equipment that may be sources of radiation or contamination. This zone contains the systems and equipment from which any contamination originates. It extends over all elevations. Zone 3 includes the reactor vaults, the containment areas and reactor auxiliary bays, the decontamination centres, some chemical laboratories and in general, all areas north of column line 11. It also includes the mechanical maintenance shop, vacuum building, and the ancillary services building.

  Zone 3 contamination surveys and the decontamination work required as a result of these surveys are governed by procedures. The spread of contamination is limited by using contamination control areas, radiation detection equipment and by using protective clothing for entry into these areas.

- Unzoned Area

  Unzoned Area is within the Zoned Area of the facility that is expected to be free of contamination and is not otherwise classified as Zone 1, 2 or 3. Areas that are within the protected area but are not included in Zones 1, 2 or 3 are collectively called the Unzoned Area. The Unzoned Area includes outdoor roadways, lawns and miscellaneous buildings and structures. It is free of radioactive sources other than those specifically approved. Material packaged and labelled in accordance with radioactive shipping requirements move through the unzoned area.

For any movement of personnel or material between zones, actions must be taken to prevent possible contamination from a zone of higher number to a zone of lower number. For this purpose, contamination monitors are located on all normal routes between zones.

Access to and from the station is from the south side on elevation 615 ft, through the Zone 1 cafeteria access lobby, or from the south-east corner of the powerhouse into the Zone 1 entrance to the Unit 8 office complex. There are emergency exits to the unzoned outdoors at the grade level at convenient locations near stairwells and traffic routes, which are marked as such. There are also large doors in the reactor auxiliary bay and the central service area to permit controlled transfer of vehicles and equipment directly to and from the outdoors. These exits are located at the east end of Unit 8, on the 591 ft elevation, and at the west end of the Unit 5, at the same elevation.

The access control and zoning described above were tested under operating conditions on Bruce A before being applied to the Bruce B.

The general zoning arrangement for each elevation of Bruce B is shown in Figure 1 through Figure 6, which were taken from the Bruce B Safety Report Figure 12-1 through Figure 12-6. Reactor Building zoning and monitor layouts are typical across Units 5-8.

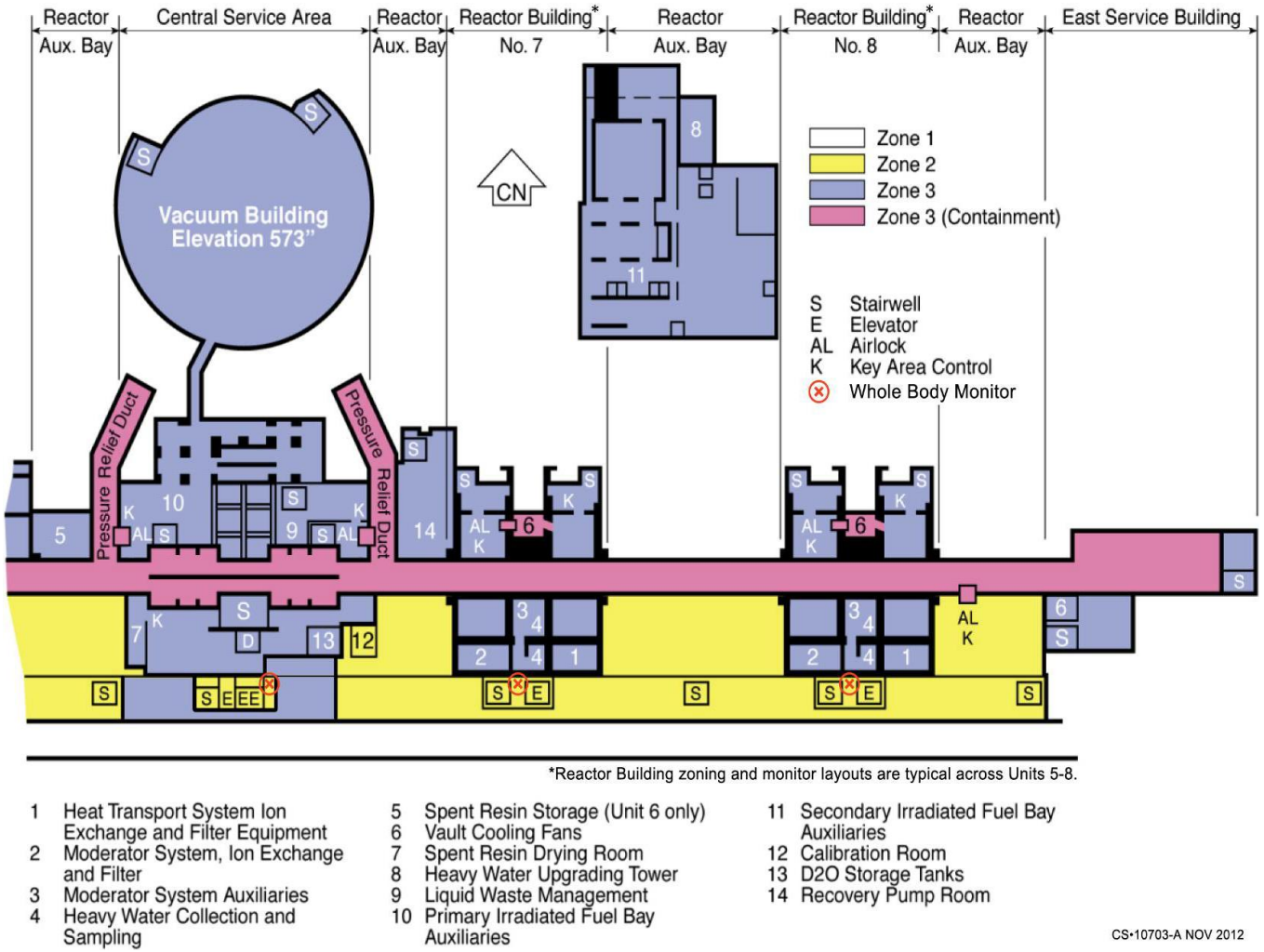


Figure 1: Plant zoning arrangement – floor plan at elevation 579 ft

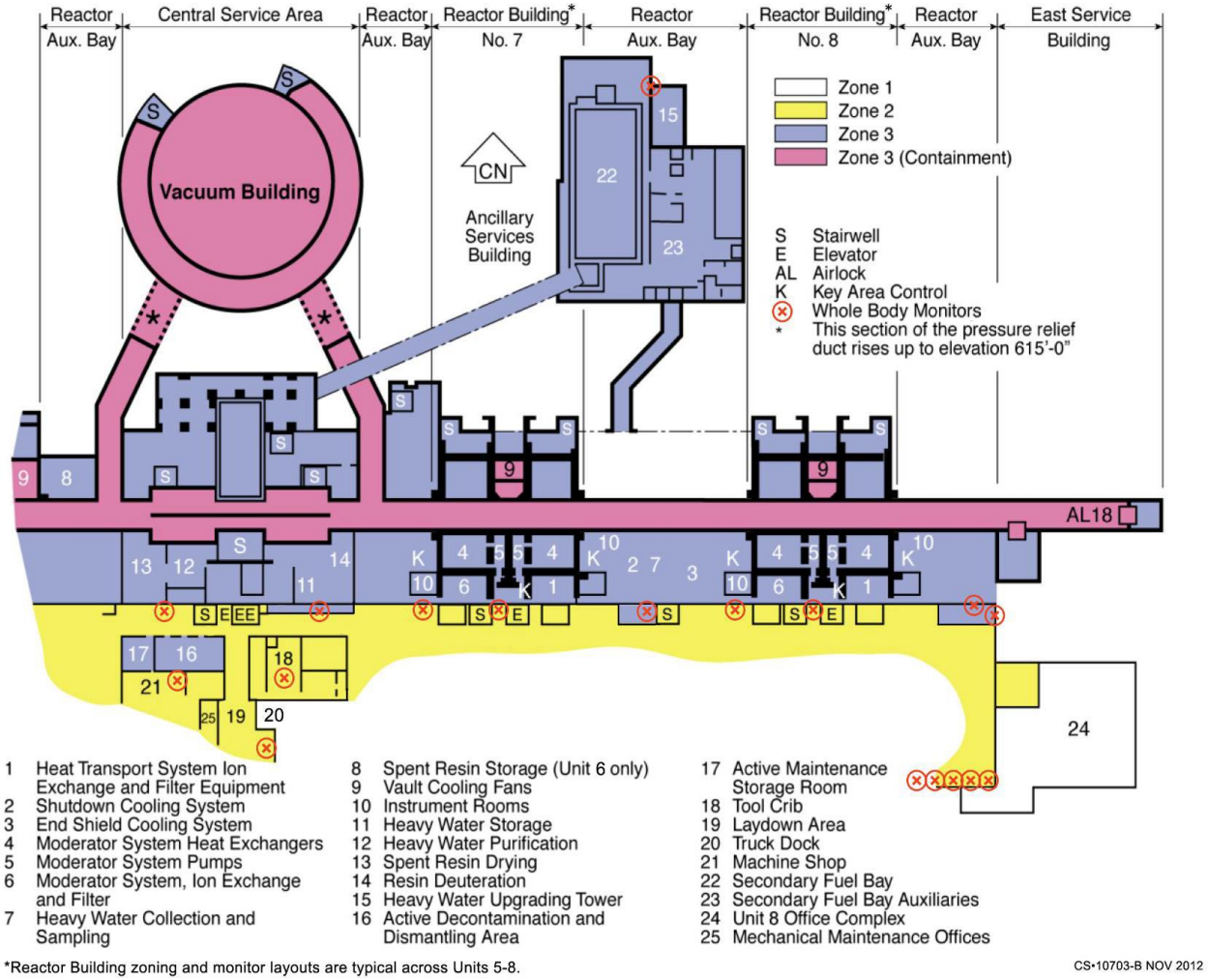


Figure 2: Plant zoning arrangement – floor plan at elevation 591 ft

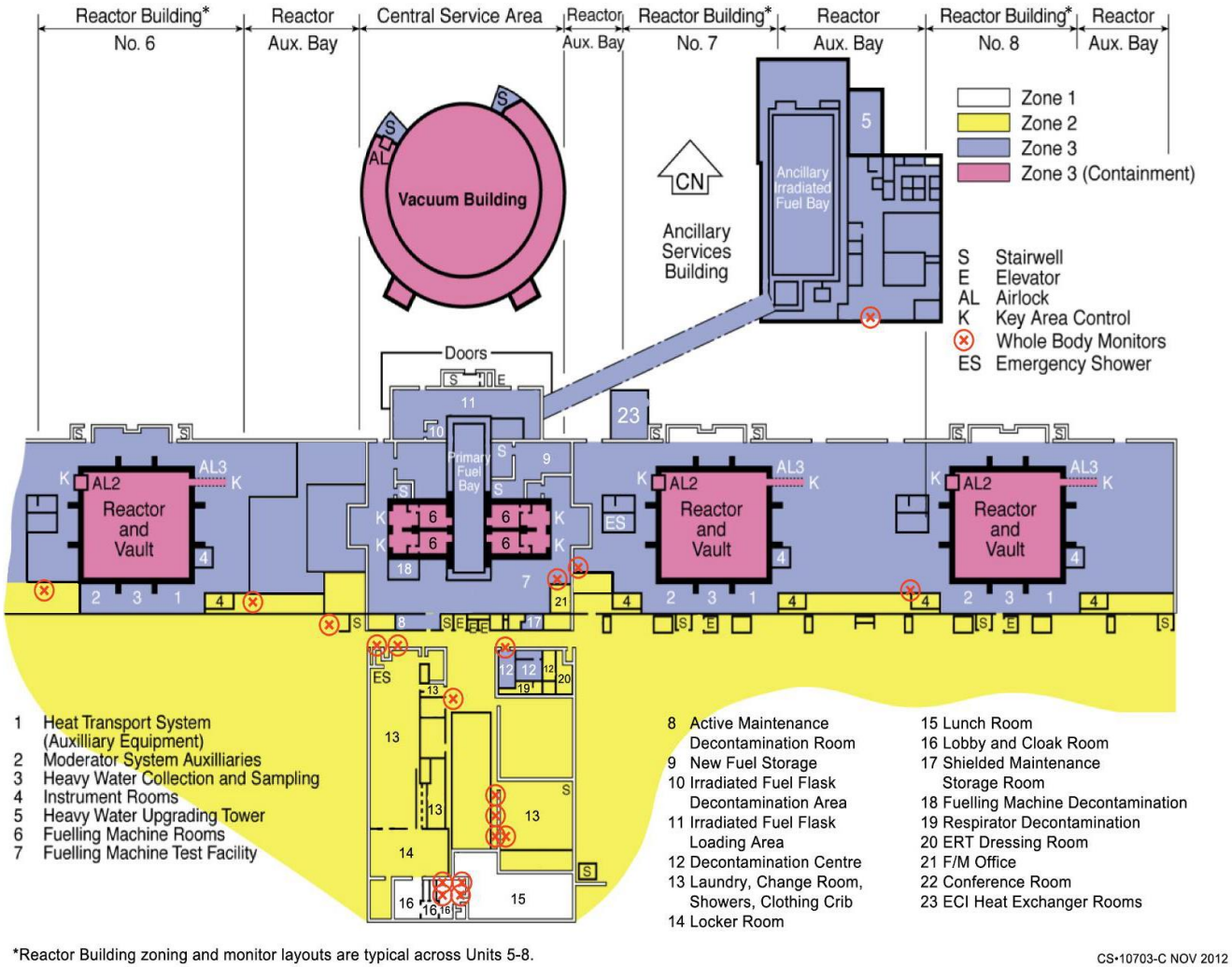


Figure 3: Plant zoning arrangement – floor plan at elevation 615 ft

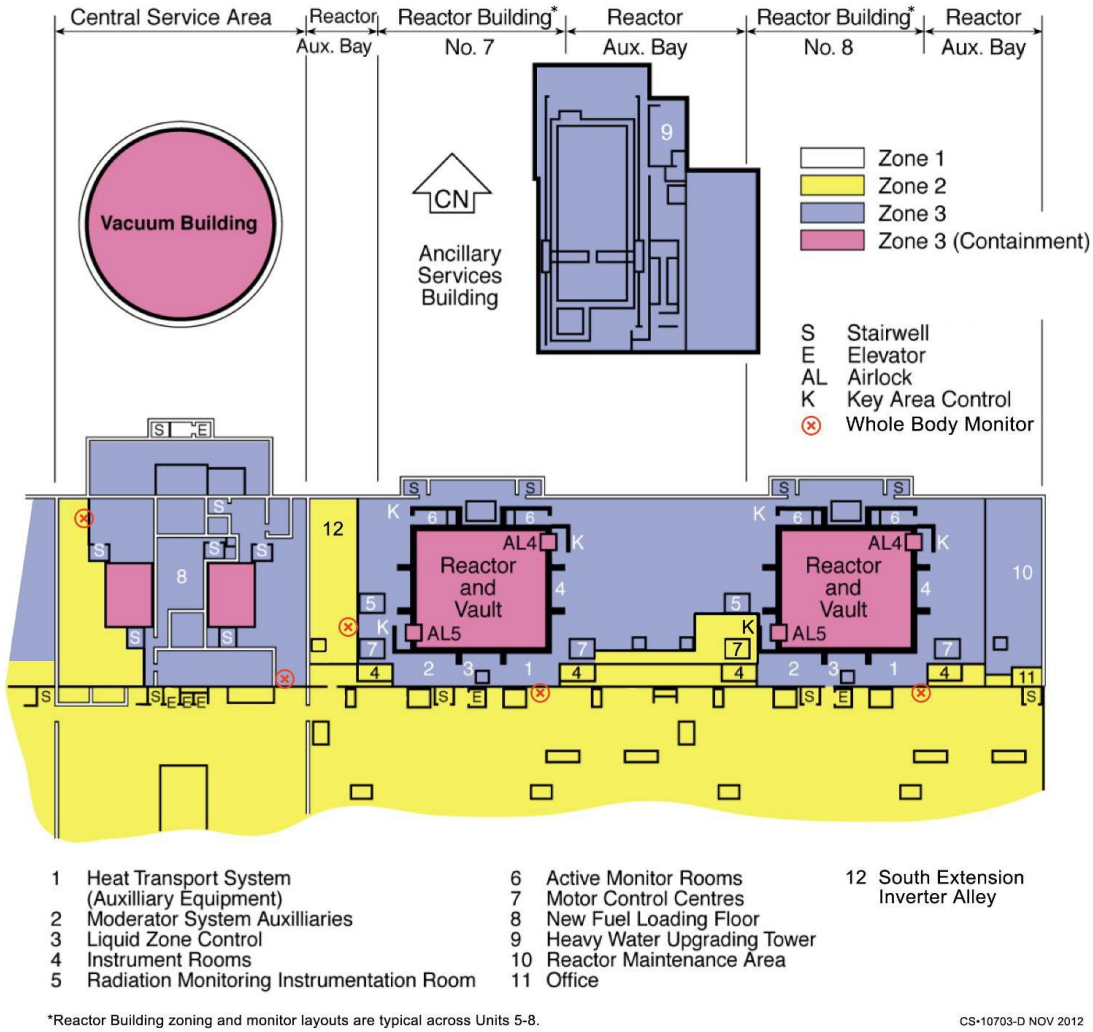
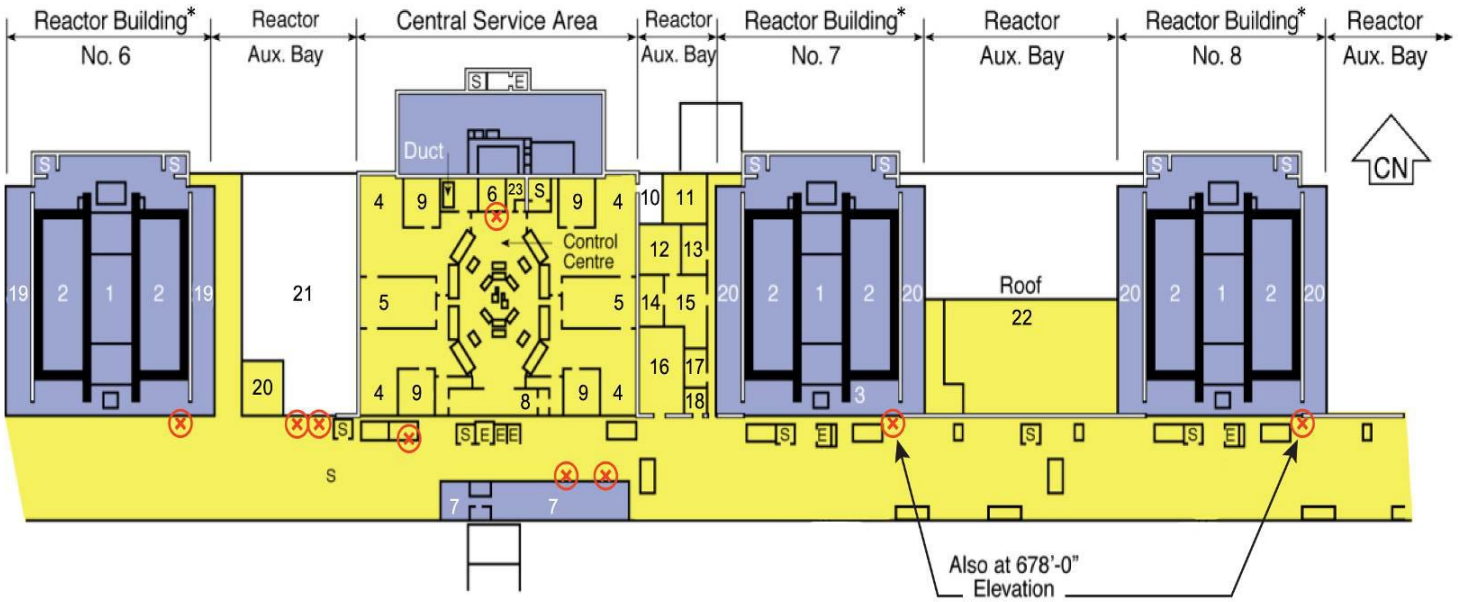


Figure 4: Plant zoning arrangement – floor plan at elevation 639 ft



1 Reactivity Mechanism
2 Boiler Rooms
3 Heat Transport System (Auxillary Equipment)
4 Control Equipment Room
5 Fuelling Machine Control
6 Computer Auxillary Room
7 Laboratories
8 Work Control Office
9 Computer Room
10 Main Control Room Lunch Room
11 F/H, D_2O and Operation Auxilliaries
12 Computer Maintenance Office
13 Fuel Handling Office
14 Storage Area
15 Computer Mainenance Room
16 Fuelling Machine Equipment Room
17 Air Conditioning Equipment Room
18 Valve Access Area North
19 Boiler Level Instrument Room East/West
20 Air Conditioning Equipement Room
21 Office Area "Taj Mahal"
22 LPF Equipment Room
23 Computer Room

Zone 1
Zone 2
Zone 3
Zone 3 (Containment)

S Stairwell
E Elevator
Whole Body Monitors

*Reactor Building zoning and monitor layouts are typical across Units 5-8.

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Figure 5: Plant zoning arrangement – floor plan at elevation 663 ft

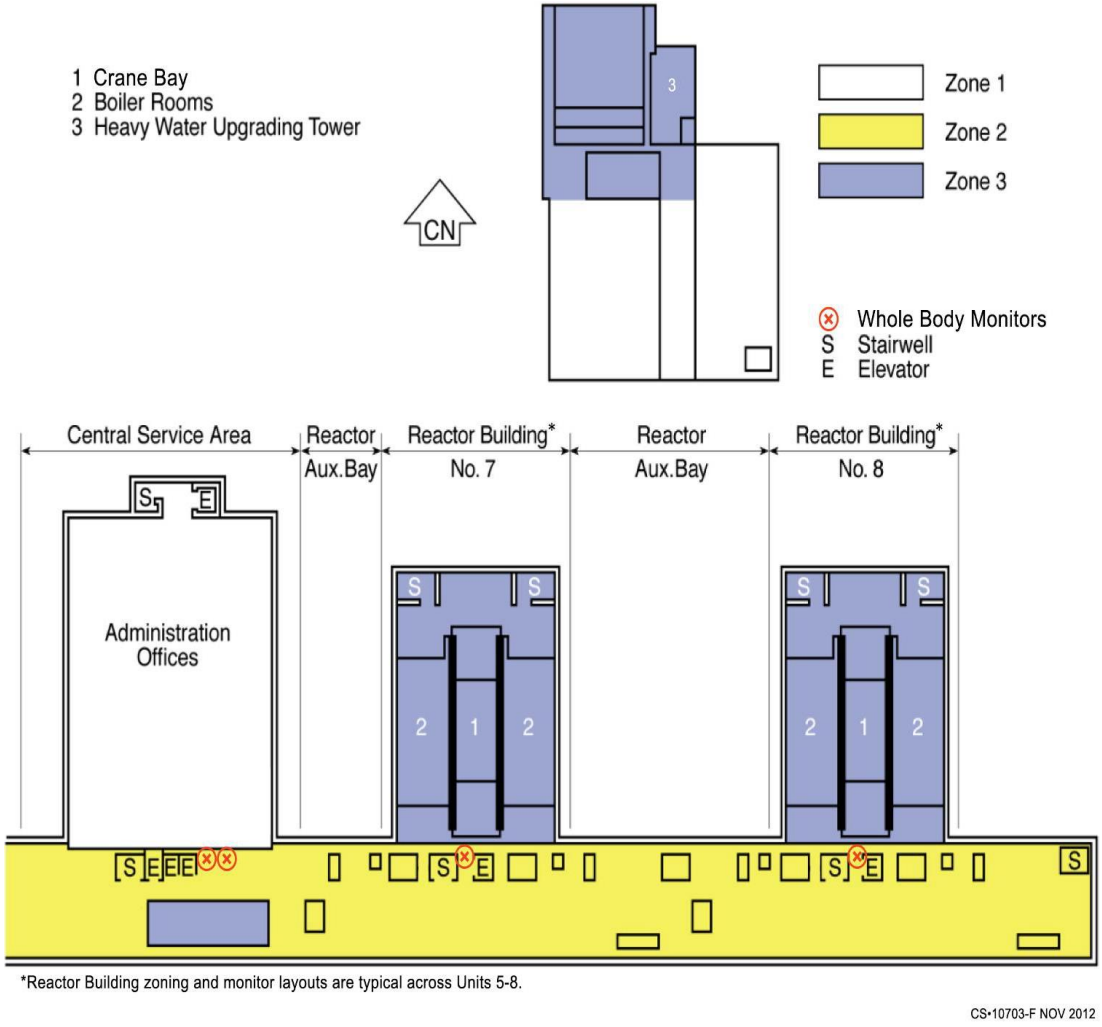

Figure 6: Plant zoning arrangement – floor plan at elevation 693 ft

Section 12.3.1.3.1 of the Bruce B Safety Report [112] provides a general description of access control:

> The plant is laid out to minimize the need for personnel to enter areas with high radiation fields. In general, operational procedures restrict access to the reactor building to qualified personnel and those escorted by qualified personnel. Access to areas that either have or could have high radiation fields is strictly controlled by the Access Control System. Extensive use is made of physical barriers, permanent and temporary signs, and other means to clearly warn and instruct personnel of any possible danger from radiation.
>
> Access controlled areas have locks and keys controlled by the shift manager. The keys are kept in the control room.

Section 12.3.1.3.2 of the Safety Report describes the access control system:

> The access controlled areas include areas in which the reactor and its auxiliaries, the heat transport system, the moderator system, and the fuelling machines are located. The level of hazard in each of these areas depends on the operating conditions.
>
> The access control system is designed to guard against personnel unwittingly approaching sources of high radiation, and also against radiation sources being transported into an area where personnel could be present. A specific example of the latter is the movement of the fuelling machines into the fuelling machine rooms.
>
> The access control system uses interlocks with large keys that are of unusual shape. The keys are easily identified and difficult to duplicate. Each door, gate or bulkhead to an access controlled area is locked with its specific key.
>
> Normally, all keys are retained in the Unit Zero Access Control Panel, which is located in the main control room. Each key has a square socket with a pattern inscribed on its base. The keys mate with specific locks to actuate a mechanical or electrical mechanism. With the keys disengaged, the fuelling machines can be moved, and reactor power raised, only to a very limited extent.
>
> When personnel are working in a controlled area, the access control key is retained in the lock while the door is unlocked, whether open or closed. Visible signals are provided in the control room to warn of unlocked doors.
>
> The fixed area monitors for any access controlled area are put into an alarm capable state when the respective access key is removed from the access control panel. Monitors in local key controlled areas remain alarm capable at all times.

Some areas are classified as access control mode P (for power).

> This indicates that the removal of a key from the control room keyboard will cause an alarm when the reactor is above a certain pre-set low power level. The levels vary for different areas.
>
> Each reactor has its own access control subsystem. Only when all keys for a subsystem are in their transfer locks can the reactor power be raised above 0.2% full power. This power interlock feature can only be overridden by the unit operator. Authorization to override must be obtained (in advance) from the shift manager. When access control is overridden, this will be annunciated in the control centre on the corresponding panel as a reminder to the unit operator that access areas may be occupied.
>
> The unit control computer prevents the reactor power from being raised if an access key is removed at a power level above 0.2% full power. The unit operator can override this feature with

approval of the shift manager. The use of override and spare keys is also covered in the Bruce Power Safety Rules.

In the fuelling machine control mode... an alarm in the control room will indicate when a fuelling machine is in a position or is operating in a manner that could present a hazard to personnel. For this mode, the station is divided into six regions, and the transfer locks are interconnected at the access panel in the control room. Only when all keys for a particular region are in their respective locks will a signal be sent to the fuelling machine computers which allow a machine to enter that region. This prevents a machine from entering an accessed region. For example, if the machines were in Unit 5 (region 1) and called to move to Unit 7, they would automatically pause at the interface of Unit 5 to Unit 6, if Unit 6 (region 2) were accessed.

The fuelling machine operator can override this interlock by obtaining the region override key from the unit operator. This override will only be used when the fuelling machine movement does not pose a radiological or conventional hazard. The fuelling machine and unit operators are together responsible for ensuring that any areas affected by fuelling machine movement are evacuated if necessary.

Access keys for the procedural restriction control mode, C... are also located in the control room access panel but are not interlocked with either reactor power or fuelling machine movement. Access through these areas is expected to be infrequent and release of these keys is authorized by the shift manager only. Personnel accessing these areas are responsible for taking all necessary precautions for preventing accidental high exposures.

Section 12.3.1.3.3 of the Safety Report describes the access control locking arrangement:

Doors leading to access controlled areas of control mode P, F/M, and C are locked subject to the following:

1. It is always possible to open the door from the inside, to avoid trapping personnel.
2. When a key is used to open a lock it is not possible to remove the key without closing and locking the door.
3. It is possible to close the door without locking it.
4. Each access control device is operated by a unique key.
5. Each control room transfer lock is labeled to indicate the field device to which it applies.

On most airlocks, the outside is surrounded by a fenced enclosure with an access gate. Since it is essential that the outer airlock door be closed to allow operation of the inner door, a sign, buzzer and flashing light are mounted near the gate as a reminder.

If any outer airlock door is left open for an extended period, an alarm occurs in the control room and operator action is required to ensure the airlock door is closed.

Section 12.3.1.3.3 of the Safety Report describes personnel access control:

All access to access controlled areas is allowed only on the basis of approved Work Authorizations, and a formal written and approved request for the issuance of an access control area key. Work Authorizations must list the names of all personnel entering the access controlled area.

All listed personnel must have vacated the area before the Work Authorization is surrendered. The shift manager is responsible for ensuring that all access controlled areas are free of personnel before access control is put into effect and unit startup is initiated.

Areas of the reactor and reactor auxiliary bay and the central services and fuelling duct that are subject to access control are listed in the Bruce B Safety Report, Tables 12-3 and 12-4.

5.1.2.3. Radiation Protection Program Review

The Bruce Power RP Program documentation was assessed against guidance from WANO GL-2004 Revision 1 [54] related to classification of areas and access control. Specific guidance relevant to this review is primarily provided in the following clauses:

- Chapter III – External Radiation Dose Control
  - III.C1: External Dose Controls
  - III.C3: Identification and Control of Radiation Sources
- Chapter IV – Internal Radiation Dose Control
  - IV.C2: Identification and Control of Airborne Radioactivity
- Chapter VI – Radioactive Contamination and Radioactive Material Control
  - VI.C3: Contamination Source Identification and Control
- Chapter VII – Radiological Protection Work Control
  - VII.C1: Supervision and Monitoring of Radiological Work

The Bruce Power programs in place for zoning and access control are largely in alignment with the guidance provided in WANO GL-2004-01 [54]. Bruce Power licensed facilities are zoned based on the potential for radioactive contamination in order to protect personnel and prevent the spread of contamination. The RP Program describes the requirements to access areas controlled by the access control system and other areas where high radiation levels may exist.

A discrepancy was found between the Bruce Power RP Program and guidance provided in Clause III.C1 of WANO GL-2004-01 regarding high radiation areas. While the current radiation protection procedure on zoning [69] does not describe the use of high radiation and locked high radiation areas (LHRAs), the intent of the guideline is met with one exception. A FASA on Locked High Radiation Controls concluded that “Bruce Power’s Access Control system is a strong barrier against access to areas with potentially injurious dose rates. This system positively controls access to the majority of areas with dose rates greater than or equal to 1 rem/h [0.01 Sv/h] at 30 cm. This system largely meets the WANO guidelines for LHRA controls, but does not control access to all of the areas with dose rates greater than or equal to 1 rem/h [0.01 Sv/h] at 30 cm” (Section 7.1 [121]). A Station Condition Record (SCR) was submitted to document this discrepancy, which lead to a Document Change Request (DCR) (which was due December 31, 2014) requesting an update to the Access Control procedure BP-RPP-00008 [68] “to create the programmatic requirement for LHRA controls”. The requested update has yet to be accomplished.

Later, AR 28403609 was initiated regarding opportunities to improve radiological dose control, including assignments to:

- "Identify all areas of the Bruce B *[sic]* that are accessible to individuals with gamma dose rates greater than or equal to 1 rem/h at 30 cm."
- "Review identified areas… and propose solutions for implementing physical lockable barriers with positive control capabilities for each area."
- "Identify work groups that would be affected by proposed LHRA solutions and present proposed solutions for consideration and feedback from these groups."

Each of these assignments was canceled, noting that "AR 28403609 and assignments were created in error. AR #28415280 will replace this one." AR 28415280 has also been canceled without explanation.

The identified issues regarding LHRA controls are shown as a gap in Table 7 under SF15-2.

A trend in ineffective use of DCRs to implement procedure revisions, resulting in abandoned and/or forgotten assignments, has been identified as a gap (SF10-2) through Safety Factor 10 on Organization and Administration (see also, Section 5.6).

5.1.3. Radiological Hazard Control

5.1.3.1. Interpretation

The Bruce B reactor design features presented in support of the radiological hazard control review task element include the descriptions of radiation shielding, internal dose control and airborne contamination control provided in the Bruce B Safety Report [112].

The review of the RP Program for this review task element is interpreted to include assessment of the RP operational programs and procedures, to demonstrate that they provide suitable requirements for control of the following radiological hazards: elevated direct dose rates (and their sources) and radioactive contamination (including surface contamination, airborne contamination and discrete radioactive particles). An important contribution to radiation hazard control is provided by good source term control.

While listed separately in REGDOC-2.3.3, decontamination is an important aspect of controlling radioactive contamination and is therefore included under this assessment of radiological hazard control.

Radiological hazard posting is also an important aspect of radiological hazard control and, while not mentioned in REGDOC-2.3.3, has been included in this review for completeness.

5.1.3.2. Reactor Design Features

Section 12.3.1.1 of the Bruce B Safety Report [112] provides a description of radiation shielding:

> Radiation shielding falls into the following categories:
>
> 1. Primary shielding – shielding that attenuates radiation from the reactor.
> 2. Secondary shielding – shielding that attenuates radiation from the heat transport coolant.

3. Auxiliary shielding – shielding that attenuates radiation from auxiliary systems such as the moderator, fuelling machine, and failed fuel.

4. Supplementary shielding – shielding in addition to the above.

Shielding is designed to reduce radiation to the levels given in [Table 6].

Table 6: Radiation levels for design[19]

Region	Dose Rate
Average accessible area fields	<0.01 mSv/h
Average shutdown area fields	<0.04 mSv/h
Maximum shutdown area fields of frequent (80 h/a) attendance	<0.20 mSv/h
Non-radiation area	0.0025 mSv/h

Section 12.3.2.1 of the Bruce B Safety Report [112] discusses tritium:

> Tritium is the airborne activity that is of most concern to the station operating and maintenance staff. Wherever significant leaks of heavy water occur, the concentration of tritium in air will generally exceed the level permitted for continuous unprotected breathing. Laboratory analysis of bioassay samples are normally used to detect and evaluate internal doses of tritium.
>
> Where heavy water is vented occasionally to the atmosphere as a normal procedure, provisions are made to ensure that room air is not contaminated.
>
> Tritium is monitored by various instruments and techniques that depend on the location, application, and the sensitivity required. Tritium diffuser sampler units are used to check tritium concentrations in most areas. Portable instruments and monitors are provided for personnel protection.
>
> The reactor vault, fuelling machine duct and those confinement rooms which are known to have a potential for significant continuous leakage of tritiated heavy water are connected to the vapour recovery system. The vapour recovery system dehumidifies and recovers D_2O from the atmosphere. The level of D_2O recovery provides a measure of the airborne tritium contamination. Any contamination is kept to as low a concentration as is reasonably achievable.
>
> Local connections to the active exhaust system are used when ventilation is required for specific, local work. For example, locally vented plastic tent-like structures are used over and around equipment that is contaminated by or wet with heavy water. Such structures minimize the amount of tritium and also particulate activity escaping into the building air.
>
> Staff working near heavy water leaks, or in a generally tritiated atmosphere, usually wear a respirator or a ventilated plastic suit, whichever is appropriate considering the hazard concentration and exposure time. Breathing air for the air suits and respirators is provided wherever required. The air supply system is equipped with an integral communication system.

Section 12.3.2.2 of the Safety Report discusses airborne particulates:

[19] Table 12-1 of [112], with units converted from mrem to mSv.

> Spread of particulate activity into and by the ventilation systems in the buildings is controlled by the facilities provided for this purpose, and by using appropriate procedures. Uptake of airborne particulates may occur occasionally and is normally analyzed through bioassay samples, a whole body counter and portal monitors in accordance with Bruce Power's dosimetry program requirements. Contaminated equipment is wrapped in plastic for transportation and when direct contact is not required for dismantling and maintenance operations. When the size of the equipment permits, contaminated items are transported under wrap to the decontamination centre or to the active maintenance bays. Here, the equipment is dismantled, and cleaned with special equipment. Special ventilation can prevent the spread of activity. Such work is performed in contamination control areas.
>
> It is unlikely that the normal effluent from any of the active exhaust duct outlets on the powerhouse roof will exceed a concentration of more than 100 times the limit value for a 40 hour occupational exposure as recommended by the International Commission on Radiological Protection. Even with strong down drafts and occasional trapping, a short term dilution factor of at least 200 can be expected from the duct outlets to the ground, so the exhaust activity will not be a concern to anyone outside the buildings during normal operation. The active exhaust is sampled on an ongoing basis for any released activity.

Section 12.3.5 of the Bruce B Safety Report [112] discusses airborne contamination:

> Within Zones 2 and 3, including the reactor building, air contamination is controlled by ventilation flow, including the use of local exhaust connections. The ventilation systems are designed to transfer air from potentially less to potentially more contaminated areas. Identified sources of airborne contamination are eliminated or controlled by confinement or added local ventilation. This applies particularly to activity such as tritium from heavy water leaks.

Reactor design features are provided for the control of each of the radiological hazards identified in Section 5.1.3.1:

- Elevated direct dose rates – through radiation shielding design.
- Radioactive contamination (including surface contamination, airborne contamination and discrete radioactive particles):
  - Tritium control through monitoring, confinement, the vapour recovery system and programmatic controls.
  - Airborne contamination including particles through monitoring, ventilation and programmatic controls.
- Sources of elevated dose rates and contamination – through containment, confinement and programmatic controls.

5.1.3.3. Radiation Protection Program Review

The Bruce Power RP Program documentation was assessed against guidance from WANO GL-2004 Revision 1 [54] related to radiological hazard control. Specific guidance related to the control of dose rates (and their sources), radioactive contamination, decontamination and radiological hazard posting is provided primarily in the following clauses:

- Chapter III – External Radiation Dose Control

  - III.C3: Identification and Control of Radiation Sources
- Chapter IV – Internal Radiation Dose Control
  - IV.C2: Identification and Control of Airborne Radioactivity
- Chapter V – Radiation Dose Reduction
  - V.C1: Preliminary Planning and Scheduling
  - V.C3: Radiological Engineering
- Chapter VI – Radioactive Contamination and Radioactive Material Control
  - VI.C1: Radioactive Contamination Control
  - VI.C2: Personnel Contamination Monitoring
  - VI.C3: Contamination Source Identification and Control
  - VI.C4, item b[20]: Decontamination and reuse of tools and equipment

Bruce Power has established requirements for: contamination control in BP-RPP-00022 [87]; hazards surveys, posting, response and recording in BP-RPP-00023 [88] and decontamination in BP-RPP-00007 [84]. However, micro-gaps were identified against the guidance given regarding radiological hazard control in WANO GL 2004-01 Rev 1, as discussed in the following paragraphs.

Some deficiencies were identified during investigation of the airborne alpha contamination that occurred late in 2009, and the resulting internal exposures. These deficiencies were related to the guidance provided in Clause VI.C1 (Radioactive Contamination Control). Many of the procedures related to contamination control were revised in the aftermath of that incident through the Alpha Recovery Program. However, BP-RPP-00023, Hazards Surveys, Posting, Response and Recording [88], has not been revised to include actions that should be taken upon first discovery of airborne radioactivity to contain it. This recommendation was captured in DCR 28416907, which is at "Approved" status, with a due date of March 31, 2015. However, the current revision of the procedure (R011) was issued September 25, 2014, without the required changes. This is a discrepancy between the RP Program and the guideline Clause IV.C2. Subsequent control of airborne contamination is discussed in Section 4.1.7 of BP-RPP-00022 [87].

Through this review several specific gaps were identified against the guidance given in Clause VI.C3:

- There is no procedural requirement to avoid the use of materials that can accumulate fixed contamination in the radiologically controlled area.
- There is no procedural requirement to dismantle equipment to gain access to inaccessible surfaces to conduct contamination surveys. A recommendation from FASA

[20] The specific guidance item within the clause is identified in this case as the broader clause is related to radioactive waste, which is not included in the scope of this review; however the particular item on decontamination is relevant to radiological hazard control.

SA-RPR-2013-03 to add a statement to BP-RPP-00033 [81] to require RP Manager or AHP approval for the unconditional release of material with inaccessible surfaces and complex geometries was captured in DCR 28446123, with a past due date of July 31, 2015. However, Bruce Power HPs establish detailed contamination survey requirements for complex equipment, including dismantling to gain access to internal surfaces. RP practices that are not documented in RP Program governance is discussed in Section 5.6.

- There is no requirement that all High Efficiency Particulate Air (HEPA) unit, vacuum cleaner, and hose openings be securely covered to prevent the spread of contamination when not in use. AR 28399594 assignment 18 was raised to revise BP-RPP-00045 to include this recommendation. The assignment was closed to DCR 28417170 with a past due date of February 27, 2015.

It was concluded that Bruce Power has established radiological hazard control requirements which are generally consistent with the guidance given in WANO GL 2004-01 (Rev-1) [54]. Some specific micro-gaps pertaining to contamination control were identified. These gaps are shown in Table 7 under SF15-2.

5.1.4. Radiological Monitoring

5.1.4.1. Interpretation

The Bruce B reactor design features for RP presented in support of the radiological monitoring review task element include the descriptions of the fixed radiation monitors in place to detect and measure radiation dose rates and/or contamination levels. The fixed instruments included in the design are contamination monitors (which include whole-body monitors, friskers, gamma portal monitors and small article monitors) and FAGMs. A discussion of each type of instrument is provided in Section 5.1.4.2, as described in the Bruce B Safety Report [112].

The review of the RP Program for this review task element is interpreted to include assessment of the RP operational programs and arrangements to demonstrate that they provide suitable requirements for radiological monitoring, including:

- monitoring of personnel internal and external dose, received while working at Bruce B
- monitoring of radiological safety performance
- source term monitoring and characterization
- equipment put in place to measure radiation fields and/or radioactivity concentrations for the purpose of personnel radiation protection – this is addressed under the second review task on RP equipment and instrumentation for radiation monitoring (see Section 5.2)

Note that this review does not include radiological monitoring for the purposes of reactor operation and control.

5.1.4.2. Reactor Design Features

Section 12.3.1.2 of the Bruce B Safety Report [112] provides a description of area gamma monitors:

> Fixed Area Gamma Monitors (FAGMs) are provided to alert personnel by audio and visual alarms to changes in area radiological conditions that could result in unacceptable dose rates. They also provide information on gamma dose rates… The alarm criteria depend on the analysis of the potential hazard in the area in question. The monitors are intended to warn of hazardous changes in radiation levels under all operating and non-operating conditions. They are designed to avoid nuisance alarms triggered by random fluctuation (noise) of low level background radiation.

Fixed area gamma monitor locations are listed in the Bruce B Safety Report, Table 12-2.

Section 12.3.1.2.1 of the Safety Report provides details on FAGM alarm modes:

> FAGM alarms are generated by the main control room computer. They occur under the following conditions:
>
> 1. A high radiation level limit alarm is triggered when a steady, ambient background dose rate limit is exceeded. This mode also serves as a backup to the comparative change mode, addressed below.
> 2. A comparative change mode alarm is triggered when the positive rate of change in the ambient background dose rate is higher than a preset rate of increase.
> 3. Spurious alarm (infrequent).
>
> To avoid nuisance alarms, the comparative rate of change mode is desensitized below a safe cut-off limit to enable the monitor to distinguish between noise and persistent increases in radiation levels. Alarm coverage below and above the cut-off dose rate limit is provided by two distinct alarm modes:
>
> 1. Linear Alarm Mode. Below the low-level cut-off point (<300 mR/h), the computer generates an alarm only if the detected increase in ambient background rate has shown a persistent trend and magnitude (at least 100 mR/h increase). Comparison measurements are taken at 10 second intervals.
> 2. Proportional Alarm Mode. Above the low-level cut-off point (>300 mR/h), but below the high level alarm setpoint, the computer alarms if the change in radiation level exceeds the rate measured 10 seconds before by 30%. Should the radiation level be persistently increasing, but at a rate too low to generate an alarm in the comparative mode, an alarm will be activated by the high radiation level alarm mode when the ambient background radiation field exceeds its threshold.

Section 12.3.1.2.2 of the Safety Report provides details on FAGM alarm annunciation:

> Alarms are annunciated in the control room by the control computer. The time of an alarm, the location of the alarming unit, and the alarm conditions are printed out.
>
> When the radiation level exceeds the pre-programmed threshold (the rate meter alarms only at the high radiation level threshold, and with equipment failure), personnel in the field are made aware of the alarm by a klaxon horn and a red strobe beacon located near the alarming detector.
>
> The beacons and klaxon horns continue to operate until reset manually. Reset buttons are located in the same room as the monitor control units for the reactors, the Central Service Area, and the Ancillary Service Building. The monitor control units also display logarithmically the

ambient gamma rates for the corresponding detectors. This is used to obtain gamma rate estimates before entry into an area.

The units have a live zero alarm to indicate detector failure. This type of alarm will also be annunciated, and the corresponding conditions printed out.

FAGM warning lights are located at selected access points to areas of potentially high gamma fields, often some distance away from the corresponding detectors. A green and a red light, protected by a dust and spray proof box, provides a proceed or stop indication. High radiation fields trigger a red warning light. At selected airlocks leading into containment, the warning light boxes are also equipped with logarithmic rate displays.

Section 12.3.4.1 of the Safety Report provides a general description of contamination monitoring:

Fixed contamination monitoring instruments are located throughout the station at interzonal boundaries and other strategic points of high contamination potential, such as the contamination control area exits at the vault. Each contamination monitor location is equipped with a 120 V, 20 A T-slot duplex receptacle. Locations where two monitors are present will have a dual duplex receptacle supply fed from a common CLII or CLIV supply. With each monitor requiring 1 A of electrical supply a common supply is acceptable.

Section 12.3.4.2 of the Safety Report describes contamination monitor equipment:

Whole body monitors utilize large area detectors (Plastic Scintillators) to detect beta contamination of hands, feet, head and most parts of the body of personnel. In select locations, alpha detection capability is also deployed where risk of alpha contamination is considered significant.

The monitoring function is typically initiated once the individual has taken a position inside the monitor which interrupts a number of light beams. In some monitors, this must be preceded by swiping of a personal security card in a card reader which creates a computer record of the monitoring event.

Friskers utilizing handheld detectors suitable for the assessment of beta/gamma contamination levels are located at all whole body monitoring locations to assist in localizing contamination if detected with the whole body monitor. Small article monitors are available at Zone 1 entrance from Zone 2 to monitor equipment.

Portal monitors have a set of detectors to monitor personnel as they pass through. The detectors are suitable for the assessment of gamma contamination levels. The monitoring function is activated by the interruption of a light beam when a person enters the field of view of the detectors. On detection of contamination in excess of the acceptable level, an audible and visual annunciation will occur at the monitor and for some monitors in the control room.

5.1.4.3. Radiation Protection Program Review

Through a high-level assessment it was concluded that Bruce Power's RP Program documentation meets the requirements of CNSC Regulatory Guide G-228, Developing and Using Action Levels [32] (see Appendix A.2).

The Bruce Power RP Program documentation was also assessed against guidance from WANO GL-2004 (Rev-1) [54] related to radiological monitoring. Specific guidance related to monitoring

personnel dose, safety performance and station source term for the purposes of protecting personnel from radiation is provided primarily in the following clauses:

- Chapter I – Radiological Protection Organization and Administration
  - I.C4: Management Standards and Expectations
  - I.C6: Improving Performance
- Chapter III – External Radiation Dose Control
  - III.C1: External dose controls
- Chapter IV – Internal Radiation Dose Control
  - IV.C1: Internal Dose Controls
  - IV.C3: Monitoring for Internal Radioactivity
- Chapter V – Radiation Dose Reduction
  - V.C3: Radiological Engineering
  - V.C4: Radiation Dose Goals
- Chapter VII – Radiological Protection Work Control
  - VII.C1: Supervision and Monitoring of Radiological Work

It was concluded that Bruce Power has a comprehensive program to monitor employee external exposures and doses, which is consistent with the guidance given in WANO GL 2004-01 (Rev-1). The average and maximum effective doses to Bruce Power workers are reported annually by the CNSC in their annual regulatory oversight reports for Canadian nuclear power plants.

Bruce Power also has a comprehensive program to monitor employee internal exposures, much of which falls with the scope of the Dosimetry Services Licence. As was noted in Section 3.6, the guidance given in Section IV of WANO GL 2004-01 (Rev-1) was interpreted to include airborne tritiated water vapour, which is not addressed in detail in the Guideline. According to an RP improvement initiatives update from Q2 2015, “in 2013 Bruce Power was the best performer in Canada for internal dose from tritium uptakes and units 2, 5 and 7 were top quartile performance for CRE [Collective Radiation Exposure] for CANDU reactors in North America.” [108]

Bruce Power commissioned an Independent Review of Exposure of Workers to Alpha Radiation at Bruce A Restart, Reactor Unit 1 Bruce Power by the Radiation Safety Institute of Canada following an airborne alpha exposure event in 2009 [122]. The results of this review have been included in the historical effectiveness baseline review provided in a separate report: Historical Effectiveness Baseline Review of the Bruce Power Radiation Protection Program Prior to October 2013 Against WANO GL 2004-01 (Rev-1) [123].

It was concluded that the Bruce Power RP Program and associated procedures adequately address the WANO GL 2004-01 (Rev-1) recommendations regarding monitoring radiological safety performance and source term monitoring and characterization.

In 2014, the CNSC recommended ([113], Section 4.4.1) that Bruce Power "develop and implement additional dose reduction measures to achieve their business goal of achieving industry best Collective Radiation Exposure performance." (See Section 7.3 for more detail.)

Bruce Power has since achieved top ranked status for CRE in North America, as described in the July 19, 2016 edition of The Point [125]:

> The latest World Association of Nuclear Operators (WANO) numbers are in and Bruce Power's Unit 2 leads the way in the Collective Radiation Exposure (CRE) performance indicator. Unit 2 had the lowest two-year CRE (person-rem per unit) of any heavy and light water pressurized reactors in North America, while Unit 8 was close behind in third place. … The CRE indicator monitors the effectiveness of personnel radiation exposure controls. According to WANO, low exposure indicates strong attention to radiological protection and individual commitment to RP processes and procedures … "To be the Number 1 and Number 3 plants in North America is a tremendous feat and really pays testament to the dedication of our staff and strength of the programs at Bruce Power," [Department Manager, Industrial Safety and Radiation Protection Support, Bruce A] said.

Bruce Power's industry-leading performance in CRE has been identified as a strength.

5.1.5. Summary of Review Task Assessment

REGDOC-2.3.3 [3], Section A.3.1, states that the review of reactor design features for RP "should demonstrate that the ALARA principle has been incorporated in the reactor design and operational programs and arrangements…" This first review task therefore involves reactor design features for RP along with assessment of the RP Program established in support of the operation of the reactors as designed.

This review has demonstrated that Bruce Power has addressed radiation protection through reactor design in the following areas:

- The ALARA principle, through:
  - The establishment of an RP Program
  - Detailed system dose analysis performed during the original reactor design
- Zoning and access control, through:
  - A plant zoning arrangement established based on the potential for contamination and other radiological hazards
  - An Access Control System that prevents unapproved entry into areas that either have or could have high radiation fields
- Radiological hazard control, for:
  - Elevated direct dose rates – through radiation shielding design.
  - Radioactive contamination (including surface contamination, airborne contamination and discrete radioactive particles):

- Tritium control through monitoring, confinement, the vapour recovery system and programmatic controls.
- Airborne contamination including particles through monitoring, ventilation and programmatic controls.
- Sources of elevated dose rates and contamination – through containment, confinement and programmatic controls.

- Radiological monitoring, through:
  - FAGMs in place to detect and measure radiation dose rates
  - Fixed contamination monitors, including whole-body monitors, friskers, gamma portal monitors and small article monitors

Assessment of the Bruce Power RP Program against the relevant clauses of WANO GL-2004 (Rev-1) [54] demonstrated that the ALARA principle has been incorporated into the operational programs and arrangements as they relate to: the ALARA program, zoning and access control, radiological hazard control and radiological monitoring. A few specific micro-gaps were identified between the RP Program and the WANO guideline. These gaps are categorized and summarized in Table 7.

5.2. Radiation Protection Equipment and Instrumentation

The second review task involves RP equipment and instrumentation. The review of RP equipment and instrumentation is described by REGDOC-2.3.3 as intended to demonstrate that there are adequate provisions "for monitoring all significant radiation sources, in all activities throughout the lifetime of the reactor facility. These should cover operational states and accident conditions and, as practicable, beyond-design-basis accidents, including severe accidents" (Section A.3.2).

An assessment of radiation monitoring during accident conditions is included in the scope of Safety Factor 13 – Emergency Planning, and is not included in this review (see Section 6).

5.2.1. Interpretation

This review task is interpreted to include a review of the programs and procedures in place to ensure that the RP instrumentation provided at Bruce Power is adequate for monitoring all significant radiation sources during all activities associated with normal operations.

This review includes demonstration that the RP Program:

- includes equipment and instrumentation required to measure radiation fields and/or radioactivity concentrations for the purpose of personnel radiation protection; and
- addresses ageing and obsolescence of RP equipment and instrumentation so that they are maintained and used in good working condition.

For this review task, RP equipment and instrumentation is interpreted to include:

- radiation protection equipment such as temporary shielding, the audio-visual teledosimetry system, RPPE, contain-at-the-source (CATS) contamination control equipment, high-efficiency particulate air (HEPA) vacuums, and portable ventilation units; and
- instrumentation used for monitoring of alpha, beta, gamma and neutron fields, as well as radioactive contamination, excluding use as dosimetry (see Section 3.2.2):
    - portable radiation protection instrumentation (system USI 67877);
    - fixed radiation protection instrumentation (system USI 67874); and
    - area radiation monitors such as fixed area gamma monitors (FAGMs), continuous tritium air monitors, air particulate monitors, and contamination monitoring equipment.

5.2.2. Radiation Protection Program Review

Bruce Power has established several procedures for the management of RP equipment and instrumentation:

- BP-PROC-00908, Radiation Protection Equipment and Material Management [66] – This procedure defines “the process for obtaining approval to use new RP Equipment and/or Material at Bruce Power” (Section 1.0). The procedure applies to CATS devices, temporary shielding, decontamination supplies and radiation signage. The processes and approvals required for identification of the need for, evaluation, trial and implementation of RP equipment are provided. The procedure addresses thorough evaluation to determine the adequacy of the new RP equipment for the identified purpose. While there is no direction provided in this procedure regarding lifecycle management, or ageing and obsolescence, RP equipment is evaluated prior to use and replaced as necessary.
    - BP-RPP-00036, Management of Temporary Shielding [126] – This procedure provides “a process for requesting, approving, installing, removing, inspecting and evaluating, temporary radiation shielding” (Section 1.0). While it is not clearly stated in the procedure it can be inferred that BP-RPP-00036 applies to temporary shielding already approved for use on site. For situations where new temporary shielding is required that is not already available and approved for use on site then the user is referred to BP-PROC-00908 [66] (discussed above). The process presented in this procedure involves multiple stages of shielding evaluation, inspection and review for adequacy and effectiveness.
    - SEC-RPR-00065, CATS Devices Field Guide [127] – “The purpose of this procedure is to provide guidance for contamination Control At The Source (CATS) and to identify the different methods available to assist in CATS” (Section 1.0). Direction is provided on the use of CATS devices, including the use of local ventilation, to aid in contamination control “approaching excellence”. The procedure describes each type of CATS device, including points to consider

when assessing the adequacy of a device for a particular application and inspection requirements.

- BP-RPP-00048, Large Area Containments (Tents) [90] – This procedure provides "guidelines for large area containment (tent) requirements, design, inspection, construction, and use of containments to control the spread of radioactive contamination" (Section 1.0). Section 4.3.3 provides several specific tent evaluations to be performed by the HP as well as guidance they must provide related to use of large area containments and monitoring requirements in area. Section 4.5 provides direction on the lifecycle management of large area containments including: selection, fabrication, installation, inspection, use, maintenance and removal.
- SEC-RPR-00021, Munter Setup and Removal [128], "describes the criteria for moving the Munter and associated equipment from the storage area to the outage unit vault and back to the storage area … Munter is a large dehumidifier used to remove tritiated D_2O from the air. Typically used during a planned maintenance outage inside containment boundary of a reactor unit … The Munter is critical to reducing tritium levels in the reactor vault. This is why proper transfer and set up is important to allow safe operation of the Munter" (Section 1.0–4.0) The procedure states that purchase of new Munters is controlled by BP-PROC-00908, which does provide direction on determining the adequacy of RP equipment, but does not provide direction on lifecycle management.

- BP-PROC-00858, Radiation Personal Protective Equipment (RPPE) Life Cycle Management [64] – This procedure defines "the process by which Radiation Personal Protective Equipment … is approved for use at Bruce Power" (Section 1.0). Section 4.8, Management of RPPE, provides the requirements for the lifecycle management of all RPPE in service on site. A documented review of the RPPE in use is required every three years (such as was done in [129], see Section 7.1 of this report for more detail). The review is required to provide evaluation of the technical specifications of the product to determine if it still meets the current needs. The outcome of the review will be either the RPPE continues in service, governed by this procedure, or a change to RPPE is recommended following the process in this procedure.
- BP-RPP-00045, Management and Use of HEPA Vacuums and Portable HEPA Filtration Systems for Radiological Use [130] – This procedure provides detailed guidelines on the use, testing, inspection, and maintenance of HEPA units, required to ensure continued safe operation. Several measures are described which are intended to ensure that HEPA units are adequate for the particular task. The process map shown in Appendix A indicates that when RP receives a HEPA unit they perform an aerosol test. If the unit passes the test then a tamper evident seal is attached and the unit has been deemed adequate and is approved for use. If the unit does not pass the test then it is "not acceptable for radiological use". The user is required to confirm that an aerosol test has been performed on the unit within the last twelve months prior to using a HEPA unit. While Section 4.6 addresses "guidelines for the determination of HEPA filter life", there is no direction provided in this procedure regarding lifecycle management or ageing and obsolescence of HEPA units (vacuums and portable filtration systems), only the filters.

However the units are evaluated by RP prior to being given to workers for use and are replaced as necessary.

- Electronic Personal Dosimeters (EPDs) lie in the space where RP equipment, dosimetry and RP instrumentation overlap. While EPDs are instruments used to measure radiation dose rates, and used as part of RP work oversight through the Audio Visual Teledosimetry System (AVTS), they are also used to measure dose for work planning, dose monitoring and back up dosimetry. Section 4.3 of BP-RPP-00020, Dosimetry and Dose Reporting [97] describes the types of EPDs used at Bruce Power, how to wear and use them, the quantities that they measure, how to respond to audible and visual warning signals, potential faults and what to do with EPDs that cannot be used. No direction is provided in the RP Program regarding: who holds responsibility for the management of EPDs; what technical requirements should be considered when determining their adequacy for use in various applications at Bruce Power; or lifecycle management of EPDs.
- The AVTS is described in SEC-RPR-00037, AVTS Operating Procedure [131]. The AVTS "is a critical tool used to minimize worker dose, identify ALARA … issues, improve dose tracking, and ensure worker dose remains within Radiation Exposure Permit (REP) limits" (Section 1.0). Related equipment is described in SEC-RPR-00033, Thermo Teledosimetry Radio(s) Setup [132]. "This procedure will assist in configuring the Siemens/Thermo Telemetry Radios for use in personnel and area monitoring. This procedure aids to satisfy *[sic]* the requirements of the governing document SEC-RPR-00037, AVTS Operating Procedure… The Base and Repeater Radios are an integral part of the Teledosimetry system, these radios are used to send the information from the devices… ([EPD], Portable Area Gamma Monitor [PAGM], Area Monitor Probe [AMPs], etc.) through the Local Area Network (LAN) to be displayed on ViewPoint" (Section 1.0 and 1.1). The AVTS operating procedure identifies common system failures and provides direction on how to respond.
- BP-PROC-00192, Radiation Instrumentation Management [70] – This procedure "sets the expected standards for all RP Instrumentation … used at Bruce Power for the purpose of detecting and measuring radiation hazards and radioactive contamination in support of the RP Program" (Section 1.0). Section 4.2, Instrument Life-cycle Management, provides the requirements for: acquisition of RP instruments; placing them in service; and their removal from service. The acquisition process involves a detailed assessment of the instrument adequacy by the Instrumentation Health Physicist (IHP). Removal of a type of instrument from service requires evaluation by the IHP. Individual portable RP instruments can also be removed from service due to age or serviceability provided equivalent replacements are available.

  In a Type II inspection report on the subject of Radiation Hazard Control [133], the CNSC recommended that "Bruce Power … identify the numbers and locations of available whole body monitors required to provide adequate coverage in the stations and to develop and implement a corrective action plan to ensure this minimum adequate level of coverage is achieved and sustained" (Section 4.4). See Section 7.3 for further detail.

- Instrumentation used for continuous monitoring of tritium in air is identified in BP-PROC-00917, Tritium Air Monitoring Program [67]. This procedure provides "guidance on the placement of tritium air monitors for the purpose of continuous tritium monitoring of generally accessible areas of the station, monitoring for work in progress, and monitoring of areas with potential for leaks" (Section 1.0). The tritium monitors used for continuous air monitoring are identified as the Overhoff Model 357RM, which is listed in the procedure SEC-RPR-00088, Portable Radiation Instrumentation Use by Radiation Protection Staff [134]. The governing document structure indicates that these instruments come under the authority of BP-PROC-00192 [70], which addresses instrument adequacy and lifecycle management.
- The FAGMs system (USI 67873) presents a unique RP instrumentation situation since responsibility for the system lies with System Engineering, not RP. While BP-PROC-00192 addresses involvement of the IHP and AHP in ensuring that new FAGMS are adequate for their particular application, the procedure indicates that responsibility for FAGM management lies with the Responsible System Engineer. No direction regarding lifecycle management or ageing and obsolescence of the FAGM system is provided in the RP Program. Further, there is evidence that FAGM system equipment is frequently out of service:
  - BP-PROC-00192 includes direction on the process to be followed when FAGMs are out of service, indicating that this is a regular occurrence. The Q3, 2015 Radiation Safety Monitoring System Health Report [135], which includes the FAGMs (USI 67673B) indicates that the system was in an undesired condition due to the number of FAGM unit functional failures; primarily due to failure to perform periodic calibrations and obsolescence issues. To correct this, changes were made to how FAGM calibrations are managed within the preventive maintenance and work management systems. All FAGMs in accessible areas were calibrated by August 30, 2015.
  - The CNSC also observed that some FAGMs were not calibrated at the required frequency [136]. Bruce Power has since "taken appropriate corrective actions to oversee fixed area gamma monitor calibration" [137]. In July 2016, Bruce Power provided an update to the CNSC on the status of the FAGMs system [138]. "There are 80 non access-controlled and 83 access-controlled FAGMs in Bruce B … Non access-controlled FAGMs are mandatorily calibrated every year … Access-controlled FAGMs … are scheduled to be calibrated during outages every two years." In April 2016 the CNSC approved a two-year calibration frequency for FAGMs in access-controlled areas to properly align with outages. Work is ongoing to initiate a project to replace all FAGMs at Bruce B by 2026.

  According to the Safety Factor 4 report on Ageing there is no lifecycle management plan in place for the FAGMs system.

In summary, when compared with the review elements identified in REGDOC-2.3.3, Section A.3.2, Bruce Power RP Program documentation addresses the requirements of this review task with regards to ageing and obsolescence of RP equipment and instrumentation with two exceptions:

- There is no documented lifecycle management process for the FAGMs system. As discussed in detail in Section 7.3.5, there is evidence that the FAGMs system has been in poor condition in the past, with improvements made recently [135], [138].
- The RP Program does not include direction regarding who holds responsibility for the management of EPDs, or provide direction on lifecycle management for EPDs.

These items have been identified as review task gaps (Programmatic Gaps 1 and 2), and are shown in Table 7 under SF15-3.

The Bruce Power RP Program documentation was also assessed against guidance from WANO GL-2004 Revision 1 [54] related to RP equipment and instrumentation. Specific guidance is provided primarily in the following clauses:

- Chapter III – External Radiation Dose Control
  - III.C2: Personnel Monitoring for External Radiation
- Chapter IV – Internal Radiation Dose Control
  - IV.C2: Identification and Control of Airborne Radioactivity
  - IV.C3: Monitoring for Internal Radioactivity
- Chapter VI – Radioactive Contamination and Radioactive Material Control
  - VI.C1: Radioactive Contamination Control
  - VI.C2: Personnel Contamination Monitoring
  - VI.C3: Contamination Source Identification and Control

While Bruce Power has established several procedures for the management of RP equipment and instrumentation, several gaps were identified against the guidance given regarding lifecycle management and personnel contamination monitors in WANO GL 2004-01 Rev 1. These gaps are described below and are captured under SF15-3 in Table 7.

Six micro-gaps were identified against the guidance on contamination control monitors given in Clause VI.C2 of the WANO guideline.

1. The whole-body contamination monitor alarm set points used at Bruce Power have not been evaluated or confirmed since 2005. BP-PROC-00037, Calibration and Maintenance of Fixed Contamination Monitors [71] establishes the alarm set points for fixed contamination monitors, including whole-body monitors based on the technical basis provided in the report, “Radiation Protection Alarm Set-points implemented at Bruce Power in comparison with industry best practices and International Standards” [139]. In 2013, AR 28399592 assignment 03 was raised to evaluate the whole body monitor alarm set points with respect to the WANO guidelines. The AR was closed to DCR 28470411 to revise BP-PROC-00037. The procedure was later revised to R005 in September 2015, without addressing the

request to evaluate the WBM alarm set points. Ineffective use of the action tracking system to address RP issued is discussed in Section 5.4.

2. Whole-body monitor alarm checks for monitors at Zone 2 to 1 boundaries are required bi-weekly at Bruce Power, rather than daily as suggested by the WANO guidance. BP-PROC-00037, Appendix B provides the alarm check test frequency for fixed contamination monitors [71], but the technical basis for this frequency is not documented [140]. In 2013, AR 28399592 assignment 04 was raised to evaluate the response test frequency of Zone 2 to 1 release instrumentation with respect to WANO guidelines. The AR was closed to DCR 28470415 with a past due date of August 11, 2015. There is a note in the DCR dated October 16, 2015, saying, "Not evaluated during Revision 005". Ineffective use of the action tracking process to address RP issues is discussed in Section 5.4.
3. BP-PROC-00037, Appendix B, does not require use of a whole-body monitor response check source that approximates the station isotopic mix. The alarm check source used is not representative of the station isotopic mix for beta sensitive WBM, as identified in the technical basis document for WBM alarm set-points [139]. In 2013, AR 28399592 assignment 05 was raised to evaluate the use of a response check source that approximates the station isotopic mix (including consideration of using Tc-99 vs. use of Cs-137). The AR was closed to DCR 28470398 with a past due date of April 22, 2015. There is a note in the DCR dated October 16, 2015, saying, "Not evaluated during Revision 005." Ineffective use of the action tracking process to address RP issues is discussed in Section 5.4.
4. There is no programmatic requirement to perform routine tests to challenge whole-body contamination monitors using a smear source representative of the station nuclide mix to determine the reliability and sensitivity. This constitutes a gap against the guidance regarding performance of periodic monitor challenges.
5. There is no programmatic requirement to have gamma-sensitive whole-body detection capability in place at all exits from controlled areas. However, whole-body monitors with gamma detection and measurement capability are in place at all Zone 2 to 1 exits at Bruce B. RP practices that are not documented in RP Program governance are discussed in Section 5.6.
6. The portal monitor alarm set points used at Bruce Power (BP-PROC-00037, Appendix B) are not consistent with the WANO guideline. The alarm level of 200 nCi of Cs-137 is more than twice the level of 75-80 nCi of Cs-137 recommended by WANO. The most recent, documented evaluation of portal monitor alarm set-points from 2005 indicates that “it is reasonable to lower Portal Alarm set-points to around 100 nCi” [139]. In 2013, AR 28399592 assignment 08 was raised to evaluate the portal monitor alarm set-points. The AR was closed to DCR 28470421, with a past due date of August 10, 2015. There is a note in the DCR dated October 16, 2015, saying, "Not evaluated during Revision 005." Ineffective use of the action tracking process to address RP issues is discussed in Section 5.4.

An update on RP improvement initiatives from Q2 2015 [108] noted that significant improvements in Bruce Power’s whole-body monitor technology were taking place at Bruce B. “Whole Body Monitors (WBM) at Bruce B... are being replaced and the first phase of the project

is complete with 25 new WBMs in place and in service … This capability significantly enhances the ability to detect discreet radioactive particles and further improves the alpha radiation protection program." [108] Additional units have been purchased and are awaiting installation and commissioning.

The Overview of RP Performance Trends from 2013 [141] provides evidence that the condition of RP equipment had not been assessed or well maintained at times. The Contamination Control Area (CCA) Performance Measures indicate that the number of CCA audits performed by RP was below target and the number of CCAs quarantined by RP was above target (status for both shown as red). Section 4.1.2 of the report describes a trend in unreliable fixed radiation measuring instruments:

> The two instruments resulting in ~83% of the SCRs filed for Fixed Radiation Measuring Instruments were the Whole Body Monitors (WBMs) and the Fixed Area Gamma Monitors (FAGMs). 83% of the SCRs regarding WBMs were a result of monitors being out of service. Common trends were:
>
> - Spare parts not available
> - Failure to pass constancy checks…
>
> Trends arising with the FAGMs were spurious alarms and units out of service with no spares or availability of the approved replacement monitor, Portable Alarming Gamma Meter (PAGMs) *[sic]*." The SCR categories that contributed most to the SCR volume at Bruce B included Fixed Radiation Measuring Instruments, and Portable Radiation Measuring Instruments.

The WBM Program Health Report for July 2016 [142] indicates that an average of 89.89% of WBMs were in service during the month of July, against a target of 90%. The program health indicator, based on the number of successful source checks by station area, was at a value of 81.18% for July.

There are further indications of RP instrumentation condition through communications from the CNSC (as discussed in Sections 7.3.1, 7.3.2, 7.3.4 and 7.3.5). While Bruce Power has responded to the CNSC regarding each of the issues identified and established actions to address them, there appears to be a continuing trend in deficiencies in fixed RP instrumentation condition as documented through communications with the CNSC.

Further support for the conclusion that whole-body monitors have not been reliable at Bruce B is evident from SCR 28514490 that was generated as a result of the International Atomic Energy Agency (IAEA) Operational Safety Review Team (OSART) review that took place from November 30 to December 17, 2015. The team observed that "At Bruce B there are currently 20 out of 110 monitors out of service. This does not meet our standard. Current target is > 90% availability. This has been identified as a gap when reviewing the IAEA safety guidelines."

Though improvements have been documented, a gap (Effectiveness Gap 1) has been identified in the effective implementation of the RP instrumentation program in order to maintain the fixed RP instrumentation (specifically FAGMs and whole-body contamination monitors) in good working condition. This gap is shown in Table 7 under SF15-3. Apart from the identified gaps Bruce Power meets the requirements of this review task.

5.3. Radiation Protection Operating Experience

The review of the use of RP-related OPEX is described by REGDOC-2.3.3 as intended to verify that OPEX reports from other reactor facilities and relevant national and international experience and research findings have been properly considered on a routine basis and that appropriate action has been taken.

5.3.1. Interpretation

This review task is interpreted to include assessment of the Bruce Power RP Program to demonstrate that processes are in place to identify good RP practices and lessons learned elsewhere, and to take advantage of improved knowledge derived from research in the area of RP.

While detailed assessment of the overall Bruce Power OPEX Program, the feedback of safety experience from nuclear power plants (both internal and external) and the feedback of research findings are covered by Safety Factor 9 – OPEX and Research and Development (R&D), application of the program specifically within the RP Program is assessed as part of this review.

5.3.2. Radiation Protection Program Review

Bruce Power has provided instruction for RP personnel, defining the requirements for screening of RP related OPEX in SEC-RPR-00013, Radiation Protection Programs Process Quality Management [59]. Section 4.1 of the procedure provides details on RP OPEX reviews:

> In accordance with BP-PROC-00062, the Corrective Actions Programs Coordinators (CAPCo) supporting RP Programs distributes (weekly) RP OPEX items requiring screening for applicability to the SM, RP Programs.
>
> The SM, RP Programs or delegate reviews the provided OPEX with RP Programs Staff and other Subject Matter Experts (SMEs), as required, to determine applicability. Following determination of applicability, the SM, RP Programs completes the required processes defined in BP-PROC-00062 to ensure the applicable OPEX is captured in RP related procedures and processes.

Section 4.2.1 provides "expectations for Document Authors when creating and revising RP Controlled Documents." One of the listed expectations is:

> Performance of OPEX reviews. The Document Author shall ensure the following OPEX reviews are conducted to determine if the OPEX can improve the current processes at Bruce Power and how it can be applied to work practices at Bruce Power:
>
> i) Internal OPEX - reviewing SCRs and DCRs entered against the document.
>
> ii) External OPEX against World Association of Nuclear Operators (WANO) GL 2004-01 (Rev-1).

iii) Other external OPEX can include benchmarking the procedure against industry best practices and/or Institute of Nuclear Power Operations or WANO reports.

Evidence that this process is being followed includes a standard section in the Bruce Power procedure template titled External Industry Standards or Internal/External Lessons Learned/OPEX. The majority of the Radiation Protection Procedures (RPPs) reviewed as part of this assessment includes this standard section, listing OPEX considered in development of the document.

The Bruce Power RP Program documentation was assessed against guidance from WANO GL-2004 (Rev-1) [54] on the subject of RP-related OPEX. Specific guidance is provided primarily in the following clauses:

- Chapter I – Radiological Protection Organization and Administration
  - I.C2: Leadership in Station Radiological Protection Activities
  - I.C6: Improving Performance

The review determined that the currently documented Bruce Power process for sharing OPEX externally, described in Section 4.3.1 of the procedure Processing External and Internal Operating Experience [143], focuses on higher threshold events where control of RP has been lost, as opposed to those at a lower threshold, which could prevent loss of RP control, or future, more significant, events from occurring. However, significance level 2, 3 and 4 RP-related events were reported to the COG community from 2014 to 2016. RP Practices that are not documented in RP program governance are discussed in Section 5.6.

The OPEX procedure [143] provides for the communication of the results of events at all significance levels to management, and for the initiation of Training Change Requests based on the results of investigations so that lessons learned can be incorporated into future training.

5.4. Radiation Protection Organization and Administration

This review task is to verify that an RP organization structure has been established that allows for adequate administration of the RP Program standards.

While this review task is not mentioned in REGDOC-2.3.3, assessment of the organization and administration of Bruce Power RP has been included in this review for completeness.

5.4.1. Radiation Protection Program Review

Bruce Power documentation related to the organization and administration of RP was assessed against guidance from WANO GL-2004 (Rev-1). Specific relevant guidance is provided primarily in the following clauses:

- Chapter I – Radiological Protection Organization and Administration
  - Chapter I.C1: Radiological Culture
  - Chapter I.C2: Leadership in Station Radiological Protection Activities

- Chapter I.C3: Management Activities
- Chapter I.C4: Management Standards and Expectations
- Chapter I.C5: Conservative Decision-Making
- Chapter I.C6: Improving Performance
- Chapter I.C7: Personnel Resources
- Chapter I.C8: Personnel Selection

Bruce Power has created a radiation protection organization to support the operation of Bruce B as described in the Bruce Power Management System Manual, BP-MSM-1 [55] and Section 4.1 (RP Management Roles, Responsibilities & Expectations) of the RP Program BP-PROG-12.05 [25] and supporting Level 2 Radiation Protection Procedures (see Section 4.1.1). These documents define the RP Functional Area and establish the roles of Corporate Functional Area Manager (CFAM) and Site Functional Area Manager (SFAM). A brief history of the RP organization from 2013 on follows.

A significant reorganization was implemented in October 2013 with the intention of providing greater RP support to station operations. Health Physicists were moved from the RP Programs and Dosimetry sections to increase HP capability in the stations, and were assigned to provide ALARA support for major outage programs. Head counts in the Station Functional Area were increased and RP technicians were assigned to all shifts to provide 24/7 support to station operations. The Manager of the Radiation Protection Programs Department was the CFAM for radiation protection while the Manager of the Radiation Protection & Industrial Safety Department was the SFAM for Bruce B.

Effective September 2014, the Radiation Protection Programs Department and the Industrial Safety Programs Department were merged to create the Safety Programs Department [144]. Responsibility for radiation protection continued to be delegated from the President & Chief Executive Officer to the Executive Vice-President & Chief Nuclear Officer (CNO) and, in turn, to the [145]:

- Vice-President, Nuclear Operations Support and Nuclear Programs Division Manager;
  - Safety Programs Department;
    - Radiation Protection Programs Section;
- Bruce B Senior Vice-President and Bruce B Plant Manager;
  - Bruce B Radiation Protection & Industrial Safety Department;
    - Bruce B RP Industrial Safety Section;
    - Bruce B Radiation Protection Outage Support Section;
    - Bruce B Radiation Protection On-line Support Section.

The Manager of the Safety Programs Department is the CFAM for radiation protection while the Manager of the Radiation Protection & Industrial Safety Department is the SFAM at Bruce B.

According to the governing Bruce Power documentation this describes the current RP organization.

The Bruce B Safety Report [112] (Section 12.4) discusses the responsibilities of the centralized and Bruce B station RP organizations:

> The Radiation Protection Programs Section at Bruce Power is responsible to establish, interpret and supervise the policies and regulations for the protection of employees, and the public, from the effects of radioactivity produced within the station. In particular, the group is responsible for the preparation and approval of procedures involving radiation protection aspects which are used for the training and qualification of personnel for radiation protection.
>
> The section reviews and assesses the effectiveness of the station radiation control program on an ongoing basis. It is also responsible for the maintenance of individual dose records, collected through Bruce Power's dosimetry program; a requisite of the CNSC-issued operating license. The collected data are issued as reports to the CNSC.
>
> The section also initiates and develops projects for the improvement of radiation protection techniques and of plant radiological conditions, and has a direct responsibility for the procedures covering exposure of personnel exceeding the permissible limits, the entry of personnel into areas of high activity, and the shipment of radioactive materials.
>
> The Radiation Protection and Industrial Safety Department at Bruce B is responsible for maintaining the quality of the radiation control program defined and approved for the station. To meet this quality mandate, this unit has the following defined functions:
>
> 1. To ensure station staff are trained and equipped to work in radiological environments on an independent basis. To this end, the unit provides the required procedures, training, equipment and instrumentation.
> 2. To provide radiological assistance to personnel carrying out station operation and maintenance programs in radiological environments.
> 3. Provide services to personnel such as checking monitor performance, providing oversight to radioactive work, and assessing plant conditions.
>
> In addition, this unit monitors adherence to radiation protection regulations and station targets. Where unacceptable deviation or inadequacies exist, this unit initiates improvements or corrective actions as required.

In general, the radiation protection standards (such as RP Fundamentals and RP Procedures) address the guidance given in WANO GL 2004-01 (Rev-1) since Bruce Power has previously benchmarked its RP Program against the guidelines and addressed most of the discrepancies. However, some gaps between the BP radiation protection standards and the WANO GL 2004-01 (Rev-1) guidance and/or industry best practices remain and these are described below.

There is a gap in the effective identification of the individual and role associated with the responsibilities of the RP Manager as identified in Clause I.C2 of the WANO guideline. The RP Program [25] refers to the "RP Programs Department Manager" – a position that is no longer identified by that title. Effective September 2014, the Radiation Protection Programs Department and the Industrial Safety Programs Department were merged to create the Safety Programs Department (NK29-CORR-00531-12197 [144]). The Bruce Power MSM Program Matrix, BP-MSM-1, Sheet 0001 [146] and the Approved Reference Chart Authorities and Responsibilities, BP-MSM-1, Sheet 0002 [145] identify the Department Manager Safety

Programs as the CFAM for the RP Program. The RP Program document and the majority of its implementing documents, however, identify the CFAM for the program as the Department Manager, Radiation Protection Programs; a role that no longer exists in the MSM. Similarly, the SFAM for Bruce B is identified in the RP Program as the Department Manager, Industrial Safety and Radiation Protection Support, while the MSM documents identify the SFAM as the Bruce B Radiation Protection & Industrial Safety Department Manager.

Following a Type II Compliance Inspection in July 2015 [133], CNSC staff recommended that Bruce Power "develop and implement a corrective action plan to ensure that identified RP deficiencies and SCR adverse trends are addressed and corrective actions are completed in timely manner" (Section 4.3.1, see Section 7.3 for more detail). Through the assessment of the Bruce Power RP Program and supporting procedures, several instances of ineffective use of the action tracking system to address RP issues were encountered. This has been identified as an effectiveness gap, shown as SF15-4 in Table 7. Examples follow:

- An SCR was initiated to document the necessary change, which led to a DCR (due December 31, 2014) requesting an update to the Access Control procedure [BP-RPP-00008] "to create the programmatic requirement for LHRA controls" (Section 7.2). The update has not yet been made.
- AR 28399588 assignment 14 was initiated to address an RP improvement recommendation regarding identification of low dose rate areas. The AR was subsequently closed to a new action, AR 28468812 assignment 1. That new action was cancelled on July 23, 2015, without explanation.
- A recommendation to revise BP-RPP-00023 to include actions that should be taken to contain airborne radioactivity to prevent the spread of contamination was captured in AR 28399591 assignment 10. The assignment was closed to DCR 28416907, with a past due date of March 31, 2015. However, the current revision of the procedure (R011) was issued September 25, 2014, without the required changes.
- A recommendation to add a statement to BP-RPP-00022 [87] that prohibits storing material, with loose or fixed contamination, in an area where it may be exposed to water was captured in AR 28399592 assignment 18. This assignment was closed to DCR 28416912. The DCR is at "Approved" status with a past due date of March 31, 2015.
- A recommendation to add a statement to BP-RPP-00033 [81] to require RP Manager or AHP approval for the unconditional release of material with inaccessible surfaces and complex geometries was captured in AR 28399594 assignment 11. The assignment was closed to DCR 28446123, with a past due date of July 31, 2015.
- AR 28399594 assignment 18 was raised to revise BP-RPP-00045 to include the requirement that all High Efficiency Particulate Air (HEPA) unit, vacuum cleaner, and hose openings be securely covered to prevent the spread of contamination when not in use this recommendation. The assignment was closed to DCR 28417170 with a past due date of February 27, 2015.
- AR 28399588 assignment 07 was raised to evaluate placement of TLDs at strategic locations on site within occupied areas to confirm that personnel outside the

radiologically controlled areas are not receiving unexpected dose from radioactive materials. However, the assignment completion notes do not give the numbers of the new actions, so their status cannot be determined.

- AR 28399592 assignment 03 was raised to evaluate the whole body monitor alarm set points with respect to the WANO guidelines. The AR was closed to DCR 28470411 to revise BP-PROC-00037. The procedure was later revised to R005 in September 2015, without addressing the request to evaluate the WBM alarm set points.
- AR 28399592 assignment 04 was raised to evaluate the response test frequency of Zone 2 to 1 release instrumentation with respect to WANO guidelines. The AR was closed to DCR 28470415 with a past due date of August 11, 2015. There is a note in the DCR dated October 16, 2015, saying "Not evaluated during Revision 005".
- AR 28399592 assignment 05 was raised to evaluate the use of a response check source that approximates the station isotopic mix (including consideration of using Tc-99 vs. use of Cs-137). The AR was closed DCR 28470398 with a past due date of April 22, 2015. There is a note in the DCR dated October 16, 2015, saying, "Not evaluated during Revision 005."
- AR 28399596 assignment 05 was raised to develop criteria for the use of specific REPs to govern work in accordance with the guidance. The assignment is shown as complete on January 19, 2016, but the completion notes say "Radiography reps are aligned and OMS is working with the stations to align outage reps."
- AR 28399596 assignment 07 was raised to "Initiate a DCR to revise BP-RPP-00011, Table B.1, Hazard Anticipation at Bruce Power Generating Stations, to expect and anticipate beta radiation any time loose or fixed contamination is present." The AR was closed on February 10, 2014 to DCR 28416993. The DCR is at "Approved" status with a past due date of March 31, 2015.

In general, it was concluded that the radiation protection standards at Bruce Power address the guidance given in the WANO guideline. Some micro-gaps were identified pertaining to ineffective use of the action tracking process to address RP issues. These gaps are shown in Table 7 under SF15-4.

5.5. Radiation Protection Training

This review task assesses RP training and qualification practices at Bruce Power against the recommendations provided in WANO GL-2004 (Rev-1) [54].

5.5.1. Radiation Protection Program Review

Bruce Power documentation was assessed against guidance from WANO GL-2004 (Rev-1) [54] related to RP training. Specific relevant guidance is provided primarily in the following clauses:

- Chapter I – Radiological Protection Organization and Administration

  - Chapter I.C9: Training and Qualification
  - Chapter I.C10: Career Development
- Chapter II – Training and Qualification of Personnel in Radiological Protection
  - Chapter II.C1: Radiological Protection Training Responsibilities
  - Chapter II.C2: General Employee Training in Radiological Protection
  - Chapter II.C3: Radiological Protection Technician Training and Qualification
  - Chapter II.C4: Radiological Protection Management, Supervisory and Technical Staff Training and Development

The Bruce Power RP Program requires that all employees receive radiation protection training that is appropriate to the needs of their position, which is consistent with WANO GL 2004-01 (Rev-1). It was concluded that the RP Program generally meets the requirements of this review task. However, in practice, one specific item was identified where RP practice is not documented in the RP Program. This instance is described below, and included as an example in the discussion of the gap presented in Section 5.6.

Clause VI.C3 of the WANO guideline recommends that RP personnel be trained in the use of CATS contamination control devices. The Radiation Protection Technician CRC status report from March 2015 [147] lists the continuing training subject areas from 2013 to 2015. Included in the training for the spring session of 2015 was “Contain at the Source (CATS): Set-up, Use and Removal” training. In this case, changes in the training program are not supported by an updated training document, TQD-00046 [148]. This is related to the gap discussed in Section 5.6 regarding RP practices that are not documented in RP Program governance.

5.6. Radiation Protection Program Documentation

This review task is to verify that the organization has described the standards expected for radiological protection activities, established the fundamental philosophy and strategy for radiological protection and created a program to ensure that a high level of radiological protection is ensured.

5.6.1. Radiation Protection Program Review

It was determined that Bruce Power has created a comprehensive RP Program [25] and supporting RP Procedures (see Table 5). However, nearly all gaps identified through the review of Safety Factor 15 on Radiation Protection are, in effect, gaps against the RP Program documentation; identifying elements of good practice not included therein.

Bruce Power RP Program documentation was assessed against guidance from WANO GL-2004-01 (Rev-1) [54], Clause I.C4, Management standards and expectations: “Radiological protection managers set high standards and expectations that are incorporated into policies and procedures. Standards and expectations are clear, concise and relevant.”

A gap was identified against Clause I.C4 of the WANO guideline regarding the effective communication and management of RP Program standards. As documented in SCR 28537725, an issue arose when significant revision to the procedure governing the requirements for execution of radiological work, BP-RPP-00041 [83] was issued, including the requirement for the mandatory completion of ALARA tickets for all radiological work. The SCR describes that the Bruce B leadership team supported the completion of ALARA tickets, but did not agree that they should be mandatory. "This procedure was also implemented before communicating the requirements to the site." The same requirement was included in a revision to the procedure governing the requirements for planning radiological work, BP-RPP-00011 [75]. Both procedures were reissued, revoking the requirement in question (along with other, unrelated updates that had been made).

During the detailed review of the RP Program documentation for each of the other SF15 review tasks a recurring theme was observed: RP Program documentation is not always updated promptly to reflect improvements and current practice. Following are examples of RP practices that are not documented in RP Program governance:

- There is no requirement in the Bruce Power ALARA Program to provide station dose status weekly during normal operations and daily during outages. However, dose information is provided as described in Section 5.1.1.3.
- There is no requirement to dismantle equipment to gain access to inaccessible surfaces to conduct contamination surveys. However, Bruce Power establishes detailed contamination survey requirements for complex equipment through release permits and health physics instructions, and these may include dismantling to gain access to internal surfaces.
- There is no procedural requirement that back-out criteria be specified in the REP for DRPs or airborne particulates, however, REPs do provide control levels to stop-work if unanticipated hazards (such as DRPs and airborne activity) are encountered (see Section 5.1.1.3).
- There is no requirement to place area TLDs at strategic locations on site within occupied areas to confirm that personnel outside the radiologically controlled areas are not receiving unexpected dose from radioactive materials. However, TLDs are placed in such strategic locations and their recorded dose reported quarterly.
- There is no programmatic requirement to have gamma-sensitive whole-body detection capability in place at all exits from controlled areas. However, whole-body monitors with gamma detection and measurement capability are in place at all Zone 2 to 1 exits at Bruce B (see Section 5.2.2).
- The currently documented process for sharing OPEX externally focuses on higher threshold events, as opposed to those at a lower threshold, which could prevent future, more significant events from occurring. However, significance level 2, 3 and 4 RP-related events were reported to the COG community from 2014 to 2016 (see Section 5.3.2).

- The Radiation Protection Technician CRC status report from March 2015 [147] lists the continuing training subject areas from 2013 to 2015. Included in the training for the spring session of 2015 was “Contain at the Source (CATS): Set-up, Use and Removal” training. Training sessions on the use of CATS devices were held in 2015. In this case, changes in the training program are not supported by updated RP Program documentation (see Section 5.5.1).

Gaps that have been identified against this review task are shown under SF15-5 in Table 7.

As a result of RP practices that are not documented in RP Program governance, aspects of the program are not in alignment with each other, the MSM, or current RP practices. Misalignment of Bruce Power procedures has been identified as gap through Safety Factor 10, Organization and Administration; specific examples follow.

SEC-RPR-00045, Radiation Protection Records Retention, was obsolete as of February 2015; however the procedure still appears in BP-PROG-12.05, the RP Program document [25]. BP-RPP-00006, Radiation Protection Qualification, was superseded on July 13, 2016, by the very program document that lists BP-RPP-00006 as an implementing document, BP-PROG-12.05 [25]. There are discrepancies between the RP Program document and supporting RP documentation.

The Bruce Power Management System Manual [55] includes the Bruce Power Program Matrix (BP-MSM-1, Sheet 0001) [146] and the Approved Reference Chart Authorities and Responsibilities (BP-MSM-1, Sheet 0002) [145]. All of these MSM documents identify the Department Manager Safety Programs as the CFAM for the RP Program. The RP Program document, BP-PROG-12.05 [25] and some of its implementing documents, however, identify the CFAM for the program as the Department Manager, Radiation Protection Programs, a role which does not exist in the MSM. Organizational changes have taken place within Radiation Protection that are not reflected in the associated program documents. As a result, there is inconsistency between the RP Program documentation and the Bruce Power MSM.

The Q2 2015 RP improvement initiatives update report [108], the Radiation Protection Technician Curriculum Review Committee (CRC) status report from March 2015 [147] and Health Physicist and Authorized Health Physicist CRC status report from February 2015 [150] all report significant changes and improvements being made to the RP training program. While there are documented improvements being made to the RP Worker, RP Technician, Health Physicist and Authorized Health Physicist training programs, program documentation has not been updated to reflect current practice.

The Radiation Protection Technician CRC status report from March 2015 [147] lists the continuing training subject areas from 2013 to 2015. Included in the training for the spring session of 2015 are “Contain at the Source (CATS): Set-up, Use and Removal” and “Stop Work Authority/Risk Recognition (Error Prevention Topic)” training. While training is done on these subjects, neither the Contamination Control procedure [87] nor the TQD for RP Technicians [148] identifies the need for such training. Changes in the training program are not supported by updated RP Program documentation.

Several RP procedures include out of date references; identified as a gap (SF10-3) through Safety Factor 10, Organization and Administration. Examples include:

- References to CNSC regulatory standard S-99, Reporting Requirements for Operating Nuclear Power Plants, as opposed to the document that replaced it, REGDOC-3.1.1, Reporting Requirements for Nuclear Power Plants.
- References to the PROLs, as opposed to the joint single PROL for both Bruce A and Bruce B (such as SEC-RPR-00040).
- References to the position title “Department Manager Radiation Protection Programs”, a role which no longer exists and introduces ambiguity of responsibility amongst Bruce Power documents (such as BP-PROG-12.05).
- References to the position title “Responsible Health Physicist”, while this title has been replaced with “Authorized Health Physicist” (such as BP-RPP-00027).

Another issue that was encountered multiple times is ineffective use of DCRs to prompt RP procedure improvements. Frequently AR assignments are closed to DCRs against RP procedures in order to address some adverse condition. In some cases those DCRs have not resulted in effective implementation of procedure revisions resulting in abandoned and/or forgotten assignments. This has also been identified as a gap (SF10-2) through Safety Factor 10 on Organization and Administration.

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 A.2, addresses requirements regarding radiation protection considerations in plant design.
- “Safety Factor 4: Ageing” addresses the review of programmatic and technical aspects of the ageing management program, which includes life cycle management.
- “Safety Factor 8: Safety Performance” addresses INPO 05-008-R02, noting that it includes, for example, updated alpha monitoring requirements, refinements on the performance indicators and the addition of references to more recently issued EPRI documents.
- “Safety Factor 10: Organization and Administration” addresses the administration of program documents and use of the action tracking system to initiate procedure improvements through DCRs.
- “Safety Factor 11: Procedures” in Appendix B.2, assesses requirements and guidance related to radioactive waste (see note on BP-PROC-00878 in Table 5), packaging and transport of nuclear substances (see note on BP-PROC-00188 in Table 5) and procedure process and adequacy.
- “Safety Factor 12: The Human Factor” in Appendix B.1, addresses the review of the CNSC REGDOC-2.2.2 on Personnel Training.

- "Safety Factor 13: Emergency Planning" in Section 5.1, provides an overall review of emergency planning including the impact on people and the environment during accident situations.
- "Safety Factor 14: Radiological Impact on the Environment" in Section 5.7, discusses off-site monitoring and the radiological impact to members of the public.

For the purposes of this assessment, the following interpretations of scope have been adopted 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: 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 (this report): 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

As described in Section 4.2, a lot of RP improvement initiatives began in 2013; to both the program documentation as well as its implementation. Most notably, a significant reorganization of the RP Departments at Bruce Power facilities took place in October 2013 (see Section 5.4). These extensive changes have reshaped the RP Program, organization and approach to such an extent that evaluations of the program and its effectiveness (including audits, inspections and self-assessments) that were conducted prior to the changes are not believed to be representative of the current RP Program and organization. For the purposes of this assessment it is therefore assumed that the reorganization of Radiation Protection that took place in October 2013, along with the establishment of a wide range of RP improvement initiatives, marks a significant change in implementation based on program deficiencies observed in the years previous[21].

The remainder of this Section provides information regarding the assessments, audits and inspections that have been performed on the RP Program and its implementation since October 2013. Section 7 supplements the assessments of the review tasks in Section 5, by providing

[21] A detailed assessment of the historical effectiveness of the RP Program at Bruce Power prior to October 2013 is provided in a separate report: Historical Effectiveness Baseline Review of the Bruce Power Radiation Protection Program Prior to October 2013 Against WANO GL 2004-01 [123]. The historical assessment provides context surrounding the need for RP improvements.

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 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 each assessment are compared with business needs, the Bruce Power management system, industry standards of excellence and regulatory/statutory or other legal requirements. Where gaps are identified, corrective actions are identified and implemented.

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.

The following Bruce Power Focus Area Self Assessments (FASAs) were completed since October 2013:

7.1.1. Focus Area Self-Assessment SA-RPR-2013-04, Locked High Radiation Area Controls, November 2013

A conclusion of this FASA was that:

> … although there is no regulatory requirement, Bruce Power should have a Locked High Radiation Area (LHRA) program to control access to gamma dose rates greater than or equal to 1 rem/h [0.01 Sv/h] at 30 cm as recommended by… WANO GL 2004-01 (Rev-1). The current Access Control Program at Bruce Power controls access to many but not all of the areas with dose rates at this level. (Section 2.0, [121])

This assessment identified both a strength and an adverse condition in the same paragraph:

> Bruce Power's Access Control system is a strong barrier against access to areas with potentially injurious dose rates. This system positively controls access to the majority of areas with dose rates greater than or equal to 1 rem/h [0.01 Sv/h] at 30 cm. This system meets the WANO guidelines for LHRA controls, but does not control access to all of the areas with dose rates greater than or equal to 1 rem/h [0.01 Sv/h] at 30 cm. (Section 7.1, [121])

An SCR 28404094 was initiated to track the suggested revision to BP-RPP-00008, Access Control, "to create the programmatic requirement for LHRA controls." A DCR 28404289 was submitted against BP-RPP-00008 as a result. This DCR is in approved status with a past due date of December 31, 2014.

7.1.2. Focus Area Self-Assessment SA-RPR-2013-05, Discrete Radioactive Particle Control Evaluation for Bruce A, December 2013

According to the Executive Summary of this FASA: "In July of 2012, BP-RPP-00022, Contamination Control was revised. The revision included an additional section on Hot Particle Controls. The objective of this report is to review the hot particle controls established mid-2012 to determine effectiveness" [151] and recommend any changes necessary to improve the program.

The following four major changes regarding hot particles had been made to the procedure:

1. The hot particle definition was reduced from 100 mrem/h [1 mSv/h] to 50 000 cpm;
2. Control measures for discrete radioactive particles less than 50 000 cpm were added;
3. Locations were hot particles can be anticipated were identified; and
4. Control measures were added for work involving hot particles.

The purpose of the FASA was "to evaluate each of the four changes to the contamination control program and to identify if the changes were effective in reducing dose from contamination" (Section 4.0, [151])

Later in the FASA report, it is stated in Section 6.0: “Personal Contamination Events reduced by 35% from 2011 and 2012 to 2013 ... There has been a 72% reduction in loose contamination events from 2012 to 2013.” [151]

Three adverse conditions were identified: one related to the dose savings benefits of additional RPPE, one regarding the integration of DRP controls into work and one regarding the identification of DRP hazards in REPs. Three assignments (16, 17 and 18) were added to AR 28339706 to track the corresponding corrective actions; all of which are marked as complete. One of the assignments requires establishment of a plan for implementation of DRP controls, which is tracked further under AR 28401870. The DRP control implementation plan AR has 21 assignments, all of which are complete.

One opportunity for improvement was also identified regarding removal of certain work requirements that were not being used in the field. The associated DCR 28384236 has been completed.

The adverse conditions identified are related to the review in Section 5.1.1 of this safety factor report on the ALARA program.

7.1.3. Focus Area Self-Assessment SA-RPR-2014-01, EPD Alarm Follow-Up at Bruce A and Bruce B, September 2014

In this FASA, Bruce Power’s processes for EPD dose and dose rate alarms were reviewed relative to external industry guidance with the conclusions that:

> Follow-up to EPD dose alarms is procedurally compliant, consistent between stations and in alignment with industry standards.
>
> Follow-up to EPD dose rate alarms is procedurally compliant, fairly consistent between stations with easily correctable exceptions. Dose rate alarm follow-up is not, however, in alignment with industry guidance. Industry expects intolerance to all EPD dose rate alarms unless they are specifically planned and documented. Bruce Power’s policy is to use dose rate alarms as a dose reduction tool, below a scaling threshold. This policy has been challenged and validated and no change is recommended. Gaps were identified in the implementation of this policy, however, in that the use of the scaling factors allows the crossing of hazard category thresholds, which is not appropriate. [152]

One adverse condition was identified regarding EPD dose-rate alarms crossing hazard categories (low, medium, high). SCR 28458449 that was initiated to track resolution of this condition was canceled by the Corrective Action Program Coordinator in May 2015. This adverse condition is related to the review in Section 5.1.4 of this report on radiological monitoring of personnel external dose.

Two opportunities for improvement were also identified; both regarding programmatic inconsistencies and documentation. Two SCRs (28458453, 28458457) were initiated to prompt the suggested program improvements. All of the associated actions documented in the SCRs are complete. These findings are related to the review in Section 5.6 of this report on RP Program documentation.

7.1.4. Focus Area Self-Assessment SA-RPR-2014-02, RP Shift Support Effectiveness, December 2014

The objective of this FASA was to evaluate if the change to a Radiation Protection Shift Support Model, providing 24/7 coverage for station activities, was effective in reducing dose and radiological risk. This was a major feature of the RP reorganization that took place in October 2013 and is related to the review of RP organization and administration (see Section 5.4).

> Moving to a 24/7 Radiation Protection Shift Support model has been a success as it relates to risk and dose. There is also a strong agreement at both stations from the Radiation Protection and Industrial Safety departments and the other station departments that RP supports, that overall, coverage, incident response and radiological assistance has improved.
>
> …
>
> The overall consensus is that by having RP Technicians working 24/7 shift (and having the increased staffing numbers), coverage and follow-up has improved in the following areas:
>
> - Help employees/work groups better control contamination
> - Provide PA [Protection Assistants] and Greenman support
> - Respond to incidents, alarms and abnormal conditions
> - Run our routine survey program including RMSA [Radioactive Material Storage Area] Audits, CCA Audits and Monitor Constancy Checks (at Bruce B) (Section 7.0 and 7.1) [153]

Through the evaluation, two adverse conditions were identified regarding work scope, work priority and personnel capability. Three opportunities for improvement were also identified: one regarding the responsibilities of each RP crew; one regarding CCA management and tracking; and one regarding personnel capabilities.

SCR 28473537 was initiated to track the corrective actions associated with these findings. All five of the SCR assignments are complete.

7.1.5. Focus Area Self-Assessment SA-TRGD-2014-04, Radiation Protection Technician Training Program: TQD Compliance and Qualification Structure Review, November 2014

In this FASA, the Radiation Protection Technician Training Program was assessed:

> … to evaluate compliance and alignment of the training program with Bruce Power's training processes and procedures. The results of this assessment revealed several gaps and opportunities to improve the training program and the qualification structure. (Section 2.0)
>
> …
>
> Based on the facts collected through this FASA, significant revisions are required to TQD-00046 Radiation Protection Technician Training and Qualifications Description to align the Radiation Protection Technician Training Program with Bruce Power's training processes and procedures. As a key qualification, where errors have the potential to directly impact station performance or

safety, it is imperative that Bruce Power has a robust Radiation Protection Technician Training Program. (Section 7.0) [154]

Ten deficiencies were identified in the RP Technician training program. These findings are related to the review of RP Training provided in Section 5.5. Actions have been captured in action tracking through SCR 28468758 to close the identified gaps. There are 13 SCR assignments: 10 are complete, one has been cancelled and the remaining two are accepted and due by September 2016.

7.1.6. State of the Functional Area Assessment (SOFA) SA-RPR-2015-SOFA, Radiation Protection Programs, April 2015

This document provides an overview of the Radiation Protection functional area achievements, strengths, and areas for concern during 2014.

The Radiological Safety Functional Area achieved the following improvements in 2014:

- In 2014 100 person rem [1 person-Sv] was saved on the business plan. This is due largely in part to low airborne tritium concentrations in Bruce B and the use of reactor face shielding at both stations. The reactor face shielding initiative has been accepted into the ALARA program and in 2014 saved an estimated 54 person rem [0.54 person-Sv]. The expected dose saving out to 2018 is 212 person rem [2.12 person-Sv].
- Industry leading improvements in PCE [Personal Contamination Event] performance. Outage PCEs are generally trending to 0.3 to 0.5 PCEs per outage day against an industry standard of 1. 2014 performance is the best Bruce Power has achieved and is an 80% reduction on the number of PCEs in 2010.
- Oversight of station RP performance improved in 2014. Oversight programs were developed for 2014 focusing on specific program elements.
- Whole Body Monitors (WBM) at Bruce B were obsolescent, employed old technology and frequently went out of service. Forty-one WBMs were replaced. This capability significantly enhances the ability to detect discrete radioactive particles and further improves the alpha radiation protection program.
- The source term project completed in December 2014 and has been accepted into the RP Program. Bruce Power now has a source term data base of all units and a process to maintain the information up to date. The source term data base is used to underpin current and future dosimetry requirements, radiological assessments and key elements of the program such a contamination control, waste management and ALARA. (Section 1.1) [155]

The report lists collective radiation exposure, availability of RP resources and radioactive material control as the key areas for concern:

- Collective Radiation Exposure – “Bruce Power’s collective radiation exposure (CRE) is high and places it in the 4th quartile for the industry and 3rd decile for CANDU PHWRs [Pressurized Heavy Water Reactor].”

- RP Resources – Due to Bruce Power and Ontario Power Generation (OPG) planned outage schedules, there may be insufficient qualified Safety Technician resources available to support Bruce Power in 2015, 2016 and onwards.
- Radioactive Material Control – Control of radioactive material, although improving and trending down, continues to challenge the functional area. Bruce A and Bruce B both had several unposted hazards events during 2014. "Each station has corrective action in place through their excellence plans and the CAP [Corrective Action Plan] process. In addition a cross site working group will be established in Q2 2015 to identify common issues and improvement plans." (Section 1.2) [155]

7.1.7. Focus Area Self-Assessment SA-RPR-2015-01, Access Control, December 2015

The purpose of this report was to assess the management of keys required to access Subsystems A, B and C as per the management expectations specified in Section 4.1 of BP-RPP-00008, Access Control [68]. "No weakness[es] have been identified …The feedback from both Operations and RP Departments indicates that the key system to control Access Controlled Areas is effective. The Unit 0 operators did not report any deficiencies and they considered the log method and the key controls to be effective." [156]

This self-assessment is related to the review task on access control discussed in Section 5.1.2 of this report. The conclusion of this report refers to an action request generated through a previous self-assessment regarding a discrepancy between the Bruce Power Access Control program and a recommendation made in the WANO guideline:

"A final comment in regard of AR 28399588-13: 'consider incorporating into the BP-RP Programs the requirement for additional physical controls to prohibit inadvertent exposure to high activity material with reading greater than 1 R/h.' Bruce Power Radiation Protection management analysis indicates that the control imposed by the current procedures cover adequately the philosophy of the WANO recommendations in this area" (Section 5.0, [156]). The AR assignment is marked as complete.

One DCR, 28530142, was generated as a result of this assessment requesting the addition of an explanation of the access control subsystems to BP-RPP-00008, Access Control [68]. This improvement to the access control procedure is due February 23, 2018.

7.1.8. Focus Area Self-Assessment SA-RPR-2015-02, RPPE, September 2015

The objective of this assessment "is to benchmark Bruce Power's RPPE Program against the industry and identify which RPPE product(s) would benefit from a change. Also, to identify problem areas or areas for improvement with the current RPPE and any challenges the company may face in the future" (Section 3.0, [129]). The RPPE program was evaluated against 5 other nuclear power plants through benchmarking interviews and an internal and external OPEX review was performed.

"This review of the RPPE program helped to identify four adverse conditions and eight opportunities for improvement. These findings represent either improvement to worker safety or potential cost savings" (Section 5.0, [129]).

First, a trend was identified in the incorrect packaging of plastic suits being sent to the CMLF to be laundered. This is related to the review of radiological hazard control discussed in Section 5.1.3 of this report. SCR 28518245 was initiated to track corrective actions associated with the RPPE assessment. The assignment established to address the first adverse condition is complete.

Second, an air supplied respirator was identified that no longer meets the requirements of the Respiratory Protection program and should therefore be removed from service. This is related to the review of RP equipment discussed in Section 5.2. The SCR assignment established to address this adverse condition is complete.

The third and fourth adverse conditions identified are both related to the inadequacy of specific RPPE for some work. These findings are related to the review of RP equipment discussed in Section 5.2. No action was required to address the third adverse condition, and the SCR assignment established to address the fourth has been accepted, with a due date of January 2017.

Four of the eight opportunities for improvement identified would result in cost savings. The remaining four opportunities for improvement are intended to improve:

- worker practice during RPPE dressing and undressing
- radiological hazard control due to the use of new equipment
- RPPE inventory control
- RPPE supplier capability to address Bruce Power needs

SCR 28518249 was initiated to address all of the opportunities for improvement for which further action was required by RP. There are five assignments associated with this SCR: four are complete and one was cancelled with a completion note which indicates that TCR 27435 was entered in its place.

7.1.9. Focus Area Self-Assessment SA-RPR-2015-03, ALARA Program and Planning, September 2015

The objective of this assessment was to "evaluate the ALARA Planning process specific to programmatic alignment with Outage preparation & planning documentation and RP Program documentation" (Section 3.0, [118]). This is related to the review of the ALARA program discussed in Section 5.1.1 of this report.

> Outages represent in excess of 80% of all collective radiation exposure on site. The ALARA Program requires alignment with the outage planning and scoping processes in order to be successful in minimizing and mitigating exposures to staff. The nature of the business requires flexibility in outage scheduling and the processes need to be able to adapt to this flexibility. The ALARA planning processes lack this flexibility which makes procedural compliance very difficult,

> specifically SEC-RPR-00049 Outage ALARA Planning and Preparation Milestones requires a significant re-write.
>
> …
>
> The ALARA Planning process specific to programmatic alignment with regulations and industry guidelines is robust. This was verified by the CNSC Type II inspection results and the latest WANO evaluations at both stations. There continues to be vulnerabilities in the alignment of Outage preparation & planning documentation and RP Program documentation. Both sets of documentation require more flexibility in order to meet the dynamic nature of the business. [118]

One adverse condition was identified due to misalignment between BP-RPP-00011, Requirements for Planning Radiological Work and BP-PROC-00342 Sheet 001, Planned Outage – Preparation Milestones. SCR 28503672 was generated through a previous evaluation to track corrective actions. Through this SCR, DCR 28510392 was initiated to request revision and issue of "BP-RPP-00011 to refer to BP-PROC-00342 for ALARA Plan Due Dates and remove any prescription of specific due dates from the procedure in order to avoid any future misalignment." The fourth SCR assignment, which requires this revision to the ALARA planning procedure is marked as complete as of January 15, 2016. However, these changes were incorporated in BP-RPP-00011-R012, which was issued in December 2015 and later revoked in R013, which was issued in January 2016 [75]. As a result, the assignment is identified as complete, when it is not, and a gap remains. A gap related to the ineffective use of DCRs to result in procedure improvement (SF10-2) has been identified through Safety Factor 10 on Organization and Administration.

The assessment notes "several opportunities for improvement will be realized with the transition to MARS, Maintenance Alignment and Resource Strategy" (Section 5.2, [118]).

7.1.10. Focus Area Self-Assessment SA-RPR-2015-04, Worker Fundamentals – Supplemental Staff (Appendix A Safety Technicians), June 2015

This FASA was conducted to determine the depth of supplemental RP technicians' understanding of the essential knowledge, skills, behaviours and practices required to ensure the health and safety of workers and the public. The scope and conclusions were:

> The scope of assessment included the following:
>
> - Review of procedural guidance on RP fundamentals
> - Review of available INPO resources regarding Fundamentals and Supplemental RP staff
> - Review of onboarding process for supplemental Safety Technicians including training and roll-outs
> - Review and comparison of RP worker practices scorecard[s]…
> - Review of SCR trends to determine causal factors that contributed to events
> - Fundamental knowledge assessment of supplemental Safety Technicians (Section 4.0)
>
> …

> Based on the facts gathered… there are several examples where supplemental RP workers are failing to meet the standard, and where RP management have not adequately prepared workers, or assessed their abilities against the Radiation Protection Fundamentals. Furthermore, many comparable weaknesses exist in the program that could relate to areas for improvement identified at other utilities in the industry… While our protection model continues to be based on self-protection, there are many functions that only RP technicians can now complete. For these reasons, RP technicians need to be trained and managed to an enhanced standard. (Section 7.0)
>
> …
>
> Based on the review of observation and coaching events completed during both of the outages that were reviewed, the RP department has demonstrated a measureable improvement. (Section 7.1, [157])

Three adverse conditions were identified:

1. There is no procedural guideline that provides instruction on how to correctly provide initial orientation for short-term supplemental technicians, resulting in inconsistencies between outages.
2. There are weaknesses in RP training for supplemental staff. Training content and structure does not align with the training program for utility RP technicians and does not include continuing training.
3. Assessment of supplemental RP technician capabilities against the RP Fundamentals does not occur on a regular basis.

One opportunity for improvement was also identified in the range of focus areas that are being observed during work and the collection of observation data (observation and coaching reports).

These findings are related to the review of RP training described in Section 5.5. SCR 28505201 was initiated to track the required corrective and improvement actions. The SCR has eight assignments: four are complete, two were cancelled and two are due by October 2016.

7.1.11. Focus Area Self-Assessment SA-RPR-2015-05, Extremity TLD Use, October 2015

This evaluation [158] was prepared in response to SCR 28423845-11, which is complete. The purpose of this self-assessment was to determine if compliance with procedures regarding the use of extremity dosimetry has improved as a result of actions taken in response to a Bruce Power report written in 2014: Procedural Non-compliance during use of extremity TLDs [159].

It was determined that issues similar to those previously identified continued to exist: lost extremity TLDs, poorly labeled extremity TLD packs, extremity TLDs returned late, incorrect use of station extremity TLD logs, and incorrect identification of the requirement for extremity TLDs in REPs. SCR 28529556 was raised to address the problems encountered. The proposed solution (one of the SCR assignments) is to develop and implement a service protection model for extremity dosimetry on a trial basis; once at each of the next station outages. There are five SCR assignments: one is complete; four are open and not yet accepted or due.

A second adverse condition was identified in that 88% of the extremity TLDs analyzed by the Health Physics Lab in 2015 did not meet the minimum dose wearing criteria of 250 mrem [2.5 mSv] above whole-body or skin dose as required by BP-RPP-00020, Dosimetry and Dose Reporting. [SCR 28529558] was initiated to track the corresponding corrective actions. There are two SCR assignments, both of which are open and not yet accepted or due.

These findings are related to the review of personnel external dose monitoring described in Section 5.1.4 of this report.

7.1.12. Focus Area Self-Assessment SA-RPR-2015-07, Adequacy of Radiation Technician Worker Risk Recognition, June 2015

This FASA was the result of a root cause investigation into a Level 3 PCE that occurred during an outage in June 2014, as documented in SCR 28441908-03. The purpose of this assessment is to evaluate the strength of risk recognition used by RP technicians.

The assessment found that risk identification and recognition among RP technicians was improving. This improvement was driven by the introduction of the

> risk matrix (2x2 matrix) and the enforcing/re-enforcing *[sic]* the use of the matrix at… pre job briefs and at each work site…
>
> The implementation of the 2x2 risk matrix combined with the continual development and implementation of risk recognition within already established processes removes the requirement for immediate actions. (Section 2.0)

The 2x2 risk matrix has been in use since December of 2014. "The use of the matrix needs to continue and expand … to a standard tool used in the field alongside other HU [human performance] tools such as Situational Awareness" (Section 2.0, [160]).

The findings of this assessment are related to the review of RP training, described in Section 5.5.

7.1.13. "Quick Hit" Self-Assessment SA-RPR-2015-08, Business Impact Analysis: Radiation Protection Programs, September 2015

This self-assessment is listed here for completeness, however, an assessment of the programs and plans in place to address RP aspects for abnormal events is included in the scope of Safety Factor 13 – Emergency planning, and is not included in this review (see Section 6).

> The BIA [Business Impact Analysis] will assist each Corporate Functional Area Manager in identifying and assessing their business functions to determine which business functions are critical to avoid significant loss or harm to Bruce Power.
>
> The scope of this FASA is the Radiation Protection Programs Functional Area…
>
> The objective of the FASA is to:
>
> - Identify critical business function(s) and the required recovery time objective after an abnormal event has occurred.

- Identify critical resources required at a minimum for the critical business function to be performed.

…

BP-BCP-0001 1 Radiation Protection - Business Continuity Procedure exists and it adequately addresses the necessary steps for returning to service the critical function of dose control and measurement in the event of loss of this business function. While we have a process and procedure for short term recovery, the risk to safety barriers and possibly exceeding an administrative or regulatory barrier would increase with every day the critical function is not available. [161]

7.2. Internal and External Audits and Reviews

The objective of the audit process as stated in BP-PROG-15.01 [162] 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 [34]).

7.2.1. Internal Audits and Reviews

The following Bruce Power internal reviews, relevant to this safety factor, were completed after 2013:

- **2014-Q2 Nuclear Oversight Quarterly Report (B-AQR-02-2014) [163]**. "The Bruce Power Nuclear Oversight Assessment process is modeled after the WANO assessment process."

  Nuclear Oversight Assessments were performed at Bruce A and Bruce B during the second quarter of 2014, including an assessment of ALARA work in progress reviews at Bruce A.

  > During these assessments there were a few areas that were found to meet or exceed expectations. Most notably a beneficial practice was noted for the RP organization at both stations during outages. (Section 1.0)
  >
  > …

> The reorganization of the RP Departments in late 2013 resulted in dedicated HP support for large outage programs. For both the B1471 and A1431 outage this model improved focus on dose control and dose reduction for those programs. This is considered to be a beneficial practice that should be continued and applied more rigorously to bulk work programs for future outages.

This is evidence of good practice in RP Organization and Administration, which is assessed in detail in Section 5.4 of this report.

- **2014-Q3 Nuclear Oversight Quarterly Report (B-AQR-03-2014) [164]**. The assessment team observed that:

> Noteworthy this quarter is the completion of the assessment started during B1471 on supplemental staff. The assessment found that a large portion of supplemental staff are not receiving or being requalified in general employee training (GET). This is due to the fact that responsibility for onboarding supplemental staff resides with the line, and contract supervisors… are not always doing the right things to ensure staff are properly trained before going to work. (Section 1.0)

This is related to the review of RP Training, which is discussed in detail in Section 5.5 of this report.

- **2015-Q1 Independent Oversight Quarterly Report (B-AQR-01-2015) [165]**. "Problem Development Sheets are issued for planned assessment topics or conditions that are discovered by Independent Oversight that are significant gaps to excellence and currently impacting station performance" (Section 2.2).

  One Problem Development Sheet (PDS) raised this quarter was related to Radiation Safety: "ALARA Accountability…- SCR 28486676… Station Management is not consistently holding workers, supervisors and themselves accountable for their radiological performance in the areas of ALARA planning and dose performance" (Section 2.2). There are eight SCR assignments, all of which are complete.

  The last SCR assignment was to:

> … perform a follow-up assessment on the PDS on ALARA Accountability … The follow up has determined that there has been some improvement in accountability specifically with outages. However there are still deltas with respect to accountability. 1) The line is speaking to their RP performance but the SCRs driven from the ALARA meetings are being trended without clarity of what is being done to improve performance. 2) The MLM [Morning Leadership Meeting] monthly safety report is not placing enough focus on dose performance to drive accountability. 3) There have been significant HU RP events at BA [Bruce A] in which the contributing factor may have ties to low accountability. 4) Online dose performance has not significantly improved. As part of daily activities, Independent Oversight will be monitoring performance to see if accountability improves.

  Through one of the SCR assignments two DCRs were generated, both due June 30, 2016: 28504876 was submitted to prompt revision to BP-RPP-00044; 28504878 was submitted to prompt revision to BP-RPP-00011.

- **2015-Q2 Independent Oversight Quarterly Report (B-AQR-02-2015) [166]**. One PDS raised this quarter was related to RP:

> Radiation Protection Practices… SCR 28500400… Radiation protection and work practices are not consistently being enforced to high standards of performance. This has resulted in instances of poor radiation practices with the potential of loose contamination outside Contamination Control Area (CCA) and internal uptakes. Contributing, oversight for work groups is not consistently identifying poor radiation practices in the field. Workers showed weakness in essential behaviours and practices required to conduct radiological activities. This resulted in inconsistent radiological practices within CCAs. Contributing is the significant number of supplemental staff who may not have the same level of experience and knowledge as full time workers (Section 3.2).

There are ten SCR assignments: three are open, not yet accepted (all due in 2016); one is cancelled; and the remaining six are complete.

- **2015-Q3 Independent Oversight Quarterly Report (B-AQR-03-2015) [167]**. This report addresses Performance Area Summaries, which are:

> … issued for planned assessment topics that were examined in depth and found to be meeting standard or the gaps to excellence were not found to be causing significant performance issues at the time of evaluation. One Performance Area Summary was issued this quarter…ALARA Accountability…- SCR 28510363… Station Management is not consistently upholding expectations and reinforcing behaviours that promote excellence in ALARA practices for radiological safety. As a result, workers are potentially missing opportunities to save additional dose during daily work activities. Contributing, supervisors and workers are not always being held accountable for ALARA reduction practices and are seldom engaged in dose reduction initiatives on a continuous basis (Section 3.3).

There are four SCR assignments, and all are complete.

7.2.2. External Audits and Reviews

Bruce B was the subject of an IAEA OSART review from November 30 to December 17, 2015. In the report that provides the conclusions of the OSART review [168], elements of good practice and good performance were identified in the area of RP, as well as one issue resulting in a suggestion from the team.

> The purpose of the mission was to review operating practices in the areas of Leadership and Management for Safety; Training & Qualification; Operations; Maintenance; Technical Support; Operating Experience feedback; Radiation Protection; Chemistry; Emergency Preparedness and Response; Accident Management; interactions between Human Technology and Organization, and Long Term Operations. In addition, an exchange of technical experience and knowledge took place between the experts and their plant counterparts on how the common goal of excellence in operational safety could be further pursued…
>
> Emphasis was placed on assessing the effectiveness of operational safety rather than simply the content of programmes. The conclusions of the OSART team were based on the plant's performance compared with the IAEA Safety Standards (Introduction).

Section 7 of the OSART report focuses on RP.

Radiation work controls are discussed in Section 7.3:

The creation of radiological work packages uses historical radiological data to determine dose rate and dose limits and associated protection equipment to be used with the task. The plant uses information retrieved from a database known as the Radiation Hazard Information System (RHIS). The data for this system is provided by plant staff working within an extensive self-protection model. The result is a significant increase in the amount of useful data being available on the database. The team recognised this as a good performance.

Control of occupational exposure is discussed in Section 7.4:

The plant operates a zonal system based on radiological risk. The plant has additional areas for control of contamination and designated areas for the storage of radioactive materials. Elevated dose rates on pipework in specific areas are identified by 'hot spot' notices. These areas are periodically reviewed and signs are being updated by use of a gamma camera with a pictorial view of the area. The team identified this as a good practice." This good practice is further described in under 7.4 (a): "The plant uses an advanced Gamma camera to promote radiation area identification and shielding opportunities…

This camera allows for the posting of 'heat map' photos near key radiation work areas to provide workers with a better understanding of the primary source in the area. This helps develop the workers' mental models about where the source is and gives them the opportunity to avoid it.

The camera can be incorporated into a plant's routine survey program to track hot spots. The camera can also be used to evaluate the use of shielding to identify if there is any streaming, and also used to help in decontamination of rooms/components and long-term investigation into plant degradation due to ambient dose rates.

Section 7.4 goes on to say:

There is a detailed programme in place, including a detailed five year plan, to support dose reduction. Additional support has been provided by the radiation protection team in significant dose reduction opportunities during recent outages. The development of specific shielding opportunities and major project development specifically in the area of reactor inspection equipment have resulted in a significant dose reduction in these areas. The team recognised this as a good performance.

Radioactive systems within the plant are identified by colour coding dependant *[sic]* on the material the system contains, however some systems are not clearly identified. All temporary areas and 'hot spots' are controlled with temporary barriers and signage. However, information on barrier dose rates is not available. The team made a suggestion in this area.

The issue raised by the OSART team, resulting in this suggestion is described under 7.4 (1):

Radiological information is not always adequately used to promote radiological awareness. The team noted the following:

- Contaminated ventilation plant system is not marked with trefoil signage to indicate radioactive plant. This is applicable for all radioactive systems, although it was noted that some of the systems are colour coded.
- Posting notices contain maximum dose rate information on contents in storage areas but do not contain dose rates at barriers.
- Posting notices in respect of 'hot spots' do not clearly identify exact location of 'hot spot or maximum dose rates at temporary barriers.

- Portable Radiation protection equipment is not source checked following use to validate survey data.
- The type of Radiation protection equipment and the confirmation of source checks information are not recorded on survey sheets or electronic data to confirm requirements of radiological information required by radiological documentation.

Without accurate radiological information to plant staff, human errors could lead to inadvertent exposure.

Suggestion: The plant should consider taking actions to strengthen radiological awareness within the areas of plant where this is required.

Bruce B initiated AR 28551722 to track this suggestion and any enhancements made as a result.

Radiation protection instrumentation, protective clothing and facilities are discussed in Section 7.5:

> The plant utilises numerous instruments as part of its self-protection model recording imperial and scientific units in notifications. This may lead to misinterpretation of results. The team encourages the plant to consider standardizing instrument to scientific notification to align with training standards, currently being used at the site.

Radioactive waste management and discharges are discussed in Section 7.6. This is outside the scope of this review (see Section 6 of this report).

During the OSART review three ARs were generated related to RP observations:

- AR 28514078, Portable Radiation Instrument Traceability – "When surveys are performed with portable radiation instruments there are currently no records kept to track which instrument is used. The only time we track instrument use is our survey verification process. This has been identified as a Gap between the IAEA safety guidlines *[sic]* and our Bruce Power procedures." The completion notes indicate that instruments are tracked via the TMS (Tool Management System). When a worker is issued a radiation instrument their DISN (Dosimetry Information System Number), the date of issue and unique instrument number are all recorded in the TMS database. Reports can be run to retrieve this information at a later date. Instruments used for surveys to release items to the public domain are tracked via the URP (Unconditional Release Permit) database. This AR has been completed with no programmatic change.
- AR 28514080 REPs not Retained during Radiological Work – "Bruce Power procedures do not require workers to keep a copy of the REP (Radiation Exposure Permit) throughout the performance of the work. This has been identified as a GAP between the IAEA safety guidlines *[sic]* and our Bruce Power procedures." The completion notes indicate that the AHP directed that REPs are not required at the jobsite since all REPs are reviewed at the pre-job brief. This AR has been completed with no programmatic change.
- AR 28514490 Whole Body Monitor Availability – "At Bruce B there are currently 20 out of 110 monitors out of service. This does not meet our standard. Current target is >90% availability. This has been identified as a gap when reviewing the IAEA safety guidelines

[sic]." This AR has been completed with further actions assigned through AR 28510371 and AR 28513214. The completion notes also indicate that Control Maintenance are to perform another evaluation to determine the cause of inadequate resources and parts to address whole body monitor issues. There is no action tracking number assigned to this action.

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 licensees 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.

The following regulatory evaluations and reviews were conducted after 2013:

7.3.1. CNSC Type II Compliance Inspection Report: BRPD-AB-2014-010 – Occupational ALARA Planning and Controls

The CNSC conducted a compliance inspection of the ALARA aspect of Bruce Power's Radiation Protection Program in August 2014 [113], and concluded:

> The inspection verified compliance by Bruce Power with regulatory requirements associated to this program.
>
> …
>
> Occupational ALARA Planning and Control at Bruce Power meets the regulatory requirements, however there are two areas requiring improvement due to non-compliances with licensee procedures:
>
> - Human Performance Management – Procedural Adherence; and
> - Conduct of Licensed Activity – Verification of Work.
> - Four opportunities for enhancement were identified in relation to the following areas:

- Change Management – Procedural Control;
- Records Management – Control of Records;
- Application of ALARA – ALARA Program Administration; and
- Application of ALARA – Engineering, Plant Maintenance, and Instrumentation and Controls.

> CNSC staff identified nine additional compliant findings related to the balance of the areas inspected.
>
> As a result of the aforementioned findings, 2 Action Notices and 4 Recommendations are being raised as a result of this inspection. [113]

Bruce Power responded to the CNSC, providing corrective action plans to address the CNSC findings [114] and the corresponding Action Item was subsequently closed with a request that "Bruce Power… notify CNSC staff upon completion of both corrective action plans." [169]

The Action Notices and recommendations are described as follows:

Action Notice BRPD-AB-2014-010-AN1 – "In order for Bruce Power to become fully compliant with BP-RPP-00044 sub-section 4.1, CNSC staff request Bruce Power to develop and implement a corrective action plan to ensure that the ALARA Committees' Terms of Reference are: clearly defined and documented, consistent with the requirements of BP-RPP-00044; and adhered to in the conduct of ALARA Committee Meetings"(Section 4.2.1) [113].

Bruce Power responded indicating:

> … a corrective action has been initiated to revise the Terms of Reference for all Site and Station ALARA Committees and Sub-Committees. This revision shall ensure that all Terms of Reference for the above named committees will adhere to BP-RPP-00044 and a statement is added that the conduct of such committees will adhere to the requirements of BP-RPP-00044. [114]

The associated Bruce Power action tracking number is not provided. See Section 5.1.3.3 of this report for further detail on TOR for the ALARA Committees.

Action Notice BRPD-AB-2014-010-AN2 – "In order for Bruce Power to become fully compliant with BP-PROG-12.05 sub-section 4.6, CNSC staff request Bruce Power to develop and implement a corrective action plan to ensure that the adequacy and effective implementation of the ALARA program is regularly assessed" (Section 4.3.3, [113]).

Bruce Power responded indicating "a corrective action has been initiated to revise BP-RPP-00444, ALARA Program, to include a statement requiring a Focus Area Self-Assessment (FASA) to be performed every two years, as a minimum. A FASA of the ALARA program is on the Bruce Power 2015 FASA plan" [114]. Revision R003 of BP-RPP-00044 does in fact include the proposed FASA frequency requirement. A FASA was conducted on the ALARA Program and Planning in September 2015 [118]. This action has been completed.

Recommendation BRPD-AB-2014-010-R1 – "CNSC staff recommends Bruce Power to enhance the control and management of the ALARA Committees' Terms of Reference" (Section 4.1.1) [113].

In response, “Bruce Power accepts this recommendation. The control and management of the Terms of Reference will be reviewed and enhancements will be made based on the results of the review.” [114] The associated Bruce Power action tracking number is not provided; it is assumed that this action is still open. This is related to the assessment of the ALARA program, discussed in Section 5.1.3.3 of this report.

Recommendation BRPD-AB-2014-010-R2 – “CNSC staff recommends Bruce Power to implement planned enhancements to databases that support the ALARA program” (Section 4.1.2, [113]).

In response, “Bruce Power is considering this recommendation. For example, air sampling results are being considered for inclusion in the Source Term Characterization Database.” [114] This is related to the assessment of radiological monitoring, discussed in Section 5.1.4.3 of this report.

Recommendation BRPD-AB-2014-010-R3 – “CNSC staff recommends Bruce Power to develop and implement additional dose reduction measures to achieve their business goal of achieving industry best Collective Radiation Exposure performance” (Section 4.4.1, [113]).

In response, “Bruce Power accepts this recommendation. Improving collective radiation exposure (CRE) has been a major focus area for the Radiation Protection Department and the stations as a whole. Major improvements in CRE have been realized over the last two years and Bruce Power is committed to continue making improvements in this area. Future projects, such as cobalt control using fluoroscopy, ECI crud removal and nano fibre filtration for the PHT system, will all result in positive effects on the CRE.” [114] This is related to the assessment of radiological monitoring, discussed in Section 5.1.4.3 of this report.

Recommendation BRPD-AB-2014-010-R4 – “CNSC staff recommends Bruce Power to continue to pursue current plans to improve and sustain whole body monitor availability” (Section 4.4.4, [113]).

In response: “Bruce Power has initiatives to improve the performance and availability of our Whole Body Monitors (WBM) at both stations. We recently installed 25 new monitors at Bruce B and will soon have an additional 16 in place. We are currently implementing a corrective action plan to improve the performance and availability (95% available) of WBMs at Bruce A. We are committed to improving the performance of our WBM and are executing actions to sustain the program.” [114] This is related to the assessment of RP equipment and instrumentation condition, discussed in Section 5.2.2 of this report.

7.3.2. CNSC Type II Compliance Inspection Report: BRPD-B-2015-003 - 2015 Planned Station and Vacuum Building Outage at Bruce B

This report communicates the results of the inspection conducted during the Planned Station and Vacuum Building Outage, from April 15th to June 1st, 2015. [170]

A review of RP is described in Section 4.4 of the report. First, an analysis of worker dose control is provided in Section 4.4.1:

> Bruce Power's suite of radiation protection procedures includes the processes Bruce Power staff is *[sic]* required to follow to ensure radiation dose received by individuals is as low as reasonably achievable.
>
> Prior to any outage Bruce Power sets targets for various radiation protection areas. Bruce Power set a target worker dose limit of 25 mSv (2.5 Rem). The total dose to workers for the outage was 20 mSv (2 Rem) which is 80% of target. Dose reduction for the outage was achieved through use of mock-ups, walk-throughs, and survey maps of the fuelling duet prior to leak search and inspection activities.
>
> In addition to dose targets, Bruce Power set targets for 0 unplanned exposures, [and] 0 excessive exposures. Both of these targets were met…
>
> CNSC staff concluded that Bruce Power took reasonable and necessary precautions to ensure that worker dose was maintained as low as reasonably achievable during the 2015 Vacuum Building Outage.

An analysis of radiological hazard control is provided in Section 4.4.2:

> Bruce Power's suite of radiation protection procedures includes the processes Bruce Power staff is required to follow to ensure radiation hazards are controlled.
>
> Bruce Power set a target of 23 personal contamination events (PCEs), 0.8 per outage day, in line with industry best-practice. As a result of improved contamination control, Bruce Power had 14 PCEs during the outage, representing performance 40% better than target, demonstrating continued improvement following corrective actions to reduce outage PCEs compared to historical performance. Additionally, the majority of PCEs for the outage were related to contamination on scaffolders' footwear as, for conventional safety reasons, scaffolders could not wear the standard RPPE in the area where they were required to work. Bruce Power did not set a target for loose contamination events (LCEs) but had two LCEs related to the outage.
>
> One LCE involved contamination on the recovery floor being transferred to the vacuum building basement via hatchways during recovery floor cleanup. The vacuum building basement was not classified as contamination control area (CCA). The second LCE involved the spread of contamination from a CCA in the vacuum building basement when a fan that had been left in the on position started up as a result of the odd electrical bus being re-energized during outage lead-out activities.
>
> During the outage, CNSC staff conducted a walkdown of the unit on May 5, 2015 to verify adherence to radiation protection requirements documented in Bruce Power's radiation protection suite of procedures. Details of this walkdown are documented in e-doc 4752957. The walkdown verified; the posting of hazards, the condition of CCAs, the use of radioactive material storage areas, timely radioactive waste removal, and availability of monitors were being met…
>
> CNSC staff concluded that Bruce Power took reasonable and necessary precautions to ensure that radiological hazards were controlled and maintained during the 2015 vacuum building outage.

There are no enforcement actions as a result of the review of RP during this inspection.

7.3.3. CNSC Desktop Review: BRPD-AB-2015-005 - Health Physicist and Authorized Health Physicist training program

This report communicated the results of a Desktop Review of Bruce Power's Health Physicist and Authorized Health Physicist training program conducted in June and July of 2015 [171]. The purpose of this review was to verify the use of a systematic approach to training. It concluded:

> Based on the scope of the review conducted, CNSC staff concludes that the Health Physicist and Authorized Health Physicist training program at Bruce Power is being defined, designed, developed, and evaluated in accordance with the SAT [Systematic Approach to Training]-based training system and that the licensee meets the regulatory requirements with the exception of one non-compliance…
>
> The review identified three (3) compliant findings and one (1) non-compliant finding. One action notice and three recommendations are raised as a result of this Desktop Review. [171]

Bruce Power responded to the CNSC, providing corrective action plans to address the CNSC findings [172]. The associated Action Item remains open until the corrective actions described by Bruce Power are in fact complete [173].

The Action Notice and recommendations are described as follows:

Action Notice BRPD-AB-2015-005-AN01: "In order for Bruce Power to become compliant with BP-PROC-00201 rev.004… CNSC staff request Bruce Power to develop and implement a corrective action plan to ensure that all Field Checkouts (FCOs) associated with the HP & AHP training program are up-to-date and complete" (Section 4.3, [171])

In response, Bruce Power:

> … accepts this action.
>
> - Bruce Power will review and correct as necessary all Health Physicist and Authorized Health Physicist Field Checkouts (FCO).
> - Bruce Power will have a Subject Matter Expert perform a technical quality review of each FCO…
> - Bruce Power will have a Training Developer perform a training quality review of each FCO…
>
> These actions are targeted for completion by July 29, 2016. [172]

Recommendation BRPD-AB-2015-005-R01: "CNSC staff recommend that Bruce Power plan a revision of Job Analysis JA-1 101, Health Physicist, to ensure the key qualifications are reviewed within the prescribed frequency" (Section 4.2, [171])

In response, Bruce Power "accepts this recommendation. Bruce Power has assigned a Training Officer to complete a review of JA-1 101. This review will follow the requirements of BP-PROC-00203, Training - Prepare a Job Analysis. JA-1 101 will be revised to address any findings from the review." [172]

Recommendation BRPD-AB-2015-005-R02: "CNSC staff recommend that, for the next revision of Job Analysis JA-1 101, Health Physicist, Bruce Power includes the number of persons surveyed in the Job Analysis notes" (Section 4.2, [171])

In response, Bruce Power "accepts this recommendation. Bruce Power will document the number of persons surveyed as part of the revision of JA-1 101, Health Physicist, to be completed following the review for Recommendation R01." [172]

Recommendation BRPD-AB-2015-005-R03: "CNSC staff recommend that Bruce Power ensure that TQD-00075 [Health Physicist, Authorized Health Physicist Training and Qualifications Description] is revised as planned" (Section 4.2, [171])

In response, Bruce Power "accepts this recommendation. Bruce Power will revise TQD-00075 after the review of JA-1 101 for Recommendation R01. This revision will follow BP-PROC-00216, Training - Prepare a Training and Qualification Description (TQD)." [172] Revision 4 of TQD-00075 was issued in March 2016 [175], fulfilling Bruce Power's commitment.

7.3.4. CNSC Type II Compliance Inspection Report: BRPD-AB-2015-007 - Radiation Hazard Control

The CNSC conducted a compliance inspection:

> … on the radiation protection program elements specific to radiological hazard control at Bruce Nuclear Generating Stations A and B during the week of July 27-31, 2015.
>
> …
>
> Radiological Hazard Control at Bruce Power meets the regulatory requirements; however the inspection identified one area requiring improvement due to non-compliance with licensee procedures in relation to: Maintenance - Maintenance and Calibration of Radiation Measuring Devices and Radiation Protection Equipment. In some instances, areas of non-compliance that had been identified through previous inspections were confirmed to still be non-compliant at the time of this inspection as corrective actions have not yet been fully implemented.
>
> Seven opportunities for enhancement were identified in relation to the following areas:
>
> - Human Performance Program - Procedural Adherence
> - Conduct of Licensed Activity - Problem Identification and Resolution
> - Maintenance - Maintenance and Calibration of Radiation Measuring Devices and Radiation Protection Equipment
> - Radiological Hazard Control - Radiological Hazard Surveys and Control Programs and
> - Radiological Hazard Control - Radiation Monitoring Equipment and Instrumentation.
>
> CNSC staff identified 11 compliant findings related to the balance of the areas inspected.
>
> As a result of the aforementioned findings, 1 Action Notice and 8 Recommendations are being raised as a result of this inspection. [133]

It is worthy of note that an opportunity for enhancement in the area of procedural adherence was also identified in a previous Type II inspection on the subject of Occupational ALARA Planning and Controls that took place in August 2014 [113].

The opportunities for enhancement are described as follows.

Action Notice BRPD-AB-2015-007-AN1 – "In order for Bruce Power to become fully compliant with BP-PROC-00037 sub-section 4.1.6 and BP-PROC-00192 sub-section 4.2.3, CNSC staff request Bruce Power to develop and implement a corrective action plan to ensure that all RP instrumentation is calibrated at the required frequency and a calibration label is affixed prior to the equipment being placed in service" (Section 4.4, [133]). In response, Bruce Power initiated AR 28527104 to track the completion of this action notice and two recommendations (R3 and R4 discussed below). The AR has 21 assignments, all of which are complete. In the process of addressing the AR assignments three DCRs (28534232 due in January 2017, 28531062 due in November 2016, and 28538723 due in December 2016) were raised for revision of SEC-RPR-00058, Whole Body Monitor Alarm Set-point Checks [174], and one DCR (28538724 due in December 2017) was raised for revision of BP-RPP-00035, Use of Fixed Radiation Protection Instrumentation [72].

Recommendation BRPD-AB-2015-007-R1 – "CNSC staff recommend Bruce Power to ensure consistent use of temporary drain lines, secured in place to align with station floor drains" (Section 4.2.2 [133]). In response, Bruce Power generated AR 28524423 to track this recommendation. The AR was completed with the issuing of Revision 10 of GRP-OPS-00038.

Recommendation BRPD-AB-2015-007-R2 – "CNSC staff recommend Bruce Power to develop and implement a corrective action plan to ensure that identified RP deficiencies and SCR adverse trends are addressed and corrective actions are completed in timely manner" (Section 4.3.1 [133]).

Bruce Power responded to the Type II inspection report on Radiation Hazard Control in December 2015 [176]. The commitment listed in response to CNSC Recommendation 2 is that "Bruce Power will review the relevant processes to ensure that RP deficiencies and Station Condition Record (SCR) adverse trends are addressed and corrective actions are completed in a timely manner. Bruce Power will seek to make improvements to the relevant processes as necessary."

Recommendation BRPD-AB-2015-007-R3 – "CNSC staff recommend Bruce Power to identify the numbers and locations of available whole body monitors required to provide adequate coverage in the stations and to develop and implement a corrective action plan to ensure this minimum adequate level of coverage is achieved and sustained" (Section 4.4.1 [133]). In response, Bruce Power is tracking the issue under AR 28527104 discussed under the Action Notice, above. The relevant assignments are 8, 9 and 10; all three are complete.

Recommendation BRPD-AR-2015-007-R4 – "CNSC staff recommend Bruce Power to include in the Bruce Power RP program governance, a requirement for source check labels, similar to the requirements for calibration labels in BP-PROC-00037 - Sub-section 4.1.7.9, to improve worker awareness and confidence that fixed RP instrumentation is available for service and to help prevent errors and omissions related to source checks coincident with maintenance activities" (Section 4.4.1 [133]). In response, Bruce Power is tracking the issue under the AR 28527104 discussed under the Action Notice, above. The relevant assignments are 11 and 12; both are complete.

Recommendation BRPD-AB-2015-007-R5 – "CNSC staff recommend Bruce Power to enhance the current alpha frisking requirements by conducting frisking at the exit of all alpha

level 3 areas and not only areas with less than 50:1 ratios to ensure that potential alpha hazards from all alpha level 3 areas are identified" (Section 4.5.4 [133]).

In response, "Bruce Power acknowledges the recommendation and has added this as an item of consideration during the next revision of SEC-RPR-00016, 'Alpha Monitoring Procedure'." [176] DCR 28524606 for SEC-RPR-00016 was created with a due date of October 28, 2016, and cancelled on December 4, 2015. A new DCR, 28532122, was originated that day, with a due date of May 14, 2019.

Recommendation BRPD-AB-2015-007-R6 – "CNSC staff recommend Bruce Power to enhance the current required frequency of routine surveys at Zone 1 lunchrooms, Zone 2 coffee shops, and main control room to align with industry standards (e.g. daily surveys)" (Section 4.5.4 [133]).

In response, "Bruce Power acknowledges the recommendation and has added this as an item of consideration during the next revision of BP-RPP-0005, 'Routine Radiological Survey'." [176] DCR 28524609 for BP-RPP-00005 was created with a due date of November 18, 2016.

Recommendation BRPD-AB-2015-007-R7 – "CNSC staff recommend Bruce Power to acquire in a timely manner the acquisition *[sic]* of new inter-zonal fixed contamination monitors (SAMs [Small Article Monitors] and PMs [Portal Monitors]) that support alarm threshold settings consistent with industry standards" (Section 4.5.6, [133]).

In response, "Bruce Power acknowledges the recommendation. A project proposal has been approved for the purchase of 8 new portal monitors and funding has been granted for the purchase of 4 of these which are expected to arrive December for installation at Bruce A. A second project proposal has been approved for the purchase of 55 new Tool and Object Monitors (TOMs)." [176]

Recommendation BRPD-AB-2015-007-R8 – "CNSC staff recommend Bruce Power to periodically review and confirm the technical basis for alarm set points and source check frequency of fixed contamination monitors remains consistent with industry best practice. CNSC staff further recommends that this periodic review be documented as a re-confirmation of the existing 2005 report (Radiation Protection Alarm Set-points implemented at Bruce Power in comparison with industry best practices and International Standards) or an updated report be generated as appropriate, and that alarm set points and source check frequencies be updated in governance as appropriate pending the results of such periodic reviews" (Section 4.5.6 [133]).

In response, "Bruce Power acknowledges the recommendation. A 2013 review of the RP Program identified a need to evaluate the whole body monitor set points (complete) and a need to evaluate the whole body monitor alarm set points (which will be reviewed during the next revision of BP-PROC-00037)" [176]. DCR 28470411 for BP-PROC-00037 [71] was created with a due date of October 12, 2018.

7.3.5. CNSC Request for Information: Action Item 1407-5187 – Calibration of Fixed Area Gamma Monitors at Bruce Power

In January 2013, the CNSC requested information regarding the calibration requirements and frequency for fixed area gamma monitors (FAGMs). "The Nuclear Substance and Radiation

Device [NSRD] Regulations define a radiation survey meter as an instrument that is capable of measuring dose rates. Bruce Power staff has informally notified us that the calibration frequency for [FAGMs] at Bruce Power is every two years." [136]

The CNSC requested additional information on FAGM calibration since the NSRD Regulations state, in Clause 20, that "no person shall use, for the purpose of the Act, the regulations made under the Act or an order or a licence, a radiation survey meter that has not been calibrated within the 12 months preceding its use." [177]

In June of 2014 the CNSC wrote to Bruce Power again: "In January 2013, CNSC staff requested that Bruce Power provide information pertaining to documented requirements for the calibration of fixed area gamma monitors (FAGMs) [reference [136] in this report]. Bruce Power staff provided a response to the initial request as well as further follow-up information requested by the CNSC [references [178] and [179] in this report]. At this time, CNSC staff are still awaiting information … Bruce Power is requested to respond." [180]

The information requested was regarding:

1. A target completion date for calibration of all accessible FAGMs with calibration dates beyond twelve months
2. Calibration requirements for non-accessible FAGMs and where the requirements are captured
3. A list of documents requiring revision to reflect a change to calibration of accessible FAGMs every twelve months.

Bruce Power responded in August 2014, providing information on the questions raised by CNSC staff along with a corrective action plan [181]. In October 2015 Bruce Power provided an update indicating that the actions committed to were complete, including [182]:

- calibration of accessible FAGMs
- creation of work management predefined maintenance identification numbers for FAGM calibration
- revision of affected procedures to reflect changes to the instrument management program

In December 2015 the CNSC responded, concluding that "Bruce Power has taken appropriate corrective actions to oversee fixed area gamma monitor calibration" and therefore closed the associated Action Item [137].

This is relevant to the assessment of radiation protection equipment and instrumentation described in Section 5.2.

7.3.6. CNSC Regulatory Oversight Report for Canadian Nuclear Power Plants: 2014

Section 3.1.1.7 of the 2014 CNSC Regulatory Oversight Report discusses Bruce Power RP performance during 2014 [183]:

Based on the information assessed, CNSC staff concluded that the radiation protection SCA [Safety and Control Area] at Bruce A and B met performance objectives and all applicable regulatory requirements. As a result, each station received a “satisfactory” rating, which is unchanged from the previous year.

Application of ALARA

Bruce Power continued to implement a well-documented and mature as low as reasonably achievable (ALARA) program. CNSC staff have verified that Bruce’s five-year collective radiation exposure dose projection and reduction plans includes dose reduction initiatives, which are continuously monitored.

In 2014, CNSC staff conducted a focused inspection on ALARA planning and control at Bruce Power. CNSC staff noted an overall improving trend in the area’s performance, including extensive work planning and implementation of several ALARA initiatives resulting in dose savings. CNSC staff identified a few areas for improvement during this inspection and Bruce Power is addressing these. CNSC staff found that application of ALARA at Bruce Power meets regulatory requirements.

Worker dose control

Bruce Power continued to comply with the regulatory requirements to measure and record doses received by workers. Routine compliance verification activities indicate that performance in the area of worker dose control at Bruce A and B is effective. In 2014, no worker or member of the public received a radiation dose in excess of the regulatory dose limits or action levels established in Bruce Power’s radiation protection (RP) program…

Radiation protection program performance

Bruce Power’s RP program performance meets the requirements of the *Radiation Protection Regulations.* RP program documents and supporting procedures are maintained in terms of industry best practices. The oversight applied by Bruce Power in implementing and improving the RP program has been effective in protecting workers at Bruce A and B. Routine compliance verification activities indicate that Bruce A and B are effective in the area of RP program performance.

Radiological hazard control

No action levels were exceeded for surface contamination at either Bruce A or Bruce B in 2014. Routine compliance verification activities indicate that performance in the area of radiological hazard control at Bruce A and B is effective.

7.4. Performance Indicators

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

The radiation protection “performance indicators were defined by the RP Peer Group and selected to align with CANDU Owners Group (COG) Guideline GL 2013-01 (Rev 0): Common COG Radiation Protection Performance Indicators” (Appendix B, [58]).

The RP Program documentation requires that Bruce Power monitor the following radiation protection performance indicators:

- Non-compliances
- Personal contamination events
- Radioactive material control
- Dose control (outage and online)
- Facility/operational dose
- High radiation area events

More specific dose and PCE targets are also established in the Bruce B 2016 Operational Excellence Plan [184].

With respect to regulatory reporting, Bruce Power submits quarterly reports of Performance Indicators to the CNSC, in compliance with CNSC REGDOC-3.1.1. These quarterly reports include data on radiation occurrences and radiation doses.

"Bruce Power lead *[sic]* a COG team in 2013 and developed the CANDU standard metric based upon the WANO recommended metrics for PWR/BWR. These metrics had their first full year in service in 2014 and have been accepted by the CNSC as the reporting standard for [REGDOC] 3.1.1" (Section 2.1, [155]).

In addition to the performance indicators monitored by Bruce Power, the CNSC produces an annual report on the safety performance of Canada's Nuclear Power Plants (NPPs). The report for 2014 assigns a "satisfactory" rating[22] for both Bruce A and Bruce B radiation protection [183], unchanged from the previous three years.

8. Summary and Conclusions

The overall objectives of the Bruce B PSR are to conduct a review of Bruce B against modern codes and standards and international safety expectations, and to provide input to a practicable set of improvements to be conducted during the MCR in Units 5 to 8, as well as U0B, 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, as defined in Appendix A of CNSC REGDOC-2.3.3, is to determine:

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

[22] The CNSC can assign ratings of "Fully Satisfactory", "Satisfactory", "Below Expectations" or "Unacceptable". "A rating of 'Satisfactory' indicates that the licensee's safety and control measures are effective ..."

This objective has been met by the completion of the review tasks specific to RP as described in Section 1.2.

Bruce Power has a mature and comprehensive radiation protection program that, by 2009, had begun to show the effects of aging and lack of maintenance. This contributed to the loss of RP controls observed during the 2009 Alpha Contamination Incident. Since that time, Bruce Power has made progress in addressing the deficiencies through RP improvement and excellence programs (see Section 4.2). Bruce Power recognized that significant change was required in all areas of RP at Bruce Power, and acted on this by developing extensive RP improvement initiatives and significantly reorganizing the RP Department at each of the Bruce Power facilities.

Bruce Power has since achieved top ranked status for CRE in North America [125]. This industry-leading CRE performance has been identified as a strength in performance.

It is clear from this review that Bruce Power has addressed many of the programmatic deficiencies that were identified prior to 2013, however, a few remain. Table 7 summarizes the key issues arising from the Periodic Safety Review of Safety Factor 15.

Table 7: Key Issues

Issue Number	Gap Description	Source(s)
SF15-1	ALARA Program The ALARA Program documentation is inconsistent and lacking some recommendations made in the guidance in the areas of: conduct of ALARA Committees; ALARA incentive program; and Radiation Exposure Permits. There is misalignment between ALARA planning and outage planning target dates.	Section 5.1.1 Micro-gaps against WANO GL 2004-01 guidance clauses: I.C5 (Gap 1) V.C1 (Gap 1) V.C2 (Gap 1) VII.C2 (Gap 1, Gap 2)
SF15-2	Radiological hazard control There are noted discrepancies against the guidance in the following areas of the radiological hazard control program: LHRA controls; airborne radioactivity; and restriction of contamination prone materials in the controlled area.	Sections 5.1.2 and 5.1.3 Micro-gaps against WANO GL 2004-01 guidance clauses: III.C1 (Gap 1) IV.C2 (Gap 1) VI.C2 (Gap 1) VI.C3 (Gap 1, Gap 2)

Issue Number	Gap Description	Source(s)
SF15-3	RP equipment and Instrumentation There are noted gaps in the adequacy and condition of RP equipment and instrumentation when compared against the WANO recommendations and REGDOC-2.3.3 RP review tasks.	Section 5.2.2 Programmatic Gaps (Gap1, Gap 2) Effectiveness Gap (Gap 1) Micro-gaps against WANO GL 2004-01 guidance clauses: VI.C2 (Gap 2, Gap 3, Gap 4, Gap 5)
SF15-4	Organization and administration There are instances of ineffective use of the action tracking process to address RP issues.	Section 5.4.1 Effectiveness Gap (Gap 1)
SF15-5	RP Program Documentation There are instances of ineffective management of RP Program standards, and current RP practices are not always documented in RP Program governance: RP Manager roles; reporting lower-level significance OPEX externally; dose reporting requirements; dismantling objects to survey inaccessible surfaces for contamination; confirmation that there is no unexpected dose received outside the Controlled Area; back-out criteria for DRPs and airborne particulates; gamma sensitive whole body monitors at RCA exits; training on the use of CATS.	Section 5.6.1 Micro-gaps against WANO GL 2004-01 guidance clauses: I.C2 (Gap 1) I.C4 (Gap 1)

The following provides details on gaps that were identified during the course of this assessment and summarized in Table 7:

1. **ALARA Program (SF15-1) –** The ALARA Program documentation has not addressed several recommendations made in the WANO guidance and there is misalignment between ALARA planning and outage planning dates.
    - The Bruce B ALARA Committee TOR [116] does not include reference to BP RPP-00044 [27], the required meeting agenda items, or timelines for minute distribution. The Bruce B ALARA Sub-committee TOR [117] does not include reference to BP-RPP-00044 [27] or timelines for minute distribution.
    - There is no documented program whereby dose goals are included as part of an incentive program at Bruce Power.

- The difference between general and specific REPs is not clearly described in the RP Program documentation.
- There is misalignment regarding planning dates between BP-RPP-00011, Requirements for Planning Radiological Work [75] and BP-PROC-00342 Sheet 001, Planned Outage – Preparation Milestones [119].

2. **Radiological Hazard Control (SF15-2) –** There are noted discrepancies against the guidance in areas of the radiological hazard control program.
   - There is no LHRA program to control access to areas with gamma dose rates greater than or equal to 1 rem/h [0.01 Sv/h] at 30 cm.
   - BP-RPP-00023 [88] has not been revised to include actions that should be taken upon first discovery of airborne radioactivity to contain it.
   - There is no procedural requirement to avoid the use of materials that can accumulate fixed contamination in the radiologically controlled area.
   - There is no requirement that all HEPA unit, vacuum cleaner, and hose openings be securely covered to prevent the spread of contamination when not in use.
3. **RP equipment and instrumentation (SF15-3) –** There are programmatic gaps regarding lifecycle management of FAGMs and EPDs and identification of the person responsible for the management of EPDs. There are instances of ineffective implementation of the RP instrumentation program in order to maintain instrumentation. There are noted gaps in the adequacy and condition of RP equipment and instrumentation when compared against the WANO recommendations and REGDOC-2.3.3 RP review tasks.
   - The whole-body monitor alarm set points have not been evaluated with respect to the WANO guidelines and a procedure revision made if appropriate.
   - There is a discrepancy between the RP program and the guidance with respect to whole body monitor alarm test frequency.
   - There is a discrepancy against the guidance with respect to using a check source for whole-body monitors that approximates the station isotopic mix.
   - Periodic contamination monitor challenges are not required as recommended in the guidance.
   - There is a discrepancy against the guidance regarding portal monitor alarm set points.
4. **Organization and Administration (SF15-4) –** There are instances of ineffective use of the action tracking process to address RP issues.
5. **RP Program Documentation (SF15-5) –** RP Program documents do not always accurately or fully describe RP practice. This is in part due to the recent rapid improvement in RP practices. Examples are summarized in Table 7 and listed in detail in Section 5.6.

Based on this review, it is concluded that RP at Bruce B principally complies with:

- The requirements of CNSC G-129;
- The requirements of CNSC G-228;
- The requirements of REGDOC-2.3.3, with the exception of the gaps identified under SF15-3; and
- The most recent guidance provided in WANO GL-2004 Revision 1, with the exceptions of the gaps identified in Table 7.

9. References

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

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

The stated purpose of CNSC Regulatory Guide G-129 [31] is to help, "persons regulated by the Canadian Nuclear Safety Commission (CNSC), when implementing a radiation safety protection program, to keep the … effective dose and equivalent dose received by and committed to persons as low as reasonably achievable, social and economic factors being taken into account (ALARA)."

The document achieves that purpose by describing measures that regulated persons can take to keep doses ALARA. The measures that it describes are general and high-level.

In Clause 6.0 of the Regulatory Guide, it is stated that, "Managers should review dose levels on a continuous basis to ensure they are ALARA."

According to the ALARA Program BP-RPP-00044, Section 4.1, the Site ALARA Committee meets at least quarterly, and the Station ALARA Committee meets at least monthly to review dose performance compared with the 5 Year Dose Reduction Plan. Section 7.2 requires that Responsible Managers periodically review distribution of doses to identify trends and implement actions to ensure that doses are maintained ALARA.

G-129, Clause 7.1.1 notes that, "all levels of management, in particular the senior level of the organization, commit to a policy of safety and good radiation protection in order to keep all doses ALARA."

It is the policy of Bruce Power, as stated in Appendix A of the Management System Manual BP-MSM-1 under Radiation Protection Management, that:

> Bruce Power shall strictly control occupational and public exposure below regulatory limits and As Low As Reasonably Achievable (ALARA).
>
> Bruce Power shall manage and control the movement of people and materials to prevent the release of contamination from site in accordance with Canadian regulation and standards associated with contamination control and radiation protection.
>
> Bruce Power shall strive to achieve high standards of radiation protection performance as compared to industry leading practices and WANO GL2004 1.

The RP organization is described in Section 4.1 of the Radiation Protection Program BP-PROG-12.05. It assigns overall responsibility to the President and CEO of Bruce Power, and specific responsibilities to all lower levels of management. The Site ALARA Committee comprises members of senior management, including the Chief Nuclear Officer (CNO), Station Senior Vice Presidents (SVPs), SVP of Outages and Maintenance, VP of Nuclear Operations Support, Department Manager, Safety Programs, and Responsible Managers. The Station ALARA

Committee is chaired by the Plant Manager and includes senior management representatives from each of the major departments that either receives dose or affects radiation exposure.

G-129, Clause 7.1.2 recommends that management, “should periodically inspect the workplace to observe, first-hand, workers’ adherence to the established radiation protection and conventional safety practices.” It goes on to recommend that management regularly receive, “summary reviews of the effectiveness of the radiation protection program and practices being implemented in the workplace.”

The procedure Oversight of Radiological Work, BP-RPP-00040, requires Line Managers to conduct observation and coaching of their workers to ensure effective implementation of the RP Program. According to the ALARA Program BP-RPP-00044, the Station ALARA Committee reviews progress against ALARA Plans and the 5 Year Dose Reduction Plan. In addition, the Department Manager, Safety Programs, has the responsibility to ensure that a self-assessment is performed on the ALARA Program at least every two years. Section 4.2 of the Radiation Protection Department Fundamentals BP-PROC-00581 is explicit:

Execution of sound fundamentals requires that supervisors and managers ensure effective performance of fundamentals by:

1. Observing work practices first-hand.

2. Providing ongoing communication and feedback using observations, traveling file entries, and daily interface.

3. Identifying and evaluating event precursors, indicators and trends from diverse sources such as traveling files, Corrective Action Program (CAP), Scorecards; taking proactive corrective actions as required.

4. Executing formal training.

5. Conducting fundamental self-assessments.

G-129, Clause 7.2 deals with personnel qualification and training, and advocates commitment to radiation safety by all workers, and relevant and adequate training for all personnel including management.

Section 4.2 of the RP Program, BP-PROG-12.05, gives an overview of RP qualifications and training. All radiation workers are required to have a level of RP training commensurate with their duties, and RP staff require training at a higher level. Failure by a worker to perform according to the RP program standards and requirements may lead to a loss of their qualification. Detailed responsibilities of workers performing radiological work are given in Section 7.15, including that they perform work in compliance with the RP Program.

G-129, Clause 7.3.1 addresses the need for appropriate resources, including staff, equipment and facilities, to adequately control doses.

The Management System Manual, BP-MSM-1, in Section 7.4 gives the Bruce Power Executive Team responsibility, “To ensure that adequate, suitably qualified and experienced persons, and other necessary resources, are identified and are available.” The corporate commitment to maintain doses ALARA is expressed in the Radiation Protection Management policy, quote above.

G-129, Clause 7.3.2 advises regular review of dose records and other appropriate indicators to ensure that doses are ALARA. The reviews should identify trends that will show the effectiveness of dose reduction efforts. It notes that, "Justification is required for any proposal involving a predicted increase in worker doses."

Section 4.1.4 of the RP Program, BP-PROG-12.05, states that, "ALARA Committees review performance against dose targets and goals in accordance with BP-RPP-00044. Their objective is to drive performance to be better than target." Under the ALARA Program, BP-RPP-00044, Responsible Managers are responsible to periodically review, "distribution of doses at their facility/project to identify trends and implement actions to ensure doses are maintained ALARA" (Section 7.2.6).

G-129, Clause 7.4.1 advocates the use of radiological work plans for work in areas where workers may accumulate significant dose. The work plans should include:

- Radiological surveys of the area in advance of the work
- Estimates of exposure times
- Dose estimates
- Identification of protective equipment and clothing to be used
- Actions to be taken in case the anticipated dose or dose rate is exceeded.

The work plans should be reviewed by management, RP staff and those conducting the work before and after the work is done. Approval of the work plan should involve a level of management higher than the level that is supervising the work.

The requirements for planning radiological work at Bruce Power are described in BP-RPP-00011. These may include both a Radiological Exposure Permit and an ALARA Plan, depending on the radiological risk associated with the work. The level of approval of both types of plan increases with increasing risk, with higher-risk work requiring approval by RP staff, up to and including the Authorized Health Physicist. The procedure Executing Radiological Work BP-RPP-00041 describes the requirements for both pre-job briefs and post-job ALARA reviews. Both require the participation of the workers involved.

G-129, Clause 7.5 comprises other measures that should be considered. It includes clear and complete documentation of the radiation protection program, and setting radiological performance targets against which results are subsequently reviewed.

Bruce Power has a well-developed governing document structure for radiation protection, as illustrated in Appendix B of the RP Program BP-PROG-12.05. The process for developing the 5 Year Dose Reduction Plan is described in Section 4.2 of the ALARA Program BP-RPP-00044, and establishing dose goals and targets is described in Section 4.3. Additional radiation protection performance indicators are defined in SEC-RPR-00012.

G-129, Clause 8.0 provides some general guidance on what might be reasonable in implementing the ALARA principle.

No gaps with respect to CNSC G-129 were identified in this high-level review.

A.2. CNSC G-228, Developing and Using Action Levels

CNSC G-228 [32] 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 4.0, Action Levels for Radiation Protection, discusses the slightly different definitions of "action level" contained in the *Radiation Protection Regulations* and the *Uranium Mines and Mills Regulations*. The definition that is relevant to the present assessment is that an AL is "a specific dose of radiation or other parameter that, if reached, may indicate a loss of control of part of a licensee's radiation protection program, and triggers a requirement for specific action to be taken."

Clause 5.0, Understanding Action Levels, provides guidance on the purpose of ALs, and the parameters for which ALs may be set.

Clause 6.0, Developing, Using and Revising Action Levels, provides a step-by-step process for developing and using ALs. It stipulates that, "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, it 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.

Clause 7.0, Monitoring, discusses the need for suitable methodology to monitor the parameters to which the ALs apply.

Clause 8.0, Responding When an Action Level Is Reached, spells out the process a licensee is to follow when an AL has been exceeded.

The Bruce Power procedure SEC-RPR-00022, Action Levels [26], defines ALs for radiation protection and describes the process to change an AL. These ALs were developed using the guidance of G-228, have been accepted by the CNSC, and are reflected in Licence Condition 7.1 (Section 3.2.1) of the PROL. This Licence Condition also stipulates that Bruce Power notify the CNSC within seven days of becoming aware that an AL has been exceeded. Any changes to ALs require formal correspondence with the CNSC, and must comply with G-228.

Bruce Power's RP Program documentation meets the requirements of CNSC Regulatory Guide G-228.

Appendix B – Review Against Codes and Standards

This appendix presents the clause-by-clause assessments that are performed for this Safety Factor. The PSR Basis Document provides the following compliance categories and definitions for clause-by-clause assessments:

- Compliant (C) – compliance has been demonstrated with the applicable clause;
- Indirect Compliance (IC) – Compliance has been demonstrated with the intent of the applicable clause;
- Acceptable Deviation (AD) – Compliance with the applicable clause cannot be demonstrated; however, a technical assessment has determined that the deviation is acceptable. For this case a detailed discussion and explanation shall be included in the PSR documentation;
- Gap – system design and/or operational improvements may be necessary;
- Guidance: A potential programmatic, engineering, analytical or effectiveness gap found against non-mandatory guidance;
- Relevant but not Assessed (RNA) – The PSR Basis Document defines RNA as "the particular clause provides requirements that are less strenuous than clauses of another standard that has already been assessed". The definition also includes the guidance portion of clauses in which a gap has already been identified against the requirement;
- Not Relevant (NR) – The topic addressed in the specific clause is not relevant to the safety factor under consideration but may well be assessed under a different Safety Factor; and
- Not Applicable (NA) – The text is not a clause that provides requirements or guidance. Also used if the clause does not apply to the specific facility.

B.1. Review Against WANO GL 2004-01 Rev 1

In support of the review tasks listed in Section 5, a detailed assessment of WANO GL 2004-01 Rev 1 has been performed in Table B-1.

Table B-1: WANO GL 2004-01 Rev 1, Guideline for Radiological Protection at Nuclear Power Stations

Article No.	Clause Requirement	Assessment	Compliance Category
I.C1.	Radiological protection managers positively reinforce, through consistent words and actions, an atmosphere that firmly establishes radiological health and safety as a high priority and part of the core business activities. Radiological health and safety issues receive the attention warranted by their importance. Other station organisations, such as Maintenance, Operations, Chemistry and Engineering, are aligned to support radiological protection and take ownership for their radiological performance. Radiological protection managers foster an environment of continuous learning and improvement. Programmes and processes are continually evaluated to improve radiological safety, optimise work processes, increase process efficiencies and incorporate industry best practices. Radiological protection managers emphasise the following: o Accurate and effective communication of radiological risk; o Effective vertical and horizontal	Programmatic: Compliant Radiological Culture In Section 1.0, the Radiation Protection (RP) Program [BP-PROG-12.05] establishes and implements processes to ensure, "the achievement of high standards of RP performance in accordance with industry best practices and the WANO [World Association of Nuclear Operators] Guidelines for Radiological Protection at Nuclear Power Plants [WANO GL 2004-01, Rev. 1]" Later, in Section 4.1.1 it states that the "...DM, RP Programs provides oversight of the implementation of this program through monitoring and ensuring performance standards are met, identifying gaps in performance and driving towards standardized industry best practices." This demonstrates a programmatic emphasis on continuous learning, improvement and striving to align with industry best practice. Areas for continuous improvement are identified through program oversight, independent audits and peer reviews. Section 1.0 of the RP Program also states, "Radiation protection (safety) is one of the four pillars of nuclear safety which supports a healthy nuclear safety culture. This	C

Article No.	Clause Requirement	Assessment	Compliance Category
	communications; o Professionalism at all levels of the organisation; o Adherence to high standards; o High-quality procedures; o Training to improve performance; o Programme ownership; o Accountability for results; o Constructive relationships between managers and employees; o Qualified professional radiological protection staff. Senior station and corporate managers develop and implement a radiological protection strategy and philosophy that promotes a strong radiological health and safety culture. Recommendation 1 of WANO SOER 2001-1 addresses the importance of the senior management commitment to supporting the radiological protection programme. This includes establishing the expectation that each individual is personally responsible for their own radiological safety and compliance with radiological protection procedures and requirements. The credibility of the radiological safety message from both station and corporate management depends largely on management decisions that exemplify the principles of the message. Maintaining credibility	Program is designed to embrace and contribute to the principles of nuclear safety..." This demonstrates a programmatic focus on strong safety culture. Section 4.1.1 of the RP Program defines the organization framework for the management of RP at Bruce Power and establishes responsibility for the program at all levels within the company, including the highest levels of management. Managers are required to "...ensure high standards of radiation protection are adopted in their organizations, and also accept responsibility for their organizational radiation protection performance." Section 4.1.1 of the RP Program states, "All workers performing radiological work are responsible for the safe conduct of radiological work in accordance with the instructions they have been provided, and have the authority to stop work or prevent the initiation of work that could result in a violation of this Program, radiation protection standards or procedures, unplanned radiation dose, or that which could otherwise endanger personnel. This is further described in BP-RPP-00041, Executing Radiological Work." This demonstrates that the RP Program meets the guidance principle that each individual is personally responsible for their own radiological safety and compliance with radiological protection procedures and requirements. Section 4.1.1.1 of the RP Program describes the roles and responsibilities of the Authorized Health Physicist (AHP). "An AHP must be trained, qualified, and certified under the PROLs in accordance with the requirements of CNSC Regulatory Guide, RD-204, Certification of Persons Working at Nuclear Power Plants. AHPs are selected, developed, and certified in accordance with SEC-RPR-00023, Certification of	

Article No.	Clause Requirement	Assessment	Compliance Category
	requires strong reinforcement of radiological safety when decisions are made that affect cost, production, and schedule. High radiological safety standards and a clear vision of excellence are internalised and used to align the radiological protection of staff and nuclear workers. Key values and behaviours include the following: o Maintaining a great respect and sense of responsibility for the potentially hazardous radiation source term contained within the reactor core, spent fuel pool, and dry fuel storage containers; o Assuming responsibility for the radiological health and safety of station workers and the public, including maintaining individual and collective dose as low as reasonably achievable (ALARA); o Making decisions and taking actions that ensure radiological health and safety; o Taking prompt, decisive and conservative actions appropriate to the significance and scope of radiological safety issues; o Engaging the support of other station groups needed to achieve a high level of radiological health and safety; o Challenging decisions at all levels, when	an Authorized Health Physicist, and trained in accordance with TQD-00075, Health Physicist, Authorized Health Physicist Training and Qualifications Description, an implementing document of BP-PROG-02.02 ... AHPs shall attend continuing training to maintain job performance capabilities while developing a broader scope and depth of position specific knowledge and skills, in accordance with BP-PROC-00667, Certification Training - Conduct of Continuing Training for Authorized/Responsible Health Physicists, an implementing document of BP-PROG-02.02, Worker Training and Qualification." Section 4.2 of the RP Program describes RP Qualifications and Training more generally, and identifies the specific Training and Qualification documents applicable to the Health Physicist, Authorized Health Physicist and Radiation Protection Technician. These requirements indicate that Bruce Power programs require qualified professional radiological protection staff. [BP-PROC-00581] and [BP-PROC-00819] both set expectations for performing, assessing and reinforcing the RP fundamentals which "support leaders by specifying 'what good looks like'...The implementation of Fundamentals supports nuclear safety and contributes to WANO [World Association of Nuclear Operators] Principles for a Strong Nuclear Safety Culture, in particular... 'Everyone is Personally Responsible for Nuclear Safety'" (Section 1.0, BP-PROC-00581). This demonstrates that Bruce Power programs and procedures provide guidance and requirements regarding high standards for safety culture and implementation. A Focus Area Self Assessment (FASA) was performed on supplemental RP staff worker fundamentals in June 2015	

Article No.	Clause Requirement	Assessment	Compliance Category
	appropriate; o Fully understanding the consequences and radiological safety impact of actions prior to execution; o Stopping in the face of uncertainty and resolving questions before proceeding; o Being self-critical and open to constructive feedback in the spirit of continuous improvement; o Ensuring the radiological protection organisation is led by highly qualified radiological protection professionals. Refer to WANO GL 2006-02 Principles for a Strong Nuclear Safety Culture for additional information.	[SA-RPR-2015-04]. Three adverse conditions were identified, and corrective actions to address them were established. One of those actions [AR 28505201-06] involves development and implementation of a revision to Appendix A of [BP-PROC-00581], Radiation Protection Department Fundamentals (due July 30, 2016). The other two adverse conditions are addressed in assessments done under other clauses.	
I.C2.	A unique by-product of nuclear electric generating station operations is the creation of highly radioactive material. If not controlled carefully, this material can adversely affect the health of individuals exposed to hazardous levels of radiation, contaminate station areas and the environment and inhibit plant access for operations and maintenance work. The radiological protection manager holds a position of major responsibility and trust for the health and safety of nuclear workers, the public, and the environment. Foremost, this manager	Programmatic: Gap Leadership in Station Radiological Protection Activities The RP Program [BP-PROG-12.05] describes RP Management Roles, Responsibilities and Expectations in Section 4.1: "The DM [Department Manager], RP Programs manages the development and approves site-wide radiation protection procedures, standards and processes (known collectively as the RP Program) in compliance with regulatory requirements and consistent with excellent standards of performance. The DM, RP Programs benchmarks this	Gap

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	provides leadership by setting high standards for performance and technical excellence, while creating a safety culture with a conservative approach to radiological health and safety. The radiological protection manager is an advocate for radiation safety. This individual's values, beliefs, and advocacy for radiological safety-as demonstrated by words and action-will shape the radiological protection organisation's beliefs and performance (and, more broadly, overall station performance). The radiological protection manager advises station management on radiological risk and consequences and champions initiatives that will reduce the radiation source term and minimise collective dose. The effective implementation of radiological protection activities crosses organisational boundaries. Due to this, the radiological protection manager will instil ownership for performing radiological protection activities to high standards throughout the station organisation. These guidelines can help the manager make decisions that will have a positive, long- lasting effect on the operation of the nuclear plant and result in increased radiological health and safety. The best utilities are not satisfied with the status quo, but frequently seek out the best industry practices, set challenging goals, monitor and measure, and then provide positive reinforcement to continually improve overall performance.	Program against programs of the best in the industry and against WANO Radiation Protection Program objectives, and also analyzes Operating Experience (OPEX) for its applicability. Based on the benchmarking results, the Program is improved accordingly and continually... The DM, RP Programs provides oversight of the implementation of this Program through monitoring and ensuring performance standards are met, identifying gaps in performance and driving towards standardized industry best practices. This is achieved through leadership of and challenges to both the RP Peer Group (defined in BP-PROG-01.02, Bruce Power Management System Management), and Authorized Health Physicists (AHPs)." Also in Section 4.1, the RP Program identifies the DM RP Programs as the Corporate Functional Area Manager (CFAM) for radiation protection and the Department Manager, Industrial Safety and Radiation Protection Support as the Site Functional Area Manager (SFAM) at Bruce B. Other responsibilities of the DM, RP Programs are listed throughout the RP Program and summarized in Section 7.13. Some of those responsibilities include: - Ensures the development, revision, and interpretation of the RP Program, and its implementing Procedures. - Benchmarks the RP Program against programs of the best in the industry and against WANO RP Program objectives and analyzes OPEX for applicability. Makes improvements to the RP Program as required to meet objectives. - Provides oversight of the implementation of the RP Program through monitoring and ensuring performance standards are met, identifying gaps in performance, and drives towards	

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		standardized best practices. Determines and implements changes to the RP Program as necessary to address adverse performance. - Leads and challenges the Radiation Protection Peer Group and AHPs. - Defines the governance and oversight requirements for Bruce Power's Dosimetry Program. -Defines the governance and oversight of Bruce Power's Radioactive Material Transportation Program -Selects and recommends individuals for key Safety roles such as RSOs. - Defines and approves RP training requirements, ensuring a training program is in place for RP. - Sets standards for access control system requirements, contamination levels in zones, radiation hazard posting, and approves zoning plans. - Identifies and approves RP instruments and personal protective equipment that can be purchased and used at Bruce Power and establishes the requirements for their lifecycle management. - Sets Exposure Control Levels (ECLs) and Administrative Dose Limits (ADLs). - Establishes a process for managing individual dose ALARA. - Identifies performance indicators to be used to assess the adequacy of performance with respect to best industry practice. - Approves the program for routine radiological surveys for all	

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		facilities/projects and any deviations. - Requests audits of the RP Program and oversees self-assessments of the program. - Sets expectations and standards for reporting and investigating radiological incidents and events; this includes the involvement of the AHP and CNSC notification when applicable. Bruce Power procedure RP Department Fundamentals [BP-PROC-00581] also requires in Appendix A that RP Managers "reinforce, communicate and do not compromise high standards of behaviour." The Bruce Power RP Program provides expectations for the role of RP Manager that are aligned with WANO guideline Clause I.C2: a position of major trust and responsibility that pursues continual improvement and drives other leaders in the organization to uphold high RP standards. It is not clear, however, which individuals fill the RP Management roles that are responsible for the items listed above. The RP Program refers to the "RP Programs Department Manager" - a position that is no longer identified by that title. Effective September 2014, the Radiation Protection Programs Department and the Industrial Safety Programs Department were merged to create the Safety Programs Department [NK29-CORR-00531-12619]. The Bruce Power MSM Program Matrix [BP-MSM-1, Sheet 0001] and the Approved Reference Chart Authorities and Responsibilities [BP-MSM-1, Sheet 0002] identify the Department Manager Safety Programs as the CFAM for the RP Program. The RP Program document and the majority of its implementing documents, however, identify the CFAM for	

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		the program as the Department Manager, Radiation Protection Programs; a role that does not exist in the MSM. Similarly, the SFAM for Bruce B is identified in the RP Program as the Department Manager, Industrial Safety and Radiation Protection Support, while the MSM documents identify the SFAM as the Bruce B Radiation Protection & Industrial Safety Department Manager. There is a gap in the effective identification of the individual and role associated with the responsibilities of the RP Manager as identified in the WANO guideline. **Gap 1** This particular clause of the WANO guideline also specifies that "The effective implementation of radiological protection activities crosses organisational boundaries" (Clause I.C2). This is addressed in Section 4.1 of the RP Program through the establishment of a CFAM and SFAMs for the program. The CFAM and the SFAMs form the RP Peer Team. The Bruce Power Governance, Oversight, Support and Perform (GOSP) Implementation Handbook [B-HBK-08130-00001] provides definitions for the roles of the CFAM, SFAM and the Functional Area Peer Group, in this case the RP Peer Group. Section 1.0 states "the CFAM is responsible for governance and oversight of the Programs and processes in the Functional Area. The CFAM looks at leading practices outside of Bruce Power in order to define excellence within Bruce Power. The SFAM is responsible for performance according to the established Programs and processes within the Functional Area. The CFAM and SFAMs collaborate via the Functional Area Peer Group." Section 4.7 of the handbook goes on to state "Peer Groups provide a forum for the CFAM and SFAM peers to collaborate on issues with respect to the Functional Area. If	

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		disagreements cannot be resolved through the Peer Group, these issues shall be escalated…" Appendix E of the handbook provides a list of good practices for Peer Groups including: "The CFAM ensures knowledge transfer and initiative coordination between sites."	
I.C3.	Radiological protection managers and supervisors define and communicate clear expectations for radiological work performance to station personnel. They require the involvement of line management in day-to-day radiological work planning and execution, to ensure worker safety. Radiological protection managers and supervisors monitor personnel performance, measure against expectations, assess, correct the cause(s) of performance weaknesses to eliminate repeat problems and coach personnel to achieve the desired behaviour. They hold workers and their supervisors accountable for radiological work performance. Managers establish and clearly communicate short- and long-term strategic direction and priorities.	Programmatic: Compliant Management Activities The document Radiation Protection Department Fundamentals [BP-PROC-00581] details in Appendix A the behaviours expected of RP Department management and staff. For RP managers, these include: "Reinforce, communicate and do not compromise high standards of behaviour." "Ensure department activities and performance are monitored and shortfalls in meeting expectations are evaluated and addressed promptly." "Personally observe activities, coach, mentor, and reinforce expectations and standards." "Encourage and support personnel to identify and take initiative to improve performance." "Coach and mentor personnel, conduct frequent field observations." "Demonstrate commitment to improve station radiological	C

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		performance and to achieve station goals and objectives." For RP First Line Managers (FLMs), relevant behaviours are: "Ensure high standards for procedure work plan use and adherence." "Model, implement, and reinforce policies, procedures and practices that reflect a strong commitment to radiological safety." "Monitor and coach to improve performance of workers and RP Technicians." Section 4.4 of the RP Program [BP-PROG-12.05] describes the Bruce Power ALARA Program [BP-RPP-00044] which "identifies planning strategies to control dose and minimize exposure As Low As Reasonably Achievable at Bruce Power to meet the requirements outlined in CNSC Regulatory Guide G-129, Keeping Radiation Exposures and Doses 'As Low as Reasonably Achievable (ALARA)'. In order to achieve this, the following processes, defined in BP-RPP-00044 and associated procedures are in place to ensure effective ALARA planning prior to work execution: 1. ALARA Program Management. 2. A 5 Year Dose Reduction Plan. 3. Processes for establishing dose goals and targets consistent with the 5 year dose reduction plan. 4. Standards and processes for managing individual doses below exposure control levels and ALARA. 5. Pre-work ALARA planning, including the preparation and control of Radiation Exposure Permits (REPs).	

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		6. Work-in-Progress and Post-Job Reviews. 7. Processes for managing dose reduction/ALARA initiatives." The Bruce Power ALARA Program [BP-RPP-00044] further elaborates on each of the items listed above (some excerpts provided below): Section 4.1, ALARA Program Management: "The ALARA Program is developed by the Department Manager (DM), Safety Programs with input from Responsible Managers, Authorized Health Physicists (AHP), Radiation Safety Officer (RSO) and ALARA Health Physicists (ALARA HP). "Responsible Managers implement the ALARA program at their facility/project and provide ALARA HPs, AHPs and/or RSO as resources in support of ALARA at their facilities/projects." Section 4.2, 5 Year Dose Reduction Plan: "The 5 Year Dose Reduction Plan summarizes current activities being utilized for dose reduction and provides senior management a road map for future exposure reduction initiatives required for Bruce Power to achieve excellence in Collective Radiation Exposure (CRE). "Preparation of the 5 Year Dose Reduction Plan is responsibility of the Responsible Manager for each Station... "The 5 Year Dose Reduction Plan is reviewed and approved by the Station ALARA Committee and is implemented by the Plant Manager. The Site ALARA Committee provides oversight on the implementation of the 5 Year Dose	

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		Reduction Plans. "Through the calendar year progress of approved ALARA dose reduction initiatives will be reviewed against the 5 Year Dose Reduction Plan by the Station and Site ALARA Committees and their status tracked through meeting actions and minutes referencing the corresponding project (i.e., via CD#) or action request (AR). "The 5 Year Dose Reduction Plan is required to be revised annually based on updated ECLE Plans, outage schedules and new initiatives and may require updating prior to the one year if there are significant changes to either inputs throughout the year." Section 4.3, Establishing Collective Radiation Estimates and Dose Goals: "In order to improve performance in CRE, dose goals and targets are established and performance against these measured at various levels of the organization in accordance with SEC-RPR-00012, Radiation Protection Performance Indicators. "Business plan dose targets are prepared by the Responsible Manager and approved and by the Station ALARA Committee and the CNO [Chief Nuclear Officer] and are based on the 5 Year Dose Reduction Plans, approved dose reduction initiatives and corporate objectives... "To achieve the business plan goal, Plant Managers shall ensure that the approved dose reduction initiatives are implemented at their facilities/projects. Responsible Managers shall perform a gap analysis to identify factors that affect their facility/project's ability to meet the business plan	

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		goal and present these gaps at Station ALARA Committee meetings to develop action plans to address the identified gaps. "Lower level dose targets are established to provide focus and ownership of dose by work groups performing radiological work and are consistent with the business plan dose target. These lower level dose targets include outage, on line, monthly, work group level and work program level targets. Dose targets are reviewed, approved and tracked at Station ALARA Sub-Committee meetings. "For each of the lower level dose targets, task level dose estimates will be determined by Line and/or RP Assessors of [sic] from approved ALARA Plans... These dose estimates will be reviewed on an ongoing basis by Line Management, ALARA Health Physicists and RP Assessors in order to identify gaps between the estimates and the station business plan dose targets, the need for further dose control efforts, and improvements to the dose estimation process." Section 4.4, Individual Dose Limits and Exposure Control: "In support of keeping Collective Radiation Exposure and individual exposures ALARA, the DM, Safety Programs determines Administrative Dose Limits (ADLs) and Exposure Control Levels (ECLs) for individual exposure which are challenging to the organization..." Section 4.5, Pre-Work ALARA Planning: "Responsible Managers shall ensure the implementation of the radioactive work planning process..." The Bruce Power RP Program and ALARA Program clearly establish the expectations for: performance of radiological	

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		work; involvement of management; monitoring performance; correcting weaknesses; accountability for performance; and communication of short and long-term goals. This WANO guideline clause stipulates "radiological protection managers and supervisors… hold workers and their supervisors accountable for radiological work performance." The Independent Oversight Quarterly Report for Q1, 2015 [B-AQR-01-2015] discovered a "significant gap to excellence"… "currently impacting station performance," in the area of ALARA accountability. SCR 28486676 was initiated to document the issue: "Station Management is not consistently holding workers, supervisors and themselves accountable for their radiological performance in the areas of ALARA planning and dose performance." There are eight SCR assignments, all of which are complete. Since this issue is being tracked and the associated corrective actions are complete the identified lack of ALARA accountability is not identified as a gap as part of this review. As a result of the Independent Oversight Quarterly Report for Q3, 2015 [B-AQR-03-2015], SCR 28510363 was initiated on the topic of ALARA accountability: "Station Management is not consistently upholding expectations and reinforcing behaviours that promote excellence in ALARA practices for radiological safety. As a result, workers are potentially missing opportunities to save additional dose during daily work activities. Contributing, supervisors and workers are not always being held accountable for ALARA reduction practices and are seldom engaged in dose reduction	

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		initiatives on a continuous basis." There are three SCR assignments: two are complete; one is open, not yet accepted and due June 29, 2016. Since this issue is being tracked through an SCR it is not identified as a gap as part of this review.	
I.C4.	a. Management standards Radiological protection managers set high standards and expectations that are incorporated into policies and procedures. Standards and expectations are clear, concise, and relevant. They include expectations for radiological protection personnel to make conservative decisions, take action and implement changes that contribute to worker radiological health and safety. b. Programme monitoring Goals and objectives for the radiological protection organisation should support corporate and station goals and objectives while addressing areas where performance improvements are needed. Radiological protection managers establish measurable, achievable, and challenging radiological protection goals to improve performance. Typical performance indicators, such as those noted below, are used as tools to monitor and trend performance.	Programmatic: Gap Management Standards and Expectations a. Management standards: Gap Bruce Power procedure RP Worker Fundamentals [BP-PROC-00819] sets forth "the expectations for performing, assessing, and reinforcing the Radiation Protection (RP) Fundamentals to ensure RP activities achieve industry best performance. These fundamentals constitute a set of standards and behaviours for RP qualified workers at Bruce Power facilities." The procedure RP Department Fundamentals [BP-PROC-00581] sets forth similar expectations "for the Radiation Protection Department at Bruce Power facilities." In Appendix A, the procedure requires that RP Managers "reinforce, communicate and do not compromise high standards of behaviour." Appendix A of the RP Department Fundamentals further requires the following behaviours (excerpts provided below): RP Technicians:	Gap

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	o Station outage and on-line collective dose; o Unplanned internal dose greater than 0.1 mSv; o Individual and work group dose; o Number of radiological hot spots; o Radiation source term, as measured on out-of-core piping (boiling water reactor radiation assessment and control [BRAC] points; PWR Electric Power Research Institute [EPRI] standard radiation monitoring programme [SRMP]); o Radiation source term, as measured from the station chemistry effectiveness indicator (CEI); o Occurrences of unplanned individual dose above administrative or radiological work permit control levels; o Control of high radiation areas (HRAs), as measured by the number of occurrences of unposted HRAs or unauthorised entries into HRAs; o Leak containment devices installed on contaminated systems; o Amount of recoverable plant area contaminated Exempted areas include the following: - Locked high radiation areas;	"- Demonstrate a culture of safety over production through decisions and actions - Stop work when faced with uncertain or unexpected plant radiological conditions to ensure that workers or the environment are not at risk - Anticipate and question conditions that are out of the ordinary, unexpected, or that could result in unplanned dose or contamination... - Critique performance to identify lessons learned and initiate actions to improve performance... - Maintain a questioning attitude. Recognize when you are uncertain, stop and escalate for resolution" Health Physicists: "- Monitor operating experience, industry best practices and regulatory changes and take action to incorporate into procedures or work plans - Determine and implement controls and barriers to reduce radiological risk - Maintain a questioning attitude to identify opportunities for risk, dose and contamination minimization and engagement to ensure all aspects of radiological risk are considered and controlled - Identify and champion source term and dose reduction initiatives to improve radiological safety performance... - Maintain a questioning attitude. Recognize when you are uncertain, stop and escalate for resolution - Decisions are made using strong technical and industry	

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	- High radiation areas where ALARA comparison of estimated dose savings is less than estimated dose to decontaminate the area; - Areas that by nature are not intended to be decontaminated, such as decontamination rooms, sample sinks, fume hoods and downdraft tables; - Areas posted as contaminated for outage activities several weeks prior to the outage through several weeks following the outage. o Skin and clothing personnel contamination events by EPRI action levels 1, 2, and 3; o Positive whole-body counts; o Instances of uncontrolled radioactive material found either outside the radiologically controlled areas (RCAs) or outside the protected area; o Instances in which contaminated individuals or material were detected at the protected area exit portal monitors; o Electronic dosimeter accumulated dose alarms; o Unanticipated valid electronic dosimeter dose rate alarms; o Human-performance-related improper radiological work practices; o Ratio of self-identified problems versus problems identified by others;	knowledge, input from peers and work groups, and align with the Radiation Protection Program" RP FLMs: "- Maintain a questioning attitude. Recognize when you are uncertain, stop and escalate for resolution" The Bruce Power RP Fundamentals for RP workers and for the RP Department provide clear, high standards and expectations regarding RP knowledge and performance. A selection of some of the specific requirements for different RP roles shows that the RP Department Fundamentals procedure also demonstrates compliance with the intent of requiring RP personnel to use conservative decision making and implement change to improve performance. A FASA was performed on supplemental RP staff worker fundamentals in June 2015 [SA-RPR-2015-04]. Three adverse conditions were identified, and corrective actions to address them were established. One of those actions, AR 28505201-06, involves development and implementation of a revision to Appendix A of BP-PROC-00581 Radiation Protection Department Fundamentals (due July 30, 2016). The other two adverse conditions are addressed in assessments done under other clauses. There are many instances of RP practices not documented in RP program governance, as described throughout this assessment. **Gap 1** b. Program monitoring: Acceptable Deviation The Bruce Power RP Performance Indicators document	

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	o Performance of portable and fixed radiological survey instruments, to include metrics such as calibration and source-check failures; o Performance of the primary dosimeter system, as measured by quality control testing of primary dosimeter reading bias outside the control band; o Radioactive waste volume generation; o Gaseous and liquid effluent activity; o Number of high radiation and locked high radiation areas; o Number of outside radioactive material storage areas that are unprotected from the elements; o Number of personnel dose extensions beyond administrative dose control level. Other performance measures can be developed and used to improve performance in a specified area.	[SEC-RPR-00012]: "… outlines the performance indicators (metrics) used to measure the effectiveness of BP PROG 12.05, Radiation Protection Program, through the application of this program, in the operation of the Bruce Power Site. "The Radiation Protection Program establishes a high standard of measuring, monitoring and identifying gaps in performance to reflect a strong commitment to the nuclear safety program, as one of the four pillars of nuclear safety. "This procedure provides instruction to Radiation Protection (RP) Staff and Line Managers when measuring the performance of BP PROG 12.05, by: 1. Describing each performance indicator and its significance. 2. Defining the requirements for management in determining performance indicators. 3. Identifying the process for setting a target. 4. Defining performance indicator monitoring and reporting criteria. 5. Setting expectations regarding event follow up." Appendix B of [SEC-RPR-00012] lists the RP performance indicators used at Bruce Power. The indicators are categorized under seven headings: Non-compliances; Personal Contamination Events (PCEs); Radioactive Material Control; Dose Control (Online and Outage); Facility/Operational Dose; High Radiation Area Events; Site ALARA. While there are a number of performance metrics defined and tracked according to Bruce Power procedure,	

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		some of those listed in the guidance are not tracked (i.e., number of radiological hot spots, radiation source term, Personal Contamination Incidents (PCIs) at the exit portal monitors, ratio of self-identified versus other-identified problems, performance of PRI, performance of the primary dosimeter system, radioactive waste volume generation, number of Locked High Radiation Areas (LHRAs), number of outside Radioactive Material Storage Areas (RMSAs)). AR 28396465-05 was raised to expand the RP performance metrics to include additional items contained in the Exelon set of metrics (60 parameters). The action has been completed, with a note that the RP performance indicators have been "updated for 2014 based on COG Performance Indicators GL 2013-01: 'Establish CANDU [Canada Deuterium Uranium] standards for RP performance that are based on established standards for RP in the industry (e.g., INPO [Institute of Nuclear Power Operations], NEI [Nuclear Energy Institute], IAEA [International Atomic Energy Agency], ICRP [International Commission on Radiological Protection], etc.) and the development and inclusion of standards that are uniquely related to CANDU operation (e.g. fuel handling, tritium, carbon-14, etc.)'" Adoption of the COG Performance Indicators rather than those specified in the WANO Guideline is an acceptable deviation.	
I.C5.	The radiological protection manager strongly instils and periodically reemphasises principles of radiological health and safety. Pressures to reduce cost must not affect the conservative decisions needed to ensure radiological health	Programmatic: Gap Conservative Decision Making	Gap

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	and safety. Work schedules must not compromise radiation protection standards and controls. Personnel must not feel a sense of pressure to proceed in the face of uncertainty, or to compromise radiological protections standards, to meet schedules. Clearly establish management expectations and guidance for reacting in a conservative manner when faced with uncertain or unexpected radiological conditions. Communicate management's support for conservative decision-making by personal example and in clear, unequivocal terms. Frequently reinforce this through training, observing field activities and coaching. Use industry and plant operating experience to demonstrate vulnerability to similar events. Stress the importance of recognising activities that increase the risk of a radiological event. Reinforce conservative decision-making principles, including the following, to radiological protection personnel at all levels: • Question and validate available information; • Do not proceed in the face of uncertainty; • Involve supervision; • Recognise when degraded conditions exist that could affect radiological health and safety;	Bruce Power procedure RP Department Fundamentals [BP-PROC-00581] sets forth "the expectations for performing, assessing, and reinforcing the Radiation Protection (RP) Fundamentals to ensure RP activities achieve industry best performance. These fundamentals constitute a set of standards and behaviours for the Radiation Protection Department at Bruce Power facilities." Appendix A of the RP Department Fundamentals establishes the behaviours expected of RP Technician, Health Physicists and RP FLMs as described above under Clause I.C4. A selection of some of the specific requirements for different RP roles shows that the RP Department Fundamentals procedure demonstrates compliance with the intent of management clearly communicating the expectation to use conservative decision making: maintaining a questioning attitude; stop in the face of uncertainty; and seeking outside input. As a result of a root cause investigation into a Level 3 PCE, a FASA [SA-RPR-2015-07] was performed in June 2015 to evaluate the strength of risk recognition used by RP Technicians. The assessment determined that since the SCR event, risk identification and recognition among RP Technicians had improved. The observed improvement was said to be associated with the introduction of a "2x2 risk matrix". Continued use and expansion of this risk identification and mitigation tool is recommended in the FASA, but the matrix is not mentioned in the RP Program or supporting documentation. The procedure RP Worker Fundamentals [BP-PROC-00819] sets forth expectations "for	

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	• Gather and analyse information from relevant sources and key stakeholders to clearly define and provide options for problem resolution; • Use all available technical resources, including people off site if necessary; • Critically and objectively consider the short- and long-term radiological risks, consequences and aggregate impact associated with the various decision options; • Develop implementation plans that include contingencies and compensatory measures to maintain and enhance radiological health and safety; • Clearly identify decision-makers and their roles and responsibilities; • Communicate the bases for the decisions throughout the organisation. Refer to the following WANO documents for additional information: • WANO GL 2002-01 Principles for Effective Operational Decision-Making • WANO GP ATL 08-003 Human Performance Tools for Managers and Supervisors	RP qualified workers at Bruce Power facilities." Appendix A of the RP Worker Fundamentals provides the expectations for workers with RP qualification. The Manage the Risk fundamental is particularly applicable to this assessment. Workers with RP qualifications are required to: "- Demonstrate a culture of safety through decisions and actions. - Stop work when faced with uncertain or unexpected plant radiological conditions to ensure that workers or the environment are not at risk. - Anticipate and question conditions that are out of the ordinary, unexpected, or that could result in unplanned dose or contamination. - Have a low threshold for identifying and addressing radiological risk. - Identify, document, communicate, correct, and escalate potential radiological issues." FLMs and Managers are required to: "- Demonstrate safety through decisions and actions - Be intrusive in order to understand risk thoroughly. - Know the standards for responding to abnormal conditions. - Reinforce the expectation that RP workers, when faced with uncertain or unexpected conditions, exercise stop work authority." Appendix A of the RP Worker Fundamentals further requires the following (excerpts provided below):	

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		Yellow Qualified Workers: "- Monitor your work activities closely for changing and unanticipated radiological conditions... - Minimize the potential for unplanned dose by requiring the use of operating experience and detailed planning. - Ensure timely, accurate radiological information, appropriate protective and contingency measures, and back out (stop work) criteria are in place. - Routinely challenge yourself and coach peers to ensure their understanding of radiological conditions and adherence to work requirements." Green Qualified Workers: "- Monitor work activities closely for changing and unanticipated radiological conditions. - Minimize the potential for unplanned dose by requiring the use of operating experience and detailed planning. - Ensure that verbal and written radiological work instructions provide workers with timely, accurate radiological information, appropriate protective and contingency measures, and back out (stop work) criteria. - Routinely challenge and coach workers to ensure their understanding of radiological conditions and adherence to work requirements." FLM/Manager: "- Review radiological surveys. Take care to recognize errors, abnormal results or adverse trends...	

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		- Ensure controls are updated in anticipation of plant changes or in response to emergent changes. - Know the status of key plant activities and current risks. - Personally observe activities, coach, mentor, and reinforce expectations and standards. - Reinforce and recognize quality and safety behaviours. - Routinely challenge and coach workers to ensure their understanding of radiological conditions and adherence to work requirements. - Model and reinforce policies, procedures and practices that reflect a strong commitment to radiological safety. - Ensure RP workers perform all actions with the protection of plant personnel and the public as the number one priority." A selection of some of the specific requirements for different RP roles shows that the RP Worker Fundamentals procedure demonstrates compliance with the intent of management clearly communicating the expectation to use conservative decision making: ensure safety takes precedence over production; maintain a questioning attitude; recognize increased risk; seek input; and include contingencies in work planning. Each RP Procedure contains a section entitled "Roles and Responsibilities", which defines the expectations for each role regarding their RP responsibilities and authorities relevant to the subject of the RP Procedure. This demonstrates that the roles and responsibilities of RP personnel are clearly communicated in the Bruce Power RP program.	

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		Section 4.1.1 of the RP procedure Requirements for Planning Radiological Work [BP-RPP-00011] describes the approvals (decision making authority) required for radiological work planning. Table 1 of [BP-RPP-00011] shows the approvals required for ALARA Plans, based on Total Estimated Dose. In Section 4.1.1.2, Table 2 shows the Radiological Work Hazard Categories and the required approvals. Section 7, Responsibilities, also outlines the approvals designated to the Work Group Supervisor, RP FLM, HP, AHP, Station ALARA Committee and the Station ALARA sub-committee for radiological work planning. Appendix E of the RP procedure Executing Radiological Work [BP-RPP-00041] documents the approvals (decision authorities) required for ALARA Work-in Progress Reviews. Tables 1 through 4 of the RP procedure for Oversight of Radiological Work [BP-RPP-00040] identify those individuals responsible for performing and making decisions regarding various radiological work planning, work preparation, work execution and work completion activities. The Bruce Power ALARA Program [BP-RPP-00044] describes ALARA Committees as forums for discussion of ALARA issues in Section 4.1: "The Site ALARA Committee provides oversight of the Bruce Power ALARA Program. The Site ALARA Committee is chaired by the Chief Nuclear Officer (CNO) and membership includes Station Senior Vice Presidents (SVPs), SVP of Outages and Maintenance, Vice President (VP) of Nuclear Operations Support, DM, Safety Programs and Responsible Managers. The Site ALARA Committee meets at least quarterly.	

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		"Station ALARA Committees provide oversight of the ALARA Program for their facility. The Station ALARA Committee is chaired by the Plant Manager and membership includes senior management representation from each of the major departments that either receives dose or impact radiation exposures and radiation exposure planning. These departments include but are not limited to: Operations, Maintenance, Chemistry, Engineering, Outages, Work Management and Radiation Protection and Industrial Safety. The Station ALARA Committee meets at least monthly and more frequently as required by outage schedules. Areas to be discussed at the Station ALARA Committee meeting include, but are not limited to: ALARA Plan reviews, 5 Year Dose Reduction Plan and 5 Year Dose Reduction Plan action reviews. "Station ALARA Sub Committees, comprised of Section Managers (or lower) from the same departments as the Station ALARA Committee, work to provide oversight, approval and support implementation of ALARA for their facility. The ALARA Sub Committee provides a forum for line ownership of dose, working level input and approval of ALARA Plans for their facility and support for implementation of ALARA initiatives." The ALARA Program provides indirect evidence that communication of RP issues, decisions and the bases for these decisions throughout the organization is achieved through the ALARA Committees. Section 4.1 of the ALARA Program [BP-RPP-00044] also describes the requirements for ALARA Committee Terms of Reference:	

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		"All ALARA Committees are required to have Terms of Reference to define the following: 1. Chair. 2. Membership (name and position). 3. Quorum. 4. Meeting frequency. 5. Roles of members. 6. Required meeting agenda items. 7. Owner of agenda, actions, responsibilities for minutes and timelines for minute distribution." An Action Notice [BRPD-AB-2014-010-AN1] was raised by the CNSC during a Type II inspection regarding the ALARA Committees' Terms of Reference, requiring that they be "clearly defined and documented, consistent with the requirements of BP-RPP-00044; and adhered to in the conduct of ALARA Committee Meetings" (Section 4.2.1). In response to this Action Notice, Bruce Power confirmed that the Terms of Reference for each of the ALARA Committees would be revised accordingly; however no action tracking number is identified. The Site ALARA Committee Terms of Reference now include a statement that the TOR is in alignment with [BP-RPP-00044], and do align with the TOR requirements in that procedure with the exception that timelines for minute distribution are not provided. The Bruce B ALARA Committee Terms of Reference do not include reference to [BP-RPP-00044], the required meeting agenda items, or timelines for minute distribution. The Bruce B ALARA Sub-committee TOR do not include reference to [BP-	

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		RPP-00044] or timelines for minute distribution. The Site ALARA Committee Terms of Reference now includes a statement that the TOR is in alignment with BP-RPP-00044, and aligns with the TOR requirements in that procedure with the exception that timelines for minute distribution are not provided. The Bruce B ALARA Committee Terms of Reference have been revised, but do not include the required meeting agenda items, reference to [BP-RPP-00044] or timelines for minute distribution. The Bruce B ALARA Sub-committee TOR do not include reference to [BP-RPP-00044] or timelines for minute distribution. Nonconformances of the ALARA Committee Terms of Reference with [BP-RPP-00044] and failure of some to include a statement that the conduct of ALARA Committees will adhere to the requirements of [BP-RPP-00044], as committed by Bruce Power together result in a gap. **Gap 1**	
I.C6.	a. Human performance Radiological protection management establishes and reinforces behaviours that promote event-free performance. Minimising human performance errors is key to reducing the frequency and severity of radiological events. In order to progress toward excellent human performance, workers and leaders use error prevention tools routinely, communicate clearly, follow procedures, question assumptions, and seek guidance in the face of uncertainty. Human performance error trends in the corrective action programme are evaluated to determine causes and corrective	Programmatic: Compliant Improving Performance a. Human Performance: Compliant The RP Department Fundamentals [BP-PROC-00581], Section 4.0 references "several fundamental areas that must be considered by all functional areas within Bruce Power. These high level or common fundamentals include the Human Performance focus areas and help determine individual working group or divisional fundamental focus areas." Some of the items included in the Human Performance focus areas are: Radiological Safety; Pre-Job	C

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	actions. The WANO GL 2002-02 Excellence in Human Performance describes individual, leadership and organisational characteristics that have proven successful in promoting excellence in human performance. b. Monitoring and assessing performance Radiological protection managers and supervisors monitor radiological protection performance on a day-to-day basis and perform periodic assessments to identify areas for improvement. Monitoring can be accomplished by many means. These include having managers and supervisors observe radiological work; training sessions; assess the implementation of procedures and policies and perform work area risk assessments. Selected observations of radiological high-risk work activities, such as entries into elevated dose rate fields, should be performed whenever practical. These areas would be monitored by cameras, where available. Radiological high-risk activities should have an increased level of in-field supervisory oversight and approval. Responsible supervisory involvement in the radiological aspect of jobs helps convey management's attitude toward the protection to the workers. Supervisory involvement also enhances the radiological awareness of individual workers. Due to their nature, some areas or jobs always require	and Post-Job Briefs; Procedure Use and Adherence; and Human Error Prevention. The RP Workers Fundamentals [BP-PROC-00819] also lists the Human Performance focus areas, but does not include Radiological Safety as one of the focus areas. By referencing the Human Performance focus areas and their associated programs and procedures, RP management has communicated that during the performance of radiological work personnel are expected to use human performance and error prevention tools and use and adhere to the requirements of Bruce Power procedures. An Independent Oversight Quarterly Report from Q2, 2015 identified an issue related to Radiation Protection Practices, leading to the initiation of SCR 28500400. "Radiation protection and work practices are not consistently being enforced to high standards of performance. This has resulted in instances of poor radiation practices…" There are ten SCR assignments: three are open, not yet accepted (all due in 2016); one is cancelled and the remaining six appear as complete. Since this issue is being addressed through action tracking it is not considered a gap for the purposes of this assessment. Appendix A of the RP Fundamentals procedures [BP-PROC-00819] and [BP-PROC-00581] lists fundamental behaviours expected from personnel in different roles and levels of RP qualification. Fundamental behaviours are listed in the areas of: monitoring radiological conditions; control of radiological work; manage the risk; teamwork and communication; and knowledge. Through the fundamental behaviours described in detail in Appendix A of the RP Fundamentals procedures,	

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	supervisory involvement. These jobs include, but are not limited to, entry into very high radiation areas, fuel pool or reactor cavity underwater work and movement of highly radioactive material. The invitation of qualified individuals from outside organisations for periodic monitoring and self-assessments is recommended. Also, corporate individuals and other groups from outside the station organisation should periodically review and assess station performance in the area of radiological protection. Evaluate performance problems to identify causes, and implement the appropriate corrective actions. Monitoring and assessment by qualified personnel from outside organisations can often provide useful insight for station management. However, this input should supplement line organisation monitoring and self-assessment. Outside organisations should not be relied on exclusively to fulfil the monitoring and assessment function. Use all levels of department personnel in assessing activities, to increase ownership. Benchmarking of best practices at other nuclear stations has proven useful in identifying opportunities for improvement as well as templates for new procedures, training lesson plans, and change management action plans. c. Use of the corrective action programme The number and type of radiological deficiencies	RP management has communicated the expectation that personnel will maintain a questioning attitude and seek guidance when uncertain. b. Monitoring and assessing performance: Compliant The Bruce Power RP Program [BP-PROG-12.05], Section 4.6 discusses "oversight, audits, inspections and assessments" of RP performance against the RP Program. "Responsible and Line Managers provide oversight over the conduct of their work... "External audits or inspections are conducted by organizations outside Bruce Power, such as the CNSC, WANO, Health Canada, as requested by Bruce Power, or the DM, RP Programs or SFAMs, or as required by these external organizations. "In order to regularly assess the adequacy and effective implementation of RP work activities, Focus Area Self Assessments (FASAs)... are performed internally by Radiation Protection staff..." Further, the RP Program indicates in Section 4.1.1 that "independent audits of the RP Program are conducted." The Bruce Power RP Program clearly documents the requirements for: line managers to oversee conduct of their work; periodic assessment and audit of the RP program; and outside assessment of the RP Program. The CNSC issued an Action Notice [BRPD-AB-2014-010-AN2] in 2014 requesting that Bruce Power "develop and implement a corrective action plan to ensure that the	

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	is a measure of station performance in radiological protection and may be an indicator of future performance. The identification and trending of opportunities to improve radiological performance is a management tool. Therefore each station determines the appropriate level of resources devoted to these activities based on actual or potential significance. Stations with a low threshold for identifying and correcting lower-level radiological deficiencies, are more likely to prevent significant radiological events. Radiological deficiencies include violations of radiological protection procedures, work permits, signs or postings and verbal direction from radiological protection personnel. They also include improper radiological work practices that result in, but are not limited to examples such as, personnel skin or clothing contaminations; unnecessary spread of contamination in work areas; unplanned dose or electronic dosimeter alarms; increased worker radiation dose; generation of excessive radioactive liquids or solids; or damaged equipment or instruments. The corrective action programme is used to identify and correct problems. Personnel at all levels and from all work groups are expected to document problems. These deficiencies are trended, and trends are evaluated to determine underlying common themes. Plant management and training managers are informed of the results of these reviews and of the corrective actions	adequacy and effective implementation of the ALARA program is regularly assessed." Bruce Power responded indicating "a corrective action has been initiated to revise BP-RPP-00444, ALARA Program, to include a statement requiring a Focus Area Self-Assessment (FASA) to be performed every two years, as a minimum." This requirement has since been added to the ALARA Program as discussed in Section 7.3 of this report. The Bruce Power procedure Oversight of Radiological Work [BP-RPP-00040] defines the radiological oversight requirements. Section 4.3 of the procedure states that "the Line Manager shall perform observation and coaching of their workers to ensure that all of the expectations for the activities... are met and must correct any deficiencies identified immediately. This oversight involves reviews of work to be conducted, observations in the field of compliance with the requirements of the work, and review of the work once completed. The Line Manager shall be particularly attentive to work that is classified as medium or high hazard work in accordance with [BP-RPP-00011], Requirements for Planning Radiological Work since the potential radiological consequences of this work are higher. [BP-RPP-00040], Section 4.3, says "RP staff will also conduct observation and coaching on these requirements to ensure these are understood and conducted and have the authority to stop work when it is not being conducted safely." This documents the expectation that supervisors will provide oversight of radiological work, including observations of work being executed. The RP Section procedure on RP Field Inspection Oversight [SEC-RPR-00025] lists the responsibilities of the RP FLM	

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	needed to address problems. Implementing lessons learned from radiological protection events can also lead to improved performance. Events that need to be thoroughly investigated and documented include, but are not limited to, the following: • Unauthorised radiation dose exceeds corporate or station administrative dose control levels, or a considerable potential exists for a violation of regulatory limits; • An individual enters the RCA without appropriate dosimetry; • An individual receives unplanned dose of 1 mSv or more; • An individual exceeds the dose allowed by the radiation work permit (RWP); • An individual continues to work after receiving an electronic dosimeter accumulated dose or unanticipated dose rate alarm; • A high radiation area, locked high radiation area, or very high radiation area is found not properly controlled, posted, guarded, or, if required, locked; • Removable surface contamination above procedural levels is found outside the RCA; • Uncontrolled radioactive material is found outside the RCA;	and Technician regarding oversight of compliance with RP requirements. Monitoring requirements for various radiation work activities are provided. While it is not directly stated, the content of this procedure meets the intent that RP FLMs are responsible for monitoring RP performance on a day to day basis. The Bruce Power RP Program [BP-PROG-12.05] states in Section 4.1.1 that "The DM, RP Programs benchmarks this Program against programs of the best in the industry and against WANO Radiation Protection Program objectives, and also analyzes Operating Experience (OPEX) for its applicability. Based on the benchmarking results, the Program is improved accordingly and continually... The DM, RP Programs provides oversight of the implementation of this Program through monitoring and ensuring performance standards are met, identifying gaps in performance and driving towards standardized industry best practices." This documents the requirement to benchmark the RP Program and performance against best practices. The title DM, RP Programs is no longer in use; the current organization is discussed in Section 5.6 of this report. In Section 4.1.1 of [BP-RPP-00011], Requirements for Planning Radiological Work, the radiological planning requirements and approvals for radiation work are provided, which are based on the total estimated dose for the work and the anticipated radiological hazard levels. ALARA Plans are used to document the ALARA requirements for radiological work. The required ALARA Plan approvals based on total estimated dose and required approval of work based on radiological work hazard categories are provided in Tables 1 and 2 respectively. As the total estimated dose, and	

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	• Radioactive material is lost; • Inventory or control of a radioactive source is lost; • Workers are unknowingly exposed to uncontrolled or unexpected radiological conditions; • Improper radiological work planning/management results in unintended collective dose greater than 25 per cent over the planned dose for a formal ALARA plan; • Multiple personnel are contaminated during a single incident, which indicates a breakdown in contamination control; • Radiological protection personnel use stop-work authority to stop work in progress. Requiring a higher level of management allows work to resume. Investigations of radiological events are sufficient to identify apparent or root causes, and to develop effective corrective actions. Time and resources used to perform the investigation are commensurate with the actual or potential severity of the incident. Investigations of radiological events require the involvement of all affected departments. In general, the organisation responsible for the incident leads the investigation, with support from radiological protection personnel as necessary. Completed investigations are reviewed by the radiological	radiological hazard increases, so does the approval authority required. This documents the requirement that higher risk work requires higher levels of approval. Table 2 of [BP-RPP-00011] provides the increasing level of RP oversight required as the radiation work hazard category increases. "Indirect Protection" is not permitted for medium hazard radiological work, indicating that Direct Protection is required. The requirements for high hazard work are further described in Section 4.7. Oversight requirements for high hazard work include the use of Protection Assistants provided by RP. This documents the requirement for a higher level of RP oversight as the radiological risk increases. Greenmanning, Protection Assistants [BP-RPP-00019] Section 4.1.2 identifies situations during which work must be directly supervised by the green qualified individual responsible for radiation protection during execution of the work. This documents the expectation that some work will always require supervision. c. Use of the corrective action program: Compliant Section 4.7 of the RP Program [BP-PROG-12.05] provides management expectations for radiological investigation of RP incidents. "Line Managers arrange for a prompt and thorough investigation of incidents or events to ensure the safety of all workers and the public... The DM, RP Programs sets expectations and standards for reporting and investigation of radiological incidents and events... "Line Management documents incidents as instructed by BP-PROG-01.07 to ensure that corrective actions are taken to	

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	protection manager, training manager and other management personnel, as appropriate, to ensure the effectiveness of corrective actions. d. Reporting operating experience WANO has accumulated lessons learned from nuclear plant operating experience (OE) in various OE Programme documents. Implementation of these lessons has been a major factor in the significant improvements in nuclear plant safety and reliability, and in personnel safety over this period. With few exceptions, events that occur today are merely repeats of previous events. This points out weaknesses in the application of lessons learned. With the rising turnover rate of nuclear plant personnel, it is becoming more challenging and more important for a sustained high plant performance to reinforce these lessons learned. It is especially important for them to be maintained in plant processes and procedures, and internalised by persons new to the industry. A key factor in the prevention of events is routine exercise of high standards by plant personnel. They should recognise and correct conditions adverse to safety by relating such conditions to operating experience. Operating Experience (OE) and Programme Descriptions provide guidance on requirements for reporting OE. Reporting involves providing operating experience via network. All root cause analysis should also be	minimize the consequences and prevent recurrence." As mentioned previously, the title DM, RP Programs is no longer in use; the current organization is discussed in Section 5.6 of this report. [SEC-RPR-00038], Radiation Protection Response to a Radiological Event, provides Radiation Protection staff with notification and investigation processes to follow when notified of a radiological event, including action levels. The RP Program and implementing procedures document the expectation that RP events are thoroughly investigated and documented. The RP Section procedure on RP Field Inspection Oversight [SEC-RPR-00025] requires in Section 4.2 that "when a non-compliance event is observed, the RP Technician shall record and immediately correct the non-compliance, and initiate a SCR. The SCRs are used by the Radiation Protection Program Department to assess and report the level of compliance with the Radiation Protection Procedures in their Bruce Power Radiation Protection Performance Metrics Report." The procedure says that an RP Performance Metrics Report is generated, indicating that non-compliances are trended and trends evaluated. The CNSC made a recommendation [BRPD-AB-2015-007-R2] that Bruce Power "develop and implement a corrective action plan to ensure that identified RP deficiencies and SCR adverse trends are addressed and corrective actions are completed in timely manner." In response to the recommendation [NK29-CORR-00531-12856], Bruce Power made a commitment to "review the relevant processes… [and] will seek to make improvements to the relevant	

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	provided to WANO. Operating experience reports are provided through network using the formatted templates. Root cause analysis can be submitted by e-mail, electronic files (Word document preferred) or on a compact disk which can be mailed. Provide the analysis as soon as possible after station management approves the root cause. Reporting at a lower threshold is encouraged to ensure an open and frank exchange of operating experience information throughout the industry. The following reporting criteria are the minimum that should be reported to the industry through the network: • Unplanned or unauthorised exposure greater than 0.5 mSv or greater than 1 per cent of regulatory dose limit; • Unplanned internal dose or exposure to the skin over 50 mSv; • Near misses or violations of controls for high radiation areas or locked high radiation areas; • Contamination of a clean plant system; • Uncontrolled radioactive material outside of the protected area; • Radioactive material shipping noncompliance; • Equipment deficiencies that could cause	processes as necessary." There is no action tracking item associated with this commitment. [SEC-RPR-00038], RP Response to a Radiological Event, Section 4.4 states that "the RP Programs Manager will review [incident investigation] reports to trend the events. Where possible, changes to the RP program will be developed and implemented to minimize recurrences of the trended events." This indicates that it is expected that radiation events will be trended and lessons learned incorporated into the RP Program. [SEC-RPR-00038], Section 4.2 also indicates that "for incidents where Action Levels, regulatory limits, administrative levels are exceeded or other significant radiological events... have occurred... Reports from the investigation should be submitted to senior facility management, the RP Programs DM, the Station AHP, Station RPM [Radiation Protection Manager] and Joint Health and Safety Committee..." This meets the intent that managers are informed of the investigation results for significant radiological events. The title RP Programs DM is no longer current; the current RP organization is discussed in Section 5.6 of this report. The guidance states that "stations with a low threshold for identifying and correcting lower-level radiological deficiencies, are more likely to prevent significant radiological events." The procedure Processing External and Internal Operating Experience [BP-PROC-00062] includes evaluation of OPEX at all levels of significance and in Section 4.2.10 describes how OPEX is incorporated into training.	

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	inaccurate radioactivity measurements and that could apply to other utilities; • Insufficient control of work such as diving, radiography and handling of highly radioactive components that contributes to actual or potential unplanned dose, overexposure, or contamination events.	d. Reporting operating experience: Compliant The document Radiation Protection Process Quality Management [SEC-RPR-00013], Section 4.1 describes the requirements for screening of RP OPEX. Corrective Actions Programs Coordinators provide OPEX items that require screening to the SM, RP Programs who "completes the required processes defined in BP-PROC-00062 to ensure the applicable OPEX is captured in RP related procedures and processes." The procedure [BP-PROC-00062], Processing External and Internal Operating Experience, in Section 4.3.1 provides a detailed description of the process for sharing OPEX reports externally. It says that, "If an event meets the criteria in WANO OE Reference Manual for posting externally, an OPEX report is prepared and posted to WANO, INPO and COG. These reports are called WANO Event Reports (WERs)." This process excludes reporting lower-level OPEX at Levels 3 and 4. The process for sharing OPEX externally shown in Appendix B of [BP-PROC-00062] refers to posting criteria in Appendix C, but the latter shows the process for review of significant operating experience reports (SOERs) issued by WANO or INPO. This appears to be an error in the latest revision (R017) of the procedure. The WANO guideline states that "reporting at a lower threshold is encouraged to ensure an open and frank exchange of operating experience information throughout the industry," and recommends specific minimum criteria for reporting to the industry. The OPEX procedure [143] provides for the communication of the results of events at all	

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		significance levels to management, and for the initiation of Training Change Requests based on the results of investigations so that lessons learned can be incorporated into future training.	
I.C7.	The following should be considered to ensure that sufficiently trained and qualified resources are available to handle anticipated on-line and outage workloads: • If sufficient resources are not available to support planned work, inform station management of mitigating actions and plans; • Monitor work hours so personnel remain attentive to, and alert in, the performance of their responsibilities; • Establish guidance for radiological protection personnel that addresses situations in which the workload exceeds the capacity of personnel resources. This ensures that radiological safety standards are not compromised. Provide timely responses to station problems and requests for assistance and support; • Prioritise personnel resource allocation to those activities that support radiological health and safety. Promote the efficient conduct of station operation and maintenance; • Establish a process to monitor and manage workloads, ensuring that individual and work	Programmatic: Compliant Personnel Resources According to the Radiation Protection Program [BP-PROG-12.05] "the DM, RP programs ensures that a training program is in place for radiation protection. Employees, temporary and contract workers are selected, trained and qualified in accordance with [BP-PROG-02.02]," Worker Qualification and Learning" (Section 4.2.1). Bruce Power procedure [BP-PROC-00342, Sheet 0003], Planned Outage - Planning and Preparation, defines the methodology used in preparation for a planned nuclear outage. Section 4.2.2 describes the RP resource planning process: "A resource plan is produced by Radiation Safety detailing work that requires Radiation Safety personnel. Obtains and trains radiation safety greenmen resources." While it is understood that reference to Radiation Safety likely means Radiation Protection, use of this term which does not align with any department or section in the organization could lead to confusion. The procedure [BP-PROC-00342, Sheet 0003] should be revised to refer to Radiation Protection in alignment with the current organization as described in Section 5.6 of this report.	C

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	group deadlines are met and backlogs minimised; • Establish a long-term staffing plan that addresses projected workloads, retirements and specific skill-set needs; • Establish a knowledge transfer programme to identify, distil, and transfer key processes that may not be fully described in procedures before personnel with these skills leave the organisation.	Bruce Power procedure [BP-PROC-00005] describes the Limits to Hours of Work at Bruce Power: "In recognition of Bruce Power's value of Safety First and the potential impact shift work may have on safety, this procedure identifies the process for monitoring and controlling the hours of work for Bruce Power employees" (Section 1.0). Bruce Power sets work hour limits to ensure personnel remain attentive to and alert in the performance of their responsibilities. The On-Line Work Management Process [BP-PROC-00329] states that "When the volume of work exceeds resource availability, lower criticality/priority work may be removed from work week scope and rescheduled" (Section 4.2.1). This provides guidance to radiological protection personnel that addresses situations in which the workload exceeds the capacity of personnel resources. The New Work Prioritization and Approval procedure [BP-PROC-00328] provides details regarding how work is prioritized, which applies to RP resource allocation to activities that support radiological health and safety. Bruce Power procedure [BP-RPP-00041], Executing Radiological Work, describes the responsibilities associated with various roles. Section 7.1 explains that the Work Group Supervisor is responsible to "Performs a resource review… to ensure there is a sufficient number of RP Qualified Staff to perform and oversee the scheduled radiological work… [and] secures adequate number of workers…" either by contacting another work group or the RP FLM for assistance. Sections 7.3 and 7.4 further explain that the RP FLM and/or RP Section Manager ALARA provide assistance with securing RP resources for planned work.	

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		The Succession Management procedure, [BP-PROC-00221], describes a long-term staffing plan which addresses projected workloads, retirements and specific skill-set needs: "Bruce Power is committed to ensure there are capable managers to deliver on future business plans by identifying and developing successors to management positions. This is done through the succession management process" (Section 1.0). Bruce Power procedure [BP-PROC-00360], Training-Administer Critical Knowledge Retention, establishes "requirements and accountabilities for identifying, collecting and disseminating important undocumented knowledge that has the potential to jeopardize the company should the personnel holding it become unavailable…" (Section 1.0). The procedure is intended to supplement existing processes for the capture of tacit knowledge. One of the key areas for concern listed in the 2015 SOFA [SA-RPR-2015-SOFA] is the availability of RP resources. The assessment indicates that due to Bruce Power and OPG planned outage schedules, there may be insufficient qualified Safety Technician resources available to support Bruce Power in 2015, 2016 and onwards. This indicates that consideration of RP resourcing does take place well in advance of planned outages.	
I.C8.	When screening applicants for radiological protection positions, take into account the importance and complexity of the tasks they will perform. Determine if personnel have the aptitude to develop the skills and knowledge necessary to provide for the radiological health and safety of	Programmatic: Compliant Personnel Selection Bruce Power Training and Qualification Descriptions (TQDs) describe the training and qualification requirements for	C

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	station personnel and the public. This includes leadership potential, interpersonal and written communication, assertiveness, willingness to accept responsibility, standards, analytical abilities, decisiveness, willingness to accept constructive feedback, and technical knowledge. Personnel assigned responsible positions in radiological protection (managers, supervisors, technical support staff, and radiological protection technicians) must have formal training and experience in radiological protection and, as a minimum, fulfil the criteria of regulatory guides for radiological protection personnel. The radiological protection manager must meet the minimum requirements for education, training, and experience specified in regulatory guides at the time of appointment to the position. Job applicant screening includes verifying education and professional background, determining the individual's abilities to perform radiological protection activities, and assessing the potential for advancement. Pre selection testing and assessment can be an effective method of determining a candidate's potential for success. For radiological protection technician and professional positions, a candidate's ability to understand how radiological protection is integrated into plant operations and maintenance as part of operating the plant safely is essential.	various roles in the organization. [TQD-00042], Radiation Protection Training and Qualification Description: Section 4.0 describes the entry-level criteria for Radiation Protection qualifications at Bruce Power. Prerequisites for entry into orange, yellow and green qualification training are provided, along with the corresponding job expectations for each. Section 5.0 describes the various RP qualifications and a brief summary of the responsibilities associated with each. [TQD-00046], Radiation Protection Technician Training and Qualification Description: Section 4.0 describes the entry-level criteria for Radiation Protection Technicians, which includes Grade 12 education as well as two years of post-secondary education or equivalent in related subjects. Section 5.0 lists the qualifications specific to the RP Technician TQD. [TQD-00075], Health Physicist, Authorized Health Physicist Training and Qualification Description: Section 4.1 describes the entry level criteria for Health Physicists and Section 4.2 describes the entry level criteria for an AHP (which includes meeting the requirements of CNSC document RD-204). Section 4.3 describes the entry level work experience prerequisites for an AHP. Section 4.4 lists the documents that must be reviewed through self-study for AHP qualification. Section 5.0 lists all of the HP and AHP qualifications associated with this TQD. Section 6.0 provides a training program overview. Within the current Canadian regulatory framework prescriptive education, training and experience requirements are not given for RP management personnel.	

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		Bruce Power program document [BP-PROG-01.04], Leadership Talent Management defines "how managers are selected for both their leadership and technical skills, and then how managers are on-boarded, managed and developed. It also defines how Bruce Power ensures a sufficient number of managers with the right leadership and technical skills are available to deliver the business plan" (Section 1.0).	
I.C9.	Establish initial and continual training and qualification programmes based on the specific needs of the organisation and the individuals. This develops and maintains a high level of technical knowledge and skills. Programmes should include both specialised training for radiological protection personnel and general radiation worker training for nuclear workers. All aspects of training are important but special attention should be afforded to the recognition of hazardous radiological conditions; for example, the identification of, and proper response to, changing radiological conditions and conservative decision-making. In addition to technical training, consider training to improve communication, teamwork, problem-solving, decision-making, leadership and observation skills. Continued training for radiological protection professionals and technical staff should be used to maintain and advance technical knowledge, keep up with state-of-the-art technology and keep abreast of current industry issues.	Programmatic: Indirect Compliance Training and Qualification Bruce Power Training and Qualification Descriptions (TQDs) describe the training and qualification requirements for various roles in the organization. [TQD-00042], Radiation Protection Training and Qualification Description: Section 6.0 describes the RP qualification training program which includes initial training requirements (Section 6.1) and RP Training Requalification requirements (Section 6.2). [TQD-00046], Radiation Protection Technician Training and Qualification Description: Section 6.0 describes the RP Technician training program which includes initial training (Section 6.1), continuing training (Section 6.2) and relocation training (Section 6.3). [TQD-00075], Health Physicist, Authorized Health Physicist Training and Qualification Description: Section 6.0 describes the HP and AHP training program including initial training (Section 6.1), transfer of an AHP from another facility	IC

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	Chapter II, Training and Qualification of Personnel in Radiological Protection, contains additional information on radiological protection technician training programmes.	(Section 6.2), reinstatement of AHP qualification (Section 6.3) and continuing training for HPs and AHPs (Section 6.4). Each of the relevant TQDs identifies the requirements for initial training associated with the roles described. The TQDs for RP Technicians, HPs and AHPs also describe the requirements for continuing training for those roles. The TQD for general RP qualification does not include the requirement for continuing training, but does include requirements for regular requalification every two years. For yellow and green qualifications this includes an "annual requirement to provide proof of practice and to complete required readings to maintain their knowledge of radiation protection procedures and applicable OPEX." This meets the intent of the guidance regarding continuing training and therefore indirectly complies with the recommendation. A more detailed assessment of Training and Qualification of Personnel in Radiological Protection is provided for Chapter II of WANO GL-2004-01.	
I.C10.	Continued development of knowledge and skill is important to the progression of personnel through the organisation. Initiate career development plans that will expand personnel knowledge and experience. Use these plans as a means for developing a source of potential supervisors and managers within the radiological protection organisation. Assign potential management candidates to work with individuals who can serve as mentors and role models, to help develop leadership capabilities. The development of radiological protection	Programmatic: Acceptable Deviation Career Development Bruce Power program [BP-PROG-02.02], Worker Learning and Qualification, is intended to "provide competent personnel who can safely operate, maintain, and improve station performance" (Section 1.0). Worker learning is said to include "training elements that support Professional Development." [TQD-00075] Health Physicist, Authorized Health Physicist	AD

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	managers, supervisors and professionals, is important because of the profound effect they have on the health and safety of nuclear workers and the public. They should be appropriately integrated into the station management team. Refer to WANO GL 2006-03, Guidelines for Effective Nuclear Supervisor Performance, for additional guidance. Development activities that have proven beneficial at some utilities include the following: • Training and rotating individuals into line positions in other organisations such as work or outage planning; • Assigning individuals to temporary outage leadership positions; • Providing special management and leadership training; • Involving individuals in the station management decision process so that they understand and communicate why a particular decision was made; • Attending key station management and/or executive staff meetings; • Receiving senior reactor operator (or equivalent certification) training to obtain a broader perspective of plant operations.	Training and Qualifications Description: Appendix 7 lists Personal Development Program Elements for the roles of HP and AHP. The TQD for RP Technicians [TQD-00046] includes an appendix titled "Personal Development Program Elements", but the content of the appendix says that there are "none" for this role. Despite this, the more general professional development process described in [BP-PROC-00901] could be followed for RP Technicians. This is an acceptable deviation from the recommendation in the guideline. Bruce Power program [BP-PROG-02.04], Worker Development and Performance Management, describes how worker development and performance is "managed through the establishment of personal performance plans" (Section 1.0). Each plan will have a different focus depending on the performance and career interests of the individual. Bruce Power procedure [BP-PROC-00469], Employee Development Plans, "provides the necessary guidance to direct and support managers in building the organization's capability by programmatically building the performance and capability of their direct reports. In addition, this document provides all employees with an understanding of their role in improving performance for current and future roles" (Section 1.0). Bruce Power procedure [BP-PROC-00221], Succession Management, states: "Bruce Power is committed to ensure there are capable managers to deliver on future business plans by identifying and developing successors to management positions. This is done through the succession management process" (Section 1.0). The process is described further in Section 4 including: identification of	

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		future needs by position/role; assessment of incumbent performance, desires and plans; identification of potential successors for managerial positions; identification of high potential employees for future managerial positions; and development of successors. Section 4.6 provides further detail on the development of successors: "Not all development consists of taking courses. In fact most development of successors will be in the form of on the job stretch assignments, rotations, moving through different positions on a career path and self directed growth and development." This aligns with the recommendations made in the WANO guideline.	
II.C1.	The responsibilities for establishing, maintaining and implementing the radiological protection training and qualification programme are defined and clearly understood. Close coordination among the managers and supervisors of the radiological protection organisation, station work groups, and Training Department is a key element for success.	Programmatic: Indirect Compliance Radiological Protection Training Responsibilities The Worker Learning and Qualification Program [BP-PROG-02.02] has been assessed with respect to the regulatory document Personnel Training [REGDOC-2.2.2] by Safety Factor 12: Human Factors. The RP Program document [BP-PROG-12.05], Section 4.2 “defines the training requirements for workers to perform radiological work, requirements for NEWs, and radiation protection qualification requirements for individuals to access and work at Bruce Power facilities.” Section 4.2.1 of the RP Program document identifies the Department Manager of RP Programs as the individual responsible for ensuring that a training program is in place for RP. “The training requirements for achieving and maintaining	IC

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		qualifications in radiation protection are defined and approved by the DM, RP Programs. The training and qualification structure for radiation protection is described in BP-RPP-00006, TQD-00042, Radiation Protection Training and Qualification Description, TQD-00046, Radiation Protection Technician Training and Qualification Description, and TQD-00075, Health Physicist, Authorized Health Physicist Training and Qualifications Description. Line Managers identify the qualifications required for their workers in accordance with this document and based on the knowledge of the work they will be performing. When planning work to ensure doses are ALARA, the need for and provision of additional training to support the performance of high-risk work or any other work activities is determined by SFAMs. … AHPs, RSOs, the DM, RP Programs, and SFAMs have authority to remove an individual's radiation protection qualification(s) if he or she is not performing to this Program's standards and requirements … The qualification removal process is outlined in BP-RPP-00006." In the RP Program document, several references are made to BP-RPP-00006, Radiation Protection Qualification. BP-RPP-00006 is an obsolete document, superseded by the RP Program document, which in turn refers to BP-RPP-00006. This is a document control issue, which is addressed under Safety Factor 10, Organization and Administration. The RP Program clearly identifies responsibility for RP training and qualification. Involvement of CFAM, SFAMs and line managers in identifying training and qualification needs for workers is required. Through reference to the TQDs,	

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		coordination with the RP Training department is also implied. In addition, Radiation Protection Training and Qualification [TQD-00042] assigns to the DM, RP and Industrial Safety Programs, responsibility to chair the Radiation Protection Training Program Review Committee. This committee includes representatives of the training organization and station work groups. The RP Program indirectly complies with the recommendations provided in this clause.	
II.C2.	a. Basic radiation worker training Conduct general radiation worker training for station and supplemental workers, as described in Attachment, Guidelines for Radiation Worker and Radiological Respiratory Protection Training. Practical exercises that stress proper radiological work practices are part of the training programme for workers who enter the RCA. Provide periodic retraining for radiation workers to maintain and improve the knowledge and skills necessary to implement radiological protection practices effectively. Base the frequency and extent of retraining both on the need to improve and reinforce current practices, and on the proficiency of the individual or work group. Adverse trends in radiological performance may indicate weaknesses in radiation worker training. Therefore, establish mechanisms to ensure lessons learned from current industry and station	Programmatic: Compliant General Employee Training in Radiological Protection a. Basic radiation worker training: Compliant The Technical and Qualification Description for Radiation Protection [TQD-00042] describes the requirements of specific qualifications (Orange, Yellow, Green) that employees, contractors (supplemental workers) and visitors must complete. General employees and supplemental workers who require prescribed access and working rights in accordance with the procedure Facility Access and Working Rights [BP-RPP-00018] are required to have Orange Qualification and are provided with a course intended to give them the basic fundamentals in radiation protection knowledge, practices and procedures. Supporting the classroom training, a	C

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	events are incorporated into initial and continuing training. These include selected industry events that involve large, unplanned exposures and the responsibility of individuals to prevent such events. In training and retraining programmes, stress the potential for abnormally high or rapidly changing radiological conditions, and include actions required when these conditions occur. Also, emphasise the importance of a high level of awareness and sense of individual responsibility with regard to personnel radiological protection. b. Additional radiation worker training Basic radiation worker training establishes minimum requirements for entry into radiologically controlled areas. However, this may not be sufficient to ensure proficiency for some work groups or work evolutions. Provide additional practical training in radiological protection to personnel such as maintenance workers, engineers, auxiliary operators, and their supervisors who perform direct, or monitor specific work, in high radiation or highly contaminated areas. Radiological protection management should reinforce the incorporation of this training, including the following, into initial and continual training for each work group: o Determine radiological conditions and incorporate appropriate controls into qualification	radiation protection oriented facility tour is provided to the trainee. After successful completion of the classroom training and the appropriate facility tour an Orange Qualification is granted. Retraining of radiation workers is not an identified component within [TQD-00042], but requalification is required every two years. b. Additional radiation worker training: Compliant According to [TQD-00042] an individual's qualification shall be consistent with the job expectations. As stated in [TQD-00042], the YELLOW QUALIFICATION training program is advanced training required to provide self-protection from exposure to radiation dangers and consists of a knowledge component, a skills component and a nuclear facility experience prerequisite. As stated in [TQD-00042], the GREEN QUALIFICATION training program is advanced training in the protection of others from exposure to radiation dangers, and it consists of a knowledge component, a skills component and a structured experience component. Workers who perform radiological work and supervisors who have responsibilities for these workers follow written guidance in the procedure Executing Radiological Work [BP-RPP-00041], which takes authority from the Radiation Protection Program [BP-PROG-12.05]. As stated in this procedure, it is essential that the pre-job brief include a discussion on radiological hazards. As stated in [TQD-00042], Bruce Power programs require that "In addition to the training requalification requirements,	

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	training for each task; o Use dynamic learning activities to perform both routine and special task 'practical factors' training under simulated radiological conditions; o Provide mock-up training for infrequently performed tasks in work areas where significant exposure can be received in a short time (steam generator nozzle dam installation, reactor head weld repairs, and so forth). Additional training to improve radiological worker performance should include task-specific radiological controls for work in significant dose rates or contamination levels. These include response to spills, leaks, airborne radioactivity, unexpectedly high dose rates and other unusual radiological situations. Training may include cross-discipline scenarios that involve members of the radiological protection staff. This increases teamwork and communication among work groups. The use of realistic mock-ups on which personnel practice techniques for high-dose tasks has been effective in reducing cumulative dose. Mock-up training includes measurable performance standards that ensure the proficiency and skill of workers who complete the training. Training for both engineering and operations includes dose and contamination reduction techniques in the design, installation and maintenance of modifications.	Yellow and Green qualifications have an annual requirement to provide proof of practice and to complete required readings to maintain their knowledge of radiation protection procedures and applicable OPEX." c. Escorted personnel receiving occupational dose: Compliant Section 4.5 of [BP-RPP-00018] describes the RP qualifications needed to escort visitors or workers who are not RP-qualified. Section 4.3 of this procedure shows the RP qualifications required to perform radiological work and to provide protection to such workers. The greenman is responsible for ensuring that the station radiological protection requirements and procedures are followed. As stated in [TQD-00042], the fundamental prerequisite for ALL Radiation Protection Qualifications is the ability to read and understand English. All workers or visitors must be able to recognize and follow instructions on the various signs and they must be able to respond correctly in an emergency.	

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	The inclusion of lessons learned from industry and station radiological events has been effective in preventing similar events. c. Escorted personnel receiving occupational dose For escorted personnel who receive occupational dose, establish guidelines that include radiological training appropriate for the risk involved. The escort ensures that station radiological protection requirements and procedures are followed. The minimal use of escorts in radiological areas will help avoid additional personnel exposure. Workers with a limited understanding of the English language and those who are unable to complete plant access and radiation worker training successfully should not be granted unescorted access to radiologically controlled areas. For such workers, use escorts who can communicate in their native language. Escorted workers may receive specific training in their language, appropriate to the risk associated with their work assignment. Radiological protection should plan for additional oversight and support for the workers and work areas.		
II.C3.	a. Utility technicians Considering radiological protection technician performance in the field is critical to a successful radiological programme and, in many cases,	Programmatic: Compliant Radiological Protection Technician Training and Qualification	C

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	represents the last line of defence to a radiological incident, a well-trained and well-qualified technician workforce is imperative. Radiation protection management works with training personnel to establish the content for, and oversee the quality of, technician initial and continual training. This line ownership for training is intrusive and frequent, using student and incumbent feedback as well as department performance to guide training decisions. Careful consideration must also be given to approving training waivers for technicians with prior experience. Some methods for demonstrating task proficiency are valuable in determining an experienced technician's qualification level. An important aspect of training for radiological protection technicians and their immediate supervisors, regards learning to recognise and handle unusual situations. In the training programme, stress the potential for changing or abnormally high radiation, and contamination levels in certain plant areas or systems to affect work in progress. For personnel who perform dose rate surveys and monitoring, this training should address the proper operation of dose rate monitoring equipment. Evaluate the introduction of new technology, software, and instrumentation that will be used as part of the radiological protection programme. These frequently introduce new failure modes and alterations to mental models that are best	The Worker Learning and Qualification Program [BP-PROG-02.02] has been assessed with respect to the regulatory document Personnel Training [REGDOC-2.2.2] in Safety Factor 12: Human Factors. a. Utility technicians: Compliant In addition to the qualifications required for facility access and working rights documented in [BP-RPP-00018], the Training and Qualifications Description for Radiation Protection Technician [TQD-00046] provides an overview of the training and qualification requirements that must be met by personnel in order to be qualified to independently perform tasks. It describes both initial and continuing training requirements. The Training Program Review Committee (TPRC) reviews and evaluates feedback to initiate training program improvements. [TQD-00046] lists the basic qualifications required for all employees in this position, and also a number of specialized qualifications that some employees will require. Technicians hired with qualifications significantly higher than entry level may be exempted from portions of the training program. These qualifications or experiences shall be reviewed and validated by the Section Manager, Radiation Safety Training, and the relevant Manager, Radiation Safety, on an individual basis and credited accordingly. Exemptions are granted in accordance with the procedure Training-Administer Training Exemptions [BP-PROC-00174], which is assessed in Safety Factor 12. Continuing training for Radiation Protection Technicians is	

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	addressed in classroom, laboratory, or mock-up training. Several industry events occurred, because personnel did not understand the functions or limitations of newly implemented technology. Examinations (written and/or oral), practical demonstrations, on-the-job training, and task performance evaluations are used to verify that each technician has the requisite knowledge and skills to perform the job. Newly qualified technicians, and those still in training, work with qualified, experienced technicians to foster skill development. A method of tracking qualifications is used to ensure that only appropriately qualified technicians perform certain tasks. Continuing training ensures that personnel are informed of changes in radiological protection requirements and procedures; of plant modifications; and of lessons learned from recent industry and station events. Continual training also maintains and improves fundamental job-related knowledge and skills in radiological protection. Encourage professional development, such as pursuing the National Registry of Radiation Protection Technologists (NRRPT) registration. Structure individual training plans for personnel who perform specialised tasks. For example, ALARA planning, requires in- depth knowledge of electronic work order systems, outage scheduling systems, access database reporting systems, and	prescribed in Section 6.2 of [TQD-00046]. It consists of a minimum of 72 hours of training annually, and includes the following topics, which change each year based on input from the TPRC and OPEX: 1. OPEX/Emergent Activities 2. Licensing & Regulatory 3. Plant Engineering/Design Changes 4. Infrequent/Difficult Tasks 5. NRRPT Examination Preparation The TPRC has the primary responsibility to ensure the effectiveness of the defined training qualification. Training evaluation methods and processes are described in the procedure Training - Administer Training Evaluation [BP-PROC-00213], which is assessed further in Safety Factor 12: Human Factors. All training and qualifications are recorded in a database that enables supervisors to verify an employee's qualification status. A FASA conducted in November, 2014 [SA-TRGD-2014-04] found that [TQD-00046] was not in compliance with Bruce Power's training processes and procedures. Corrective actions are in progress (see Section 7.1 of this report.) b. Supplemental radiological protection technicians: Compliant Supplemental radiological protection technicians may be subjected to initial training or be considered as relocation	

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	spreadsheet development. b. Supplemental radiological protection technicians Supplemental radiological protection technicians, including loaned personnel from other stations, need to meet the same knowledge and task proficiency criteria as permanent station technicians who perform the same duties; although the qualification process may differ. Include the following actions in the supplemental technician training and qualification programme: o Review résumés carefully to identify technicians with experience in jobs similar to those in which they will be employed; o Conduct testing to verify the appropriate knowledge level in health physics theory, instrumentation and equipment; o Identify the duties technicians will be authorised to perform, as well as the knowledge and task proficiency required for the successful performance of those duties; o Train technicians in station procedures, instrumentation and equipment associated with the authorised duties; o Train technicians on recent station and industry events with significant radiological implications. These should include selected	staff [TQD-00046] and required to complete relocation training. A training plan must be prepared upon arrival based on the identified gap in training for the employee. A person's access to a facility and their ability to perform work independently and provide radiation protection to others is determined by their qualification in radiation protection according to the procedure Facility Access and Working Rights [BP-RPP-00018]. A self-assessment conducted in 2015 [SA-RPR-2015-04] found that supplemental RP technicians (Appendix A Safety Technicians) were not receiving adequate training and were not being regularly assessed. Corrective actions are in progress (see Section 7.1 of this report.)	

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	industry events that involve large, unplanned exposures, and the responsibility of individuals to prevent such events. Events That Shaped Radiation Protection describes radiological incidents that resulted in more rigorous controls and barriers to prevent serious events; o Evaluate the knowledge and skills necessary to perform site-specific tasks before personnel work independently. Evaluations should include examination and practical demonstration in carefully monitored field or laboratory settings. Supplemental and temporary personnel who work independently at the station may be exempted from initial training and task performance evaluation using the same method as for station personnel; o Conduct task performance evaluations for new tasks and for infrequently performed high-risk tasks. Commensurate with their assigned duties, supplemental technicians who work at the station for extended periods, (for example, more than six months) receive the same continual training, (such as on industry and station events, procedure changes, and plant modifications) provided to utility technicians.		
II.C4.	Use a structured method to determine and provide training to develop and maintain management and supervisory skills. Include generic training such as managerial and supervisory skills, leadership,	Programmatic: Compliant Radiological Protection Management, Supervisory and	C

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	accountability, observation and assessment, communication, teamwork and company management styles and philosophies. Also, include position-specific technical training to enable these individuals to properly oversee, coach, evaluate, communicate and maintain their areas of responsibility to current industry standards. Use career progression planning to help customise the training programme for individuals being considered for specific supervisor and manager positions. Support radiological protection personnel participation in professional societies and industry organisations to maintain and improve knowledge and skills. Encourage professional development such as senior reactor operator certification or licensing, professional engineer licensing and health physics certification. Provide individuals with opportunities to work in other functional areas such as outage planning, chemistry, maintenance, operations, quality assurance and training to broaden their perspectives on station operations. Allow personnel to benchmark top-performing nuclear stations to expand their understanding of radiological protection management and technical issues.	Technical Staff Training and Development The Worker Learning and Qualification Program [BP-PROG-02.02] has been assessed with respect to regulatory document Personnel Training [REGDOC-2.2.2] by Safety Factor 12: Human Factors. In accordance with [BP-PROG-02.02], the procedures and job aids required to implement this program allow the training elements that support worker qualifications to be created, managed and conducted using the Systematic Approach to Training (SAT). This excludes [TQD-00075] for Health Physicists and Authorized Health Physicists, which is designed to meet the requirements for certification of an Authorized Health Physicist as Identified in CNSC document [RD-204]. The CNSC conducted a desktop review of the Health Physicist and Authorized Health Physicist Training Program in June-July, 2015 [BRPD-AB-2015-005, attached to NK29-CORR-00531-12681]. The review led to three minor recommendations and one enforcement action. The latter was to "develop and implement a corrective action plan to ensure that all Field Checkouts (FCOs) associated with the HP & AHP training program are up-to-date and complete." Bruce Power accepted the recommendations and this enforcement action, and corrective actions are in progress (see Section 7.3 of this report.) Bruce Power has a program in place called Worker Development and Performance Management [BP-PROG-02.04] that supports employees to continuously develop and improve performance. Each plan will have a different focus depending on the performance and career interests of the	

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		individual. In addition, there is a Leadership Talent Management Program [BP-PROG-01.04] that defines "how managers are selected for both their leadership and technical skills, and then how managers are on- boarded, managed and developed" (Section 1.0). Programatic requirements for training related to supervisors is documented in [TQD-00011] (issued April 2016). It identifies all the training elements available for supervisors. Specific technical training elements related to RP includes Nuclear Power School (19436) and Supervisors of Radiological Work (17995). There is a process for managers to select training elements specific to the job task and job analysis based on the supervisor's function. The Radiation Protection Improvement Program (RPIP) describes a "change over in the model of radiation protection currently used from the orange, yellow and green qualification system to a threshold based model which includes specialized and highly trained radiation protection technicians, optimises the use of self protection of workers and adds a more appropriate and practical training program for radiation workers." One of the projects defined in the RPIP is to train managers and supervisors (among others) in the new RP program, standards and responsibilities in the new RP organization. Bruce Power has a procedure Professional Development [BP-PROC-00901] that documents "the steps necessary to approve participation in formal professional development programs. This includes attendance at a single professional development course, or participation in a program which	

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		results in a degree or professional certification (e.g., CMA, CHRP, P.Eng) OR the participation of an employee in the UNENE [University Network of Excellence in Nuclear Engineering] program" (Section 1.0). [BP-PROC-00901] notes that "annually there is opportunity to identify individuals who will participate in external learning opportunities offered within the nuclear industry (e.g., WANO, INPO, COG, WNU [World Nuclear University], etc.) and/or peer reviews" (Section 4.1).	
III.C1.	a. Annual total dose Stations maintain annual individual doses well below the regulation dose limits for occupationally exposed individuals. The following controls help ensure that these limits are not exceeded: 1) Administrative dose control levels Administrative dose control levels are established to prevent personnel from exceeding regulatory dose limits. Establish administrative dose control levels at a conservative level for each dose limit (for example, total effective dose equivalent [TEDE], skin, and lens of the eye). Establish additional controls to complement the administrative dose level system for high radiation and locked high radiation areas. Also consider controls for personnel dosimetry detecting different types of radiation (for example, beta and neutron). Examples of additional controls that may	Programmatic: Gap External Dose Controls a. Annual total dose: Gap 1) Administrative dose control levels: Gap The Bruce Power procedure Dose Limits and Exposure Control [BP-RPP-00009] establishes in Section 4.2 an Administrative Dose Limit (ADL), which is "a dose limit below regulatory limits … and above the corresponding ECL [exposure control level]". Section 4.4 of the ALARA Program [BP-RPP-00044] says that "the DM, Safety Programs determines Administrative Dose Limits (ADLs) and Exposure Control Levels (ECLs) for individual exposure which are challenging to the organization." [BP-RPP-00009] in Section 4.1 sets ECLs to alert employees and supervisors that additional dose control measures are	Gap

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	be used are as follows: o Use an alert list, distributed frequently to supervisory personnel, to flag the names of workers with dose greater than 80 per cent of an administrative dose control level; o Limit access to high radiation areas for individuals whose dose is within 1 mSv of an administrative dose control level; o Establish lower (electronic dosimeter) dose alarm set points to ensure combined gamma plus neutron accumulated dose does not exceed radiation work permit control levels during work in neutron radiation fields. o Obtain appropriate station and radiological protection management approval to increase a worker's dose above an administrative control level. Bona fide needs for dose extensions include: o The unique ability or experience of the individual will minimise collective dose; o Other qualified individuals with lower doses are not available. Radiological protection supervision ensures that official dose is verified (including the reading of the worker's primary dosimeter) when the individual is approaching regulatory limits. It also guarantees that the new administrative dose control level to be assigned to the worker is appropriate, based on the parameters discussed	required to ensure that ADLs are not exceeded. ECLs are continuously checked by the Radiation Information System (RIS) and warning messages are issued when a worker's dose is approaching an ECL (i.e., value is greater than 85%) and when the ECL has been exceeded. Although the alert list is set at 85% rather than 80% of the ECL, given that ECLs are set lower than ADLs, Bruce Power indirectly complies with the provided guidance. As noted in Section 4.1(8) of [BP-RPP-00009], all requests to change an ECL will result in subsequent years ECL to be reduced to ensure the 5 year ADLs are not exceeded. Sections 4.3.1 and 4.3.2 of [BP-RPP-00009] identify the criteria for removal or restriction from radiological work: "a Worker who has exceeded an ECL or ADL shall be removed from radiological work by the RIS". Given that the ECLs are set lower than the ADLs, Bruce Power indirectly complies with the intent of this guideline by removing workers from radiological work once an ECL or ADL has been exceeded. Equivalent dose limits for lens of an eye, skin, hands and feet are provided in Dosimetry Requirements [BP-PROC-00280]. However, these are the legal limits prescribed in the CNSC's Radiation Protection Regulations [SOR-2000-203] and not ADLs. The lack of an ADL for the lens of the eye is considered acceptable since skin dose is more limiting than eye dose for typical beta radiation and eye protection is required at all times when performing radioactive work (see Section 4.8.2 of [SEC-DOS-00044].) The absence of ADLs for equivalent doses to the skin, hands and feet is compensated by setting ECLs for these doses in [BP-RPP-00009]. A footnote was added to Table 3 of R009 of this procedure saying, “It is not common practice in Canadian	

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	above. 2) Equitable dose Maintain equitable dose among workers who perform similar jobs, to the extent possible. Radiological protection personnel and the workers' supervision should periodically review individual dose distribution. The trends of individuals who receive significantly higher dose than peer workers, may be an indication that the numbers of qualified workers to perform certain tasks need to be adjusted. Supervisors monitor and adjust assignments to balance dose among workers over the long term. 3) Annual dose to individuals Some workers receive substantially higher annual dose than other workers due to their unique skills. Many work at several stations during outage periods, which also contributes to higher doses. International Commission on Radiation Protection publication 103 recommends controlling individual dose to 100 mSv in five years or 20 mSv per year. Although these values are below current domestic regulatory requirements, actions should be taken to maintain total individual dose within these levels when practical, without restricting the employment of workers. Actions that can be taken to adhere to these levels include the following:	nuclear facilities to define ADL for non stochastic dose limits such as skin and extremities." This represents indirect compliance. The situation regarding the dose to the lens of the eye may change. The CNSC in Discussion Paper DIS-13.01, issued August 2013, proposed to lower the equivalent dose limit for the lens from 150 mSv to 50 mSv in a one-year period, and to add a new limit of 100 mSv in a five-year dosimetry period. If this change is enacted, it may no longer be possible to argue that skin dose is more limiting than eye dose for typical beta radiation. ECLs are set for effective dose (whole body), skin, hands and feet within [BP-RPP-00009]. These are established for all workers, including permanent employees, temporary employees, Building Trade Union workers and contractors. Dosimetry services are provided to Bruce Power workers through Bruce Power's licensed dosimetry service, assessment of which is out of scope of this review. Bruce Power licensed facilities are zoned based on the potential for radioactive contamination in order to protect personnel and prevent contamination spread, as noted in Section 4.3.2 of the Radiation Protection Program [BP-PROG-12.05]. Radiological high hazard work is described in Table 2 of the procedure Requirements for Planning Radiological Work [BP-RPP-00011]. The procedure Access Control [BP-RPP-00008] describes the requirements to access areas controlled by the access control system, in the vicinity of the reactors, fuelling machine operations and their auxiliaries where high radiation levels may exist. However, the current radiation protection procedure Zoning [BP-RPP-	

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	o Identify the population of workers who perform activities that may challenge or exceed these annual dose levels; o Establish task-specific goals for these workers that support maintaining their annual dose below 20 mSv. For example, set an outage dose goal of 5 mSv for supplemental workers who support refuelling activities; o When personnel exceed these goals, initiate actions to investigate the causes and establish actions to improve future performance; o Help industry groups and suppliers identify improved methods and technology to reduce the dose to these workers. b. Planned special exposures Under exceptional circumstances, current regulations permit personnel to receive dose greater than the annual regulation limits. Situations that require the use of the planned special exposure (PSE) provision should be rare. Have policies and procedures in place to address these types of exposures before they can occur. c. Emergency dose Issue guidance regarding dose during emergency situations as part of the site emergency plan.	00015] does not describe the use of high radiation and locked high radiation areas. The incorporation of the area classification and associated administrative and physical controls for very high radiation areas was identified as a recommendation within the focus area self-assessment conducted against WANO GL 2004-01 (Rev. 1) in 2013 [SA-RPR-2013-03] and documented in AR 28399588-01. Completion notes for this assignment read: "Our RP program has high hazard work procedures in place for controlling access to high radiation areas and very high radiation. The key control system for our locked high radiation areas are similar in nature to WANO GL and are effective for controlling access and preventing unplanned exposures. No changes to our program necessary at this time." As noted above, Bruce Power does not use the term High Radiation areas. Additionally, according to the procedure Facility Access and Working Rights [BP-RPP-00018] describing the radiological safety requirements for entering and exiting licensed nuclear facilities across Bruce Power, there are no criteria mentioned related to limiting access to individuals. FASA [SA-RPR-2013-04] on LHRA Controls identified a need for BP to have an LHRA program to control access to areas with gamma dose rates greater than or equal to 1 rem/h [0.01 Sv/h] at 30 cm. An SCR was initiated to document the necessary change, which led to a DCR (due December 31, 2014) requesting an update to the Access Control procedure [BP-RPP-00008] "to create the programmatic requirement for LHRA controls" (Section 7.2). The update has not yet been made. **Gap 1** The procedure Radiation Exposure Permits [SEC-RPR-0015]	

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	d. Dose to the embryo/foetus Establish controls for the protection of the embryo/foetus during a worker's declared pregnancy. Establish similar controls for workers who declare their intent to become pregnant. These controls should ensure compliance with regulatory requirements and protect the rights of workers. Use recommendations from the authority organisation on radiation protection and regulatory guidance documents in establishing the programme.	describes the review of Radiation Exposure Permit (REP) Electronic Personal Dosimeter (EPD) limits stating "EPD limits should not be significantly higher than those dose rates and doses being recorded when personnel use the REP or similar REPs" (Appendix C). Neutron dose contribution is not described as part of the review of REP EPD limits. This reflects the finding by the Bruce Power self-assessment conducted in October of 2013 [SA-RPR-2013-03] which recommended that Bruce Power "Evaluate the requirement for establishment of lower EPD set points when working in a mixed (gamma-neutron) field" (Section 7.3). This recommendation is documented in AR 28399588-03. Completion notes for this assignment read: "The REP hazards considers [sic] tritium, neutron and gamma dose rates. The REP computes an Individual Shift dose estimate, i.e. the total dose each worker will get, when they go on the REP that is a sum of those three components, (tritium neutron and gamma rates times the exposure time). The worker cannot sign onto the REP unless this dose estimate plus his Current year dose is less than his Exposure Control Level (ECL). The EPD dose alarm is for the WB dose component. The Radiation Data Unit (RDU) runs reports to ensure the neutron dose entered does not exceed the REP Neutron Dose limit, and any exceedences are to be sent to AHP for review/action. Thus oversight is provided for the neutron dose and it would be inappropriate to change the EPD setpoints to accommodate The neutron to gamma dose rate ratios are specified in the REP. Under an assumption that they are related and the ratio does not change (in general, the gamma might go up but not the neutron), as time goes by, the accumulated EPD and neutron dose increases at the same ratio / relative rate. Thus the EPD alarming at	

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		85%, will also be 85% of the neutron dose, unless an event took place that changed that ratio and non- reasonably probable events are beyond the intent of these guidelines for normal work activities. Both can be at 90% of their limit and still be below the job estimate computed by the REP program." Sections 4.1 and 4.2 of the procedure Dose Limits and Exposure Control [BP-RPP-00009] refer to the Exposure Control Level/Admin Dose Limit Change Request Form [FORM-13204]. This form requires answers to "Are there other individuals available with lower dose who can perform the same work?" Concurrence and approval requirements are listed in [FORM-13204] as well as in Table 2 of [BP-RPP-00009]. These include concurrence from the employee's department manager up to Vice President, and the approval of an HP, AHP and/or Department Manager, Radiation Protection Programs. The position "Department Manager, Radiation Protection Programs" no longer exists, so the procedure should be revised to refer to the appropriate position title in the new RP organization. 2) Equitable dose: Compliant As briefly mentioned in Section 7.2.6 of the ALARA Program [BP-RPP-00044], responsible managers are expected to "periodically review distribution of doses at their facility/project to identify trends and implement actions to ensure doses are maintained ALARA." Section 4.3.3 of the procedure Executing Radiological Work [BP-RPP-00041] states that "WG [Work Group] Supervisors shall track and maintain knowledge of their workers internal and external	

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		dose", and "Where possible, the dose received by a work group shall be equalized across the members of the work group." Section 4.1(1) of [BP-RPP-00009] states that when an ECL has been exceeded and the approval to increase has not been received in advance and documented on [FORM-13204], the RIS will automatically put the worker on removal. As part of the ECL/ADL change request [FORM-13204], the individual or supervisor is required to explain why the change is required, if there are other individuals available with lower dose who can perform the work, how the change will affect availability of the individual to perform rad work in future years, what additional efforts have been taken or could be taken to reduce dose to the individual, and what efforts have been made to distribute the dose equitably amongst workers in the affected work group. 3) Annual dose to individuals: Compliant Effective dose limits for NEWs, for both 1-year and 5-year dosimetry periods, are provided in Appendix A of the procedure Dosimetry Requirements [BP-PROC-00280]. These reflect the regulatory guidance provided in the Radiation Protection Regulations [SOR-2000-203]. Management of worker dose is described in Section 4.3.3 of the procedure Executing Radiological Work [BP-RPP-00041]. Planning of radiological work is performed prior to the start of the work. Radiological work requirements are planned and defined in accordance with [BP-RPP-00011] and are documented in the Radiation Exposure Permit [FORM-11106]. As stated in Section 4.7 of [BP-RPP-00041], Post-Work	

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		ALARA reviews are required when the total dose received "exceeds the total dose estimate by greater than 25%." The post-job brief described in Appendix F of the procedure Executing Radiological Work [BP-RPP-00041] includes "identification of improvements that should be incorporated into future work." b. Planned special exposures: NA Not Applicable. There is no provision for planned special exposures under the Radiation Protection Regulations [SOR-2000-203]. c. Emergency dose: Compliant Section 4.5 of the Dose Limits and Exposure Control Procedure [BP-RPP-00009] describes dose limits during an emergency and consequent immediate/urgent remedial work. d. Dose to Embryo/Foetus: Compliant ECLs and ADLs for pregnant NEWs are prescribed in the procedure Dose Limits and Exposure Control [BP-RPP-00009]. ECLs shown in Table1b, which includes breastfeeding and pregnant NEWs, are significantly less than the legal effective dose limits [SOR/2000-203].	
III.C2.	a. Dosimetry use and dose tracking	Programmatic: Compliant	C

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	1) Whole-body dose Establish a programme that includes an evaluation of all individuals within the controlled area to determine applicable dose limits and the need for exposure monitoring. Provide each worker entering an RCA with dosimetry capable of measuring the worker's dose, giving the worker the means to track individual dose. Accomplish this by using both a primary dosimeter of record and a self-reading dosimeter. Self-reading dosimeters, including electronic dosimeters, should be worn to allow workers easy monitoring. As a general rule, self-reading dosimeters are not worn inside protective clothing, as this precludes dose monitoring. They may be worn inside outer chest pockets, or in plastic bags if training includes instructions on how to read them without spreading contamination. If a need arises to have dosimeters worn under protective clothing or on an area of the body that the worker cannot view, use remote monitoring or another method of direct monitoring and a method of communicating dose received to the individual. Whole-body dosimetry is worn close together (the primary dosimeter and the self-reading dosimeter should be within a hand's width of each other). It is placed on the part of the body that is expected to receive the highest dose, normally the chest. If the highest dose location on the body is not the	Personnel Monitoring for External Radiation a. Dosimetry use and dose tracking: Compliant 1) Whole-body dose: Compliant The Bruce Power Dosimetry Section provides radiation dosimetry services in support of [BP-PROG-12.05] under a Dosimetry Service Licence (not within scope of the current periodic safety review). Licensed dosimetric assessments and methods are described in the procedure Dosimetry Requirements [BP-PROC-00280]. Section 4.1 of the procedure Dosimetry and Dose Reporting [BP-RPP-00020] establishes management expectations regarding the use of personal dosimetry. These include the requirement to wear a thermoluminescent dosimeter (TLD) badge at all times in Zones 2 and 3, and in the Unzoned Area. All electronic personal dosimeters (EPDs) must be issued against a Radiation Exposure Permit (REP), and a REP and an EPD must be used when performing radioactive work, and by pregnant workers entering Zone 3. TLD badges and accompanying EPDs must be worn together and TLD badges must be worn outside all clothing. Section 4.2.8 of [BP-RPP-00020] provides guidance on the use of multiple dosimetry. When the dose to the head is expected to exceed the dose to the trunk by 100 mrem (1 mSv), one TLD/EPD pair may be worn on the head or hard hat and a second pair on the trunk.	

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	chest, move dosimeters to the body location with the highest expected dose in accordance with guidance below. Consider using effective dose equivalent (EDE) monitoring for high dose gradient situations (see subsection C.2.c). Examples of conditions that may warrant repositioning of whole-body dosimetry or providing additional dosimeters are as follows: • Known dose rate gradients make it likely that total dose to a portion of the whole body will exceed the chest dose by more than 50 per cent (for example, dosimeter worn on the head when most of the dose rate in the work area is from overhead piping); • Dose rates in the general work area exceed 0.1 mSv/hour at 30 cm; • It is anticipated that the difference in total dose would vary by at least 0.3 mSv for an individual during the work shift or 2.50 mSv of collective missed dose for the entire job. The use of alarming electronic dosimeters and remote-reading dosimetry devices provides increased assurance that dose limits will not be exceeded. Provide clear guidance to station personnel for responses to electronic dose rate and accumulated dose alarms. Require workers to read their dosimeters periodically when in radiation areas (for example, once or twice per hour), and more frequently in high radiation areas. This will help monitor whether dose received, is	Guidance to workers on the use of EPDs is provided in Section 4.3.3 of the procedure Executing Radiological Work [BP-RPP-00041]: "If back-out limits are reached and the EPD alarms, then workers shall ensure that their work is placed in a safe state and then back-out of the area immediately as discussed in the Pre-Job Brief". Workers are required to "…check their EPDs periodically to ensure that their dose/dose rate is within the expected range and is maintained ALARA." 2) Stay times: Compliant The situations when stay times are required are specified In Section 4.7.5 (10)(b), of the REP Procedure [SEC-RPR-00015]. They are: " where gamma general dose rates are anticipated to exceed 1 rem/h. " when the individual dose estimate per entry is expected to exceed 500 mrem [5 mSv]. " when additional control over exposure to tritium oxide is required. "Stay times can also be included in instances where EPD rate alarms are anticipated to permit personnel to pass through a high dose rate area to reach their work location or when moving high dose rate equipment for a brief period of time." Stay times are calculated according to Appendix B of [SEC-RPR-00015], and are entered into the Backout/EPD tab of the REP.	

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	consistent with expectations. They should know their electronic dosimeter dose rates and accumulated dose alarm set points. Workers are not to rely solely on an electronic dosimeter's alarm to prevent dose control levels from being exceeded. Personnel should exit the radiological work area prior to receiving an accumulated dose alarm and should never work through one. Establish set points low enough to provide the worker with a warning of higher-than-expected work area dose rates for that specific job. However, set points should be set high enough to enable the worker to perform the specific job without receiving an unplanned dose rate alarm (see subsection C.3.c). Brief individuals and document anticipated alarms, before the individuals enter the work area. In each briefing, include specific anticipated dose rates and actions to be taken in the event of a dose rate alarm. Investigate and document both unplanned and accumulated dose rate alarms to determine if the workers were monitoring their exposures, radiological conditions changed, planned work scopes were altered or the dosimeters malfunctioned. Enter all valid alarms into the station corrective action programme. 2) Stay times Stay time limits are required when an individual exposure is expected to exceed 5 mSv per entry.	High-hazard work is planned using [FORM-13907]. When stay times are required, [FORM-13801] must be used to track those stay times. That form stipulates that "When the Stay Time limit is reached, the worker is required to back out of the job, even if there is allowable dose remaining on the worker's EPD." Section 4.3.1 of [BP-RPP-00020] provides guidance on the use of EPDs in high noise areas or by the hearing impaired. It specifies the use of a special case for the DMC-2000 EPD that "has the following features to ensure an alarm is noticed: - Six bright light emitting diodes (LEDs) embedded in case. - A translucent material that glows when unit alarms. - A vibration feature. - An extra-loud audible alarm (90-95 dB)." Bruce Power has a health surveillance procedure [BP-PROC-00378] which includes pre-placement screening, and re-assessment whenever there has been a significant change in employee's health status or whenever there is a question regarding the compatibility of employees and their work. Recommendation EDC-6 of [SA-RPR-2013-03] is to "Evaluate with the Wellness Department establishing the requirements to test station workers ability to hear EPD alarm tone." This recommendation was based on the finding that "no testing requirement could be located to verify their ability to hear the alarm tone on an EPD." The recommendation was tracked with AR 28399588-06. Completion notes for this assignment read: "Contact with Vendor and Wellness Department regarding the requirement to test station workers on their ability to hear the EPD alarm tone. As per wellness	

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	Stay time limits are also implemented at a predetermined dose rate level, such as 15 mSv/hour at 30 cm. This should not be interpreted to require stay times for all locked high radiation area entries; only those where the working area dose rate is equal to or exceeds the predetermined dose rate level. The selection of a dose rate at which stay times are to be implemented is flexible. Values for this dose rate may vary between 1.5 R/hr to 5 R/hr. Most stations use 1.5 R/hr as the standard. Stay times are formally documented, approved and retained as part of the radiation work permit. If a worker exceeds his or her predetermined stay time without exceeding the dose goal for the job, regardless of whether the individual is on telemetered dosimetry, the worker is removed from the high dose rate area. Work is not be allowed to continue until a new stay time is calculated, documented and approved by the same level of management, or higher, that approved the initial stay time. This recommendation has been misinterpreted with the assumption that radiological coverage required by technical specifications, eliminates the need to use stay times. A defence-in-depth approach must be in place to fulfil this recommendation. Testing should be considered for station workers to verify their ability to hear the alarm tone. Compensatory measures need to be taken in high	on 10Feb2014: Any one who has hearing tests are [sic] screened for being able to hear an EPD alarm. We use a cut off of 80 db at 6000 Hz. No further action." Per Section 4.7.3 (3) of the Radiation Exposure Permit Procedure [SEC-RPR-00015], "'Neutron dosimetry shall be specified for work where the estimated neutron dose is greater than 1 mrem [0.01 mSv]." Section 4.7 of [BP-RPP-00020] describes how neutron dosimetry is performed. A contingency plan in case of electronic dose tracking system failure has been developed and documented in the procedure Dosimetry and Dose Control During Service Interruption [SEC-RPR-00030]. There is no documented requirement to monitor unexpected Zone 1 doses by placing TLDs in strategic areas. Recommendation EDC-7 of [SA-RPR-2013-03] was to "Consider placement of area TLD dosimeters at strategic locations on site within occupied areas to confirm that personnel outside the radiologically controlled areas (i.e., outside the unzoned, zone 2 and zone 3 areas) are not receiving unexpected dose from radioactive materials." This recommendation was assessed under AR 28399588-07, and that assessment resulted in new actions on RP Programs to "benchmark numbers and locations of dosimeters as well as take a lead on the implementation of the new program requirements." The completion notes do not give the numbers of the new actions, so their status cannot be determined. However, there is evidence in the form of an e-mail from the HP Lab reporting quarterly TLD results for locations in Zone 1, showing that such monitoring is conducted.	

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	noise areas of the plant to ensure workers will be warned if their dosimeters alarm. Use compensatory measures, such as visual or vibrating alarms or remote monitoring with voice communication for personnel unable to reliably hear audible alarms. Monitor neutron dose for each worker who handles a neutron source, enters a neutron radiation area (for example, an area with neutron dose rates greater than 50µSv/hour at 30 cm), or is expected to receive greater than 100 µSv of neutron dose for any work activity. If neutron dose is expected to exceed 100µSv, include the use of a dosimeter capable of measuring neutron dose. Electronic tracking systems currently in use, automatically record and track accumulated exposure against established dose control levels each time a worker signs off a radiation work permit. Establish contingency plans, in case of electronic system failure, to manually record accumulated exposure, ensuring that dose control levels are not exceeded. Individuals and their supervisors should routinely review current year accumulated exposure. To confirm that personnel outside the RCA are not receiving unexpected dose from radioactive material in the RCA, place dosimeters at strategic locations to evaluate these areas.	3) Extremity dose: Compliant [BP-RPP-00020] requires that extremity TLDs be used when the extremity dose is likely to exceed the whole body or skin dose by 250 mrem (2.5 mSv) per day. Section 4.5.1 of the procedure Dosimetry Requirements [BP-PROC-00280] specifies that "For monitoring of equivalent doses, all statistically significant doses that could contribute to a total annual equivalent dose greater than 50 mSv shall be recorded. … for measurements made at weekly intervals (e.g., hands and feet) this corresponds to approximately 1 mSv per measurement." Section 4.4 of [BP-RPP-00020] provides detailed guidance to workers on the issuing and wearing of extremity TLDs. A self-assessment conducted in October of 2015 [SA-RPR-2015-05] found that many problems with extremity TLD usage persisted from an assessment completed the previous year. These included lost extremity TLDs, poorly labeled extremity TLD packs, extremity TLDs returned late, incorrect use of station extremity TLD logs, and incorrect identification of the requirement for extremity TLDs in REPs. These deficiencies are being addressed through corrective actions, and so are not considered to be gaps for the present assessment (see Section 7.1 of this report.) 4) Skin and lens of the eye: Indirect Compliant Section 4.7 of the procedure Selection of Radiation Personnel Protective Equipment [BP-RPP-00014], states that "plastic hood visor material is too thin to provide any	

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	3) Extremity dose In work situations where extremity dose (including penetrating and non-penetrating radiation) is significantly higher than whole-body dose, use additional dosimetry devices to measure and control dose. Unmonitored dose (that is, dose calculated from the field measurements received when extremity dosimetry was not issued), should not exceed 1 per cent (5 mSv) of the annual regulatory limit per occurrence, or 10 per cent (50 mSv) of the annual regulatory limit for all occurrences. Track the dose for monitored extremities of workers, to ensure that combined (unmonitored and monitored) extremity dose does not exceed regulatory limits. For example, each extremity of a worker is provided with an dosimeter in the event it could receive 5 mSv (beta plus gamma) and/or more than two times the expected whole-body dose. Evaluate extremity dose rate surveys carefully to ensure they are accurate. Account for any significant disparity between the location of the extremity and the centre of the sensitive volume on the instrument. Also consider geometric dependence when determining the appropriate location for extremity dosimeters. 4) Skin and lens of the eye dose Dose to the skin and lens of the eye is difficult to assess, therefore, minimise dose rates by	appreciable protection from beta radiation. Approved safety glasses with side shields (e.g., polycarbonate lenses at least 2.2 mm thick) shall be worn for the protection against beta radiation exposure to the eyes." For the skin, the emphasis is on the use of protective clothing to prevent contamination. Guidance on the selection of base protective clothing and anti-contamination protection for radiological work is provided in Appendix A of [BP-RPP-00014]. The TLD used at Bruce Power is designed to measure skin dose from low-energy photons and beta radiation. Under non-uniform exposure conditions, multiple dosimetry is used as described in Section 4.2.8 of [BP-RPP-00020], and the readings are interpreted as described in Section 4.7.1.2 of the Dosimetry Section Procedure Dosimetry Methodology - Personal TLD System [SEC-DOS-00044]. The latter procedure also explains in Section 4.8.2 that the dose to the skin of the face due to beta rays will be more restrictive that than the dose to the lens of the eye, so dosimetry specifically for the lens is not required. (See note regarding possible change of dose limit for the lens of the eye, above in assessment of Clause III.C1 (a)(1).) A personal contamination event is defined in the procedure Decontamination [BP-RPP-00007] as an event where the detected contamination exceeds 100 net cpm on a pancake detector. Dose to the skin resulting from contamination is calculated from information recorded on a Personal Contamination Incident Report [FORM-11079] according to the procedure Dosimetry Methodology - Skin Dose from Contamination [SEC-DOS-00043]. Results of the calculation are entered into the person's dose record using the form Manual Input/Edit of Dose [FORM-13384].	

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	shielding or decontamination. Determine the non-penetrating radiation energies and dose rates encountered during work. From this, develop procedures to ensure that sufficient measures are taken (for example, use of protective clothing, safety glasses and face shields) to prevent substantial skin or eye dose. Consider mobility and heat stress when determining the need for personnel to wear protective clothing. Use dosimetry to measure dose to the skin and the lens of the eye, if the dose to the worker has exceeded, or is expected to exceed, 10 per cent of the regulatory limit. Dose to the skin of the extremities or to the skin of the whole body is defined as shallow dose equivalent. Develop simple procedures for field estimation of skin dose. For example, dose estimates based on net counts per minute (ncpm) times minutes of exposure. Perform formal dose calculations for skin contamination levels greater than 50,000 ncpm on a frisker. Whenever a dose assessment is performed, enter it in the individual's radiation dose totals and retain a copy of the dose assessment in the individual's records. b. Worker dose assessments In certain instances, a dose assessment is conducted to determine the dose an individual has	b. Worker dose assessment: Compliant Section 4.2.4 of [BP-RPP-00020] lists conditions under which a TLD is to be sent for a rush readout, i.e., an urgent assessment of external dose. The conditions are: "1. The EPD indicates a dose in excess of legal limits. 2. The worker has exceeded an exposure control level (ECL) and is required to do further radioactive work before normal badge read out. 3. The EPD of a pregnant worker indicates 10 mrem or more for the dosimetry period for which the TLD badge was worn. 4. The EPD has failed or indicates an unusual reading while performing radioactive work. "The worker shall not do any further radioactive work until the dose evaluation is complete." Whole-body doses measured by TLD are compared at the end of each dosimetry period with the cumulative results from EPDs for the same period. If the difference exceeds a verification level defined by an equation given in Section 4.10.2 of [SEC-DOS-00044], the discrepancy is investigated by station HPs and the Health Physicist/External Dosimetry. The purpose of the investigation is to determine what dose to assign to the person. Section 4.10.3 of [SEC-DOS-00044] establishes investigation levels of 500 mrem for WB dose and 5000 mrem for SK dose (see explanation of dose quantities below under next heading.) Doses above these levels are investigated by the	

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	received; for example, in the following situations: • A worker enters the RCA and does not wear proper dosimetry or does not wear it in the correct location; • An electronic dosimeter malfunctions, or a self-reading dosimeter indicates off scale or malfunctions; • A comparison of primary and self-reading dosimeters for the same time period and body location, shows a significant difference in measured dose (for example, primary dosimeter or electronic dosimeter dose exceeds 1 mSv and the reading differs by more than 25 per cent); • For multi-site utilities that issue electronic secondary dosimeters from a common pool, primary-to-secondary dosimeter comparison may be normalised by accounting for known/documented intentional dosimeter bias adjustments, to focus discrepancy research on unknown/unidentified mismatch conditions; • Dosimeter results are unavailable or unreadable as a result of loss, damage, or other causes; • The dosimeter does not measure all types of radiation for which exposure is greater than 100 µSv. Dose assessments should include the following, as applicable:	Authorized Health Physicist to verify their accuracy. Appendix B of [SEC-RPR-00038] lists the information that is required to be collected following an EPD dose alarm to assist in the investigation of a radiological event and in the assignment of dose. One of the items required is the dose received by other workers involved in the task. This procedure lists in Appendix C similar information requirements following a personal contamination event and in Appendix D for a positive whole-body count. In the case of missing or replacement TLD badges, Section 4.2.7 of [BP-RPP-00020] requires the completion of [FORM-11063], Missing/Replacement TLD Badge Report, which requires the worker to indicate gamma/beta dose rates for each job and co-worker(s) names as applicable. The dosimetry badges used by Bruce Power contain four TLD elements. All four are read out, and an algorithm is used to combine the results into Whole Body (WB) and Skin (SK) doses. The algorithm also sets flags when the readings are anomalous, to permit a nonstandard assessment of the readings, as described in Section 4.3.5 of [SEC-DOS-00044]. Dose to the skin resulting from contamination is calculated from information recorded on a Personal Contamination Incident Report [FORM-11079] according to the procedure Dosimetry Methodology - Skin Dose from Contamination [SEC-DOS-00043]. Results of the calculation are entered into the person's dose record using the form Manual Input/Edit of Dose [FORM-13384]. Section 7.1 of the procedure Dosimetry Methodology - Personal TLD System [SEC-DOS-00044] assigns the Health Physicist - External Dosimetry responsibility to perform dose	

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	• Reading the individual's undamaged dosimeters and/or undamaged primary dosimeter elements; • Testing a damaged or potentially inaccurate dosimeter to ensure the device is operational, before returning it to service or to determine if the device failed (for example, spike tests); • Determining the dose to the individual based on dose received by co-workers, or calculating a dose based on occupancy time and dose rates in the work area; • For primary and secondary dosimeter discrepancies (in addition to the above), checking dose comparison data for the following: - Mathematical or bookkeeping errors; - Known response differences resulting from intentional/programmed secondary dosimeter bias; - Evaluating the dose measured from other primary dosimeter materials in the badge (for example, beta thermoluminescent dosimeter [TLD] chip), and interviewing the worker to identify possible causes of the discrepancy (such as not wearing the dosimeters close together in fields with large gradients or not wearing the primary dosimeter for a job entry); • Calculating dose caused by skin contamination (for example, using the latest	investigations and special dose assignments, and to review documentation, results and dose assignments. Section 7.3 assigns the Authorized Health Physicist responsibility to interpret and assign dose when above the investigation level. There is no requirement for each worker to sign their dose assessment, but they have access to the information through the Radiation Dose Information System. c. Total effective dose equivalent: Compliant The terminology in this clause of the WANO guidance is peculiar to the US. Bruce Power uses the term whole-body (WB) dose for the internationally-recognized quantity personal dose equivalent at 10 mm depth and the term skin (SK) dose for the quantity personal dose equivalent at 0.07 mm depth. The WB dose is equivalent to the American term DDE. When combined with internal committed dose to the whole body, the result is effective dose, equivalent to the American term TEDE. When external radiation fields are highly non-uniform, multiple dosimeters are used. Section 4.2.8 of [BP-RPP-00020] provides guidance on the use of multiple dosimetry. When the dose to the head is expected to exceed the dose to the trunk by 100 mrem, one TLD/EPD pair may be worn on the head or hard hat and a second pair on the trunk. The method for combining results from multiple dosimeters to give a better estimate of effective dose is described in Section 4.7.1.2 of [SEC-DOS-00044]. Detailed procedures for the issuing and use of all types of dosimetry are provided in [BP-RPP-00020]. Processing of TLDs is performed under the terms of the Dosimetry Service	

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	revision of the VARSKIN methodology or equivalent and considering the geometry and window area of the instrument used to measure contamination levels); • Evaluating the validity of each measurement, with consideration given to using the most conservative measurement when investigation results are inconclusive. Radiological protection supervision reviews and approves dose assessments. When possible, the worker signs the assessment to verify that the information provided is accurate, and that the worker understands the dose assigned as a result of the assessment. Dose assessment results are entered in the individual's radiation dose totals, and a copy of the assessment is retained in the individual's dose records. c. Total effective dose equivalent Whole body exposure from external sources of radiation is normally determined by a single dosimeter worn on the chest. This dosimeter measures the deep dose equivalent (DDE) component of dose. When the radiation field is highly non- uniform, the chest dosimeter is relocated to the part of the body expected to receive the highest dose. Alternatively, additional dosimeters are worn so that the highest whole body dose can be measured. DDE is added to the committed effective dose equivalent (CEDE) from	Licence, and is described in [SEC-DOS-00044]. Dose records are discussed in Section 4.13 of [SEC-DOS-00001]. d. Calibration and quality control of dosimeters: Not assessed. Not assessed - Calibration and quality control of dosimeters are required as part of the Dosimetry Service Licence under S-106, and are therefore not assessed here. e. Calibration of dose rate instruments: Not assessed. The only dose-rate instruments that are normally used for dose assignment are neutron remmeters. Calibration of these instruments is subject to the requirements of the Dosimetry Service Licence, under S-106.	

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	internal sources and compared to the occupational dose limit of 50 mSv per year total effective dose equivalent (TEDE). Difficulties arise from this practice. The regulating limit is based on a stochastic risk of whole-body exposure, which is related to the dose quantity - the effective dose equivalent (EDE). While the use of DDE to approximate EDE works well in uniform radiation fields, in highly non-uniform radiation fields the reading may be inaccurate, providing an indication of dose much higher than actual dose. In these cases, an accurate estimate of EDE is needed to improve the assessment of occupational dose. Prior to the use of EDE, provide training on the use and limitations of the EDE methodology. The level of training needs to be appropriate for all affected radiation workers and radiological protection personnel responsible for EDE implementation and oversight. Procedures control the issue, use, processing, and data recording of dosimeters used to determine EDE. d. Calibration and quality control of dosimeters Calibrate dosimetry devices to measure dose equivalent directly or indirectly (that is, through calibration factors). Establish a quality assurance programme for dosimetry processing systems. The programme		

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	applies to dosimeters processed both in house and off site by vendors. Ensure that the programme includes the following elements: • Quality control checks are performed periodically to verify proper operation of the processing system. Dosimeters irradiated to a known quantity of radiation (of appropriate energy), are read during each processing run or batch to detect reader malfunction or excessive system bias; • Quarterly or prior to each process run, a set of gamma and beta blind standards (usually called spiked dosimeters), is processed on all readers in use. Neutron blind standards are processed periodically if neutron dosimetry is used to determine official dose. The dosimeters are exposed to the types of radiation dose levels (and energy levels) they will be measuring; • The number of spiked dosimeters is statistically significant for the overall population of dosimeters. For multisite utilities that issue dosimeters from a common pool, one set of spiked dosimeters may be sufficient. However, if dosimeters are kept segregated for specific stations, then a set of spiked dosimeters representing each station is necessary to ensure sampling of the entire population; • If significant errors exist, the cause is investigated and the quality of the dosimetry system results assessed before dosimeter values		

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	are assigned. Errors in spiked dosimeter results that show greater than 15 per cent bias should be investigated, and corrective actions initiated to restore programme accuracy. Modify calibration energies when changes in isotopic compositions could affect their validity; for example, after zinc injection begins, after fuel failures and after antimony input. On an annual basis, review the analysis of the station radionuclide mix performed to comply with radioactive waste burial site requirements. Base dosimetry processing frequency on the limitations of the dosimetry system. Also consider other factors, such as the expected dose accumulation rate and worker dose compared to administrative control levels or regulatory limits. Conduct thorough evaluations to support the processing frequency. Calibrate electronic dosimetry at least once every year, or whenever results indicate that a device is potentially defective. Pocket ion chambers should be tested at least every six months. It is particularly important when electronic alarming dosimeters are used instead of a radiation survey instrument, for entry into high radiation areas; for example, during an emergency response. Procedures should describe testing, calibration criteria and restrictions on the use of electronic dosimetry. As a minimum, the procedures should include the following elements:		

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	• Use calibration energies similar to those the dosimeters will be exposed to. Typically, cobalt-60 or cesium-137 is acceptable. However, consider dosimeter response to other energies, such as nitrogen-16 or noble gas submersions. Evaluate and if necessary, apply corrections or restrictions on dosimeter use. Include a check of the dosimeter alarm function and speaker volume in the calibration; • Know the effect of neutron and beta radiation on dosimeter readings. If necessary, apply corrections or place restrictions on dosimeter use; • Carry out an electronic performance check and/or response check daily or prior to use. If the dosimeter does not have a function that verifies the detector is responding to background radiation, then perform a radiation response check. This check should also verify the dosimeter alarm function; • Ensure the type/model of dosimeter has been tested for angular dependency. Use this data in establishing dosimeter placement criteria; • Track and trend electronic dosimeter performance similarly to other types of dosimeters. Test new dosimeter systems thoroughly. Understand the limitations to different types of radiation, radio-frequency interferences and angular dependencies, prior to placing the		

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	systems in service. Testing should also include new dosimeter system software, as well as communication among software programmes used to capture, store and report dose. Do not rely solely on testing conducted by the vendor. Conduct training for all users to ensure they are familiar with dosimeter use and functions. e. Calibration of dose rate instruments Calibrate radiation survey instruments used, to assign or control worker dose using the guidance. Source-check daily or prior to use on the scale(s) expected. Each scale not source- checked, should be clearly labelled to prevent its use. Document base deviations on a thorough evaluation of historical instrument reliability, instrument age, failure rates and instrument self-diagnostic features. Record and review as-found data when performing calibrations. This data should also be reviewed collectively for each instrument type on a periodic basis, to ensure that the calibration frequency is appropriate. For example, look at the per cent of instruments being recalibrated that have as-found data outside 20 per cent of the true dose rate on any scale. Instruments should respond accurately to the gamma, beta, alpha and neutron energies and intensities encountered in the station. If calibrations are performed with sources of other energies, use calibration or correction factors.		

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	Radiological protection supervision reviews radiological instrument calibration records for completeness and adverse instrument trends.		
III.C3.	a. Survey frequency and review Conduct radiation surveys to identify and control radiation sources associated with the operation of the nuclear station. Effective surveys ensure all radiological hazards are identified and the information is relayed to workers who must access the area. When conducting radiation surveys, determine the frequency and the extent of the survey based on historical data, the potential for change and the need for reducing dose to radiological protection technicians. Perform surveys for areas routinely accessed. Conversely, restrict access to areas that do not have current approved surveys. Survey techniques need to take into account the types of radiation expected to be encountered. Limitations with survey instrumentation should be understood and factored into the types of surveys performed and the controls put in place based on survey results. Document radiation survey results as soon as possible and have radiation protection supervision review them promptly. This review is to ensure that all required surveys have been performed and that survey documentation is accurate and complete. The review may also identify trends or specific general area, and contact radiation levels	Programmatic: Indirect Compliance Identification and Control of Radiation Sources a. Survey frequency and review: Compliant According to Bruce Power's procedure Hazards Surveys, Posting, Response and Recording [BP-RPP-00023], Section 4.1.1, there are three major categories of surveys: - Work planning surveys to establish hazard conditions for exposure and ALARA purposes; - Routine surveys, described in detail in [BP-RPP-00005]; and - Non-routine surveys, which must be carried out by the work group whenever abnormal conditions are suspected or confirmed to exist. According to Section 4.2 of the procedure Routine Radiological Survey [BP-RPP-00005], the Department Manager, Radiation Protection and Industrial Safety "shall develop and maintain their respective station's routine survey program", and, "shall approve their respective facility's routine survey schedules and any subsequent additions, deletions or changes to the established programs". The routine survey schedule contains route codes, frequency and survey points. Section 4.3 of [BP-RPP-00005] states	AD

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	that require further investigation. b. Postings and use of survey information Communicate radiological hazards sufficiently to prevent unplanned exposures. Transitory high radiation areas created when large sources are moved through the RCA, need not be posted, provided that radiation protection personnel directly control the source movement, and that access to the transient high radiation area is positively controlled. Control shielded containers (SCs) such as radioactive waste cubicles (RWCs), filter housings and shielded liner storage containers as follows, when the radiological conditions inside these areas are greater than 1 R/hr: • Place signage or markings on the SC or RWC, warning individuals that Radiation Protection approval is required prior to opening. Actual regulatory postings are also acceptable. These containers should be in an area secured and controlled by Radiation Protection; • If the area containing SCs or RWCs has a locally installed lifting device, THEN the following apply: - The opening to the SC or RWC is bolted in place or is secured with a lock controlled by RP; - OR, the lifting device is physically controlled,	"surveys shall be completed as scheduled", and prescribes tolerances on the survey frequencies. A recommendation arising from a CNSC Type II inspection in July 2015 [BRPD-AB-2015-007] was to "enhance the current required frequency of routine surveys at Zone 1 lunchrooms, Zone 2 coffee shops, and main control room to align with industry standards (e.g. daily surveys)." Bruce Power has agreed to consider the recommended change in the next revision of [BP-RPP-00005] (see Section 7.3 of this report). [BP-RPP-00005] specifies the types of survey required, how the results are documented and posted, and the review and approval process. Follow-up actions for unexpected results are also given. Detailed instructions on the conduct of surveys are given in [BP-RPP-00023]. b. Posting and use of survey information: Indirect Compliance Detailed instructions on the posting of survey results are provided in Section 4.4.1 of [BP-RPP-00023]. This includes posting on flasks, containers and areas holding radioactive materials. Radioactive Material Tags support Ontario Power Generations' criteria for waste acceptance as described in the procedure Segregation and Handling of Radioactive Waste [BP-RPP-00010]. Waste management is outside the scope of this assessment. Section 4.4.1.2 (3)(b) of [BP-RPP-00023] requires that Hot Spots be identified locally with a tag where hot spots are found to be in normally accessible areas.	

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	such as secured with a lock controlled by RP; - OR, the lifting device's controls are physically controlled, such as secured with a lock controlled by RP; - Physical control of cranes or lifts needed to remove shielded container lids may include locks or mechanical devices that require the use of tools to remove; - If SCs and RWCs are in a secured area controlled by Radiation Protection, specifically securing each individual container is not required. • If the area containing SCs or RWCs does not have a locally installed lifting device, then signage on floor plugs is necessary to warn personnel that Radiation Protection approval is required prior to lifting. Physical control of the lifting device, or securing the floor plugs with a lock controlled by RP, is not essential if the device used to lift the plugs is an overhead crane, also used for general lifting (for example, refuelling floor cranes and turbine building overhead cranes). When radiological conditions inside these containers exceed 100 mR/hr, but are less than 1,000 mR/hr, the containers should include signage or markings which warn individuals that Radiation Protection approval is required prior to opening. Actual regulatory postings are also acceptable. These containers should be in an area secured and controlled by Radiation	"Low Background Area" is defined in [BP-RPP-00023], but the purpose is to describe areas "where the background radiation level is sufficiently low to allow a contamination or radiation survey to be completed in compliance with the appropriate procedure." In Appendix C of the procedure Executing Radiological Work [BP-RPP-00041] there is a requirement to cover in an ALARA Briefing the radiological conditions, including low dose waiting areas, which meets the intent of the recommendation in this clause of the WANO guideline. Descriptions of the required radiation warning signs are given in Appendix E of [BP-RPP-00023]. A State of the Functional Area conducted in April 2015 [SA-RPR-2015-SOFA] found that there had been several unposted hazard events at both Bruce A and Bruce B during 2014. The report noted that corrective actions are in progress (see Section 7.1 of this report.) c. Work control methods: Indirect compliance 1) Whole-body or extremity dose control: Indirect compliance The procedure Access Control [BP-RPP-00008] outlines the requirements to access areas of the plant where high radiation fields may exist. Access to such areas is controlled by a system of procedures, alarms and engineered controls which prevent unauthorized or inadvertent entry. Flashing lights are not mentioned in this procedure. According to [BP-RPP-00008], several access control areas	

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	Protection. Identify accessible hot spots (for example, components with contact readings of more than 1 mSv/hour, and more than five times the general area dose rates). Post them as “hot spot” or “elevated dose rates”. Posting transient hot spots (drain lines) may also be appropriate. In many cases, putting dose rate ranges on the hot spot posting may be useful in reducing technician exposure; it would not be necessary to update minor variations in dose rates. Identify low dose rate areas to designate where workers can stage material and equipment, or wait during job delays. Survey information in the form of maps, signs, radiation work permits (RWPs) or status boards should be easy to understand and readily available at the RCA access area and necessary work areas. Ensure this survey information is sufficiently detailed to educate workers regarding the dose rate profile in large areas, such as the reactor building or containment. Date the survey information, so radiological protection technicians and workers can evaluate its applicability based on known system changes. Workers review this information, attend pre-job briefings that include appropriate survey information and use the information to control their doses.	require the access control key lock and multi-locking device to be in use for all staff prior to entering the access control area. Issuing of access control keys is discussed in Sections 4.3.1 and 4.5 of [BP-RPP-00008]. Section 4.1.9 states that it "shall be possible to exit an access controlled area under any circumstances; in situations where entry to an access controlled area is necessary and the normal barriers to the introduction of hazardous radiation fields are out of service, other approved protective measures shall be taken." Section 4.4 of [BP-RPP-00008] overviews how to enter an access control area, specifying that this process is performed by a yellow or green qualified staff. There is no mention of whether encumbrances are attached to key chains to ensure that keys are not misplaced or mishandled, as was noted in [SA-RPP-2013-03]. The resulting recommendation was tracked through assignment 28399588-15, which was completed with the note: "After reviewing the information related to the FASA, the RP SM working group decided that the current program adequately addresses the control of keys in conjunction with the Operations dept access control program." A self-assessment on access control conducted in December 2015 [SA-RPR-2015-01] concluded that no weaknesses in management of access control keys had been identified. A Document Change Request (DCR) was initiated to add an explanation of the access control subsystems to [BP-RPP-00008] (see Section 7.1 for details.) The term "very high radiation area" is not used in current Bruce Power procedures. All access control areas are described in [BP-RPP-00008]. Radiological work with hazard category high, as defined in Table 2 of that procedure,	

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	c. Work control methods 1) Whole-body or extremity dose control Control access to high radiation areas as required by station technical specifications. If authorised by site-specific technical specifications, flashing lights can be used to control access to areas with whole-body dose rates equal to or greater than 10 mSv/hour at 30 cm. This should be used where no other reasonable means are available to prevent unauthorised access. Radiation protection manager approval should be required if flashing lights are in use. When locking systems are used, establish a system for maintaining positive custody of high radiation area keys. If entrances are locked while the area is occupied, locking systems should not preclude exit at any time from the high radiation area. If a normally locked high radiation area must remain temporarily unlocked (for example, broken lock mechanism or personnel working in the area), establish additional access controls to prevent unauthorised entry. Examples include a radiological protection technician or briefed radiation worker stationed outside to control entry. An effective administrative locked high radiation area (LHRA) key control system, includes separate keys for each room. Only the shift radiation protection technician and/or the RP supervisor, holds keys to the LHRA cabinet.	requires RP FLM, HP and AHP/Radiation Safety Officer (RSO) approval in accordance with requirements for planning radiological work [BP-RPP-00011]. Radiological Exposure Permits (REPs) are required for all work categories (i.e., Low to High) in accordance with requirements for planning radiological work [BP-RPP-00011]. For work in high hazard categories with gamma plus neutron dose rate > 1 rem/h, in addition to the REP, a Radiological High Hazard Work Plan [FORM-13907] is required. Additionally, the REP [FORM-11106] indicates whether high hazard work is taking place through a check mark. This form complies with intent of the guideline. Within Bruce Power's current REP system, the forms do not vary based on the radiological work hazard category from Low to High, with the exception of a marked field for high category work. As noted in the REPs, the upper bound levels are used to define the values for which a worker back-out is required, indicated on the "Backout/EPD" tab in accordance with the procedure Radiation Exposure Permit [SEC-RPR-00015]. Section 4.7.1 (7) states that the "estimated exposure time multiplied by the estimated gamma dose rate at 30 cm will provide the total gamma dose value for the Electronic Personal Dosimeter back-out recorded on the backout/EPD tab." As noted in Section 4.7.5, there is a whole-body gamma dose pre-alarm set at 80% of the upper bound value automatically. EPD limits are reviewed in accordance with Appendix C of [SEC-RPR-00015]. Recommended gamma dose rate alarm settings are 30% higher than the average of the peak dose rate received for a given REP, and the limit for gamma dose rate alarms is set at the maximum peak dose rate received	

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	LHRA keys are only issued to qualified radiation protection personnel. Master keys are only used in emergencies, however, in certain situations RP technicians may use a master key. For example, when preventive maintenance is being performed on multiple door locks or when an area is being down-posted from LHRA conditions. The situations are acceptable as long as no actual entry is made into the LHRA. Implement a formal key checkout and return process, require a routine inventory and have another individual verify that the door is locked. In addition, consider attaching a bulky key chain or device to the key as an encumbrance, to ensure that the key is not inadvertently misplaced or mishandled. In some cases, the operations control room may have a master LHRA key for emergency use only. The control and storage of this key is equivalent to that of LHRA keys stored in the radiological protection area. The key is kept in a locked storage container, with the operations supervisor controlling the key to the container. The key is also routinely inventoried to ensure its safekeeping. Additional controls are required for very high radiation areas; these need to include provisions for key control, separate from those for high radiation and locked areas. Controls include notification of appropriate station management and written approval of the radiological protection manager, prior to entry into a very high radiation	on one EPD issued to the REP. Appendix C of Executing Radiological Work [BP-RPP-00041] states that EPD dose and dose rate alarm set-points shall be covered in an ALARA briefing as well as being part of the radiological component of the Pre-Job Brief. Direction on the use of dosimetry for workers can be provided through the REP as noted in Section 4.7.4(3)(c) of [SEC-RPR-00015], including whether there is specific dosimetry placement requirements. For example, an EPD should be worn so that it can be visibly monitored, providing guidance that "EPDs should be checked once or twice per hour when working in areas with working distance dose rates below 100 mrem/h [1 mSv/h] and more frequently when in areas with higher working distance dose rates." As part of preparing the REP, as noted in Section 4.7.4 (6) of [SEC-RPR-00015], it should be determined if a Protection Assistant is required, if "the work is classified as high hazard, hot particles, or is complex radiological work". The REP is then reviewed during the Pre-Job Brief [BP-RPP-00041]. As noted in Section 4.3.2 of [BP-RPP-00041] "Radiological hazards are monitored while conducting radiological work to ensure: - That working conditions remain within the limits of the REP, - The safety of personnel engaged in the work; - The safety of other workers." Also noted in this section is that "Radiation surveys are performed before, during and after work, as defined in the REP to verify that radiological conditions are as expected".	

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	area. In general, specific radiation work permits should control work in areas with dose rates greater than 1 mSv/hour at 30 cm. Under limited conditions, area tours, operator rounds and inspections in areas with dose rates less than 10 mSv/hour at 30 cm, may be performed under a general RWP. Radiological protection management determines when and if these exceptions are warranted. Establish individual allowable dose and corresponding electronic dosimeter alarm set points (accumulated dose and dose rate), on both general and specific RWPs to align with the radiological conditions in the travel path. As well as this, align with the work area and account for the projected duration of the tasks to be performed. Establish the electronic dosimeter dose alarm set points at a threshold to not only prevent unnecessary dose, but provide sufficient margin to prevent an administrative burden. For example, an alarm set point that is 110 per cent of the anticipated dose for entry may be a reasonable threshold to consider. Periodically review and adjust electronic dosimeter dose and dose rate set points, based on data from RWP entries. For RWPs for which the average dose is less than 0.25 mSv, set the dose alarm within 0.1 mSv of the average. Establish dose rate alarm set points at thresholds, to alert workers that they have entered unexpectedly high dose rate fields. Consider	The Pre-Job Brief as described in Appendix C of the procedure Executing Radiological Work [BP-RPP-00041] is needed as "workers are required to ensure that they understand and agree with planned aspects of radioactive work". The REP is generally entered in the REP software in accordance with [SEC-RPR-00015]. Estimated doses are calculated during preparation of the REP, as described in [SEC-RPR-00015]. After anticipated radiological hazards have been entered, the required dosimetry and protective equipment are automatically specified in the REP. Section 4.3.3 of Executing Radiological Work [BP-RPP-00041] specifies that "Workers shall check their EPDs periodically to ensure that their dose/dose rate is within the expected range and is maintained ALARA", and further states that if back-out limits are reached workers shall place their work in a safe state and back out of the area immediately. Part of the pre-job brief of REPs as documented in Appendix C (11)(g) of [BP-RPP-00041] is to consider "what is the worst thing that could happen?" Also to be considered: "Is a RP Technician required?", addressing dedicated radiological protection coverage. 2) Beta dose control: Compliant Guidance on performing beta radiation surveys is provided in Section 4.3.1.2 of the procedure on hazard surveys [BP-RPP-00023]. According to Section 4.7.2 (1)(b) of the REP procedure [SEC-RPR-00015], "Beta dose rates and gamma dose rates at 30	

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	alarm set points of less than, or equal to, 150 per cent of the maximum dose rate anticipated for work areas of less than 1 mSv/hour. Consider alarm set points of less than, or equal to, 125 per cent of the maximum dose rate anticipated for work areas that exceed 1 mSv/hour. Alarm set points at thresholds in significant excess of the actual work area dose rates, will likely never be exceeded and therefore, provide no value in the prevention of unplanned exposures. In pre-job briefings, discuss and document any anticipated electronic dosimeter dose rate alarms. Delineate appropriate worker actions in response to the alarm. Any electronic dosimeter alarm not anticipated and discussed at a pre-job briefing should be considered unexpected, and the appropriate action taken by all personnel involved. Personnel monitor their dose at a frequency appropriate for the radiological conditions, and do not solely rely on alarms to alert them to unknown conditions or high accumulated dose. Prior to a job or activity, workers need a thorough understanding of the controlling RWP, and should be given the opportunity to discuss the requirements with radiological protection personnel. While on the job, workers periodically read their self-reading dosimeters; know their allowable dose; refer to survey maps; adhere to posted instructions; and, in high radiation areas, use dose rate or integrating dose meters. Radiological protection technicians use	cm will be used to automatically calculate the estimated skin dose". Dosimetry and radiation personal protective equipment (RPPE) are automatically recommended through the REP creation process. The procedure on selection of RPPE [BP-RPP-00014] describes appropriate equipment for protection from beta radiation. In Section 4.7, it notes that "Plastic suit hood visor material is too thin to provide any appreciable protection from beta radiation", and goes on to require that "Approved safety glasses with side shields shall be worn for protection against beta radiation exposure to the eyes.". A detailed justification for this requirement is provided in Section 4.8.2 of [SEC-DOS-00044]. 3) Additional Controls for Special Areas: Compliant There are no specific documented requirements to provide additional controls in areas where personnel could receive dose in excess of ADLs within a short time. The FASA [SA-RPR-2013-03] resulted in recommendation EDC-16 to consider the establishment of a dose rate threshold, above which positive physical control of the area must be established. This recommendation was tracked with AR 28399588-16, which was closed with the completion note "Due to our physical configuration, our current procedures for controlling access to higher dose areas are adequate to provide proper protection of our radworkers from unplanned and inadvertent exposures." As noted above, the procedure Access Control [BP-RPP-00008] describes the access control system as a system of procedures, alarms and engineered controls which control unauthorized or inadvertent access to areas where	

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	predetermined dose controls for work in high radiation fields (more than 1 mSv/hour at 30 cm) or, if administrative dose control levels are being approached. The key actions associated with predetermined dose controls are documented. These records are reviewed by radiological protection supervision to assess the adequacy of the dose controls used. The following are examples of dose controls: • Thorough pre-job radiological surveys; • A detailed pre-job briefing with the worker and technicians to review the task. This includes the specific steps required to complete the work and the position of the workers relative to the source(s) of radiation, the identification of evolutions when dose rates may change significantly, and any dose reduction actions to be taken; • Accurate determination of the workers' available dose; • Calculation of the estimated dose, proper assignment of stay times and predetermined accumulated dose for job termination; • Use of alarming dosimeters and alarm set points, remote monitoring dosimeters, video monitors, and audio communication devices; • Assignment of a dose rate at which the job is to be stopped (for example, dose rates 50 per cent higher than those expected or previously known);	hazardous radiation fields sufficient to cause acute high doses to station personnel may exist. Areas controlled by the access control system include those in the vicinity of the reactors, fuelling machine operation and their auxiliaries where high radiation levels may exist. Regarding work in and around spent fuel bays, [SA-RPR-2013-03] made the recommendation EDC-17 : "Consider the development of governance that requires the establishment of physical control of cables or tooling in the spent fuel pools that may contain material that could cause very high exposures in short time periods. Define methods of establishing physical control (such as locking cable to prevent inadvertent removal), issue and control of keys, and methods of monitoring and controlling materials removed from the pool." The resulting AR 28399588-17 was closed with the completion note "Current process and policy in place adequately controls the risk." As noted in [SA-RPR-2013-03], "Suspending high activity materials from cables on the side of spent fuel pools is not practiced at Bruce. The exception is Cobalt that has been harvested. Those cables are protected by a cover that is locked with key control in Operations." Special controls for handling spent fuel are described in the procedure Fuel Handling [BP-PROC-00460]. Controls on diving operations are described in the procedure Radiological Control for Diving Operations [SEC-RPR-00043]. Use of physical controls (e.g., tethering or physical barrier) is not discussed. This was noted in [SA-RPR-2013-03] and led to Recommendation EDC-18 to "Initiate a DCR to revise SEC-RPR-00043 to incorporate physical barriers or tethers to remove the potential for diver movement beyond	

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	• Anticipation of unusual, worst-case scenarios or unexpected conditions that might arise during the job, and development of contingency plans for protective actions that may be necessary; • Dedicated radiological protection coverage; • A specific radiation work or access permit to control access. 2) Beta dose control Beta dose control entails the performance of accurate surveys to identify beta radiation sources and their elimination whenever practical. Techniques to minimise beta radiation include decontaminating, shielding the source, or having the worker wear protective clothing. When selecting beta reduction techniques, consider any increase in whole-body dose that might be received while the technique is implemented. Face shields or safety glasses are used to minimise beta dose to the lens of the eye. 3) Additional controls for special areas Where personnel could receive dose in excess of administrative dose control levels within a short time, provide additional controls, such as positive lockout tag out procedures, to prevent unauthorised access. These special areas for pressurised water reactors (PWRs), include under	accepted dive boundaries." The tracking AR 28399588-18 was closed on September 4, 2014, with the completion note "Initiated DCR 28454232 against SEC-RPR-00043 to incorporate the expectations on the use of tethers or physical barriers to prevent divers from inadvertent exposure." The DCR is at Approved status with a due date of September 30, 2016. Potential neutron radiation hazard locations are identified in Table B.1 of [BP-RPP-00011]. Guidance on performing neutron surveys is given in [BP-RPP-00023], and includes a note that "Beams and streaming are potential concerns when work involves opening a reactor system shielding, as this may result in increased dose rates and neutron scattering" (Section 4.3.1.3). Neutron dosimetry required in such areas is described in Section 4.7 of [BP-RPP-00020]. Under the procedure Access Control [BP-RPP-00008], Access Controlled Areas where high dose rates may occur require the access control key lock and multi-locking device to be in use for all staff prior to entering the access control area. 4) Radiography: Acceptable deviation Radiography using radioactive sources is regulated under one of Bruce Power's Nuclear Substance and Radiation Devices Licences. Radiographers are Certified Exposure Device Operators, authorized by the CNSC. According to the procedure Conduct of Radiography [BP-PROC-00036], "Radiography is frequently performed within the protected area of the stations (e.g., Bruce A or Bruce B) where the station radiation protection procedures apply; however,	

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	the reactor cavity when in-core instrument thimbles are withdrawn; in-core instrument drive rooms and probe storage areas; inside steam generators; and within the biological shield in containment at power. For boiling water reactors (BWRs), examples of these special areas are the drywell at power, the traversing in-core probe (TIP) room, and resin transfer lines to radwaste. Take precautions for work activities in and around areas such as spent fuel pools that may contain materials with very high dose rates if unshielded. Materials with radiation levels in excess of 10 mSv/hour at 30 cm in air that are suspended from cables on the side of spent fuel pools or reactor cavities, are clearly labelled and locked. Alternatively, they are controlled by some other physical barrier such that personnel are warned of the hazard, and cannot accidentally pull the material out of the water. Items than cannot be removed inadvertently (that is, physically removed by an individual), must be clearly labelled to warn personnel of the radiological hazards associated with the items. Establish special controls for loading and unloading spent fuel storage containers. Diving operations around irradiated components or in the vicinity of spent fuel, require both administrative and physical controls (for example, tethering of the diver or installation of a physical barrier), to prevent unplanned exposures. Detailed procedures, thorough pre-job briefings, clear	because of different regulatory requirements, it is essential to recognize that in some instances the radiological safety rules that apply to the conduct of radiography may differ" (Section 4.0). This procedure provides detailed guidance on the performance of radiography by Bruce Power staff and contractors at the stations. Another procedure, Radiation Protection Oversight of Industrial Radiography [SEC-RPR-00056], explains that "Radiography, when performed, is treated as an activity with high radiological risk. The RP organization provides oversight of radiography that is performed anywhere on site, including outside the protected area and in confinement/containment in accordance with this procedure" (Section 4.0). It goes on to say "Alternate examination methods should be considered by the requesting organization prior to scheduling radiography. If no other inspection method can be utilized, then radiography is planned accordingly and this procedure is implemented." The provisions of these procedures address all of the WANO guidance items with two exceptions: radiography boundaries are set up at dose rates of 10 mrem/h, rather than the recommended 2 mrem/h, and remote instrumentation is not used to verify that the source is fully retracted and shielded. These differences were noted in [SA-RPR-2013-03], and resulted in Recommendation EDC-19, "Evaluate the requirement to lower the level at which radiography boundaries are posted to 2 mR/h. and employ the use of Portable Area Gamma meters, located near the camera body to confirm retraction of the radiography source." The recommendation was captured in AR 28399588-19, which was closed with the completion notes:	

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	assignment of responsibilities, effective communication, thorough review of industry operating experience and additional management oversight are needed. Controls are based on the highest dose rate field accessible to the diver, not just the area of the intended dive. Entries into PWR containments and BWR drywells at power also require neutron dose control. This entails performing accurate surveys to identify neutron radiation sources and minimising these sources whenever practical. Give particular attention to identifying neutron streaming. Use techniques to minimise neutron radiation, such as lowering reactor power and installing special shielding. Control system operational changes and evolutions can cause dose rate changes. Where radiation dose rates are or can exceed 1 R/hr, post appropriately. The radiological protection manager, or designee, approves each access and controls the keys to these areas. If possible, equipment that can cause elevated dose rates, such as traversing in-core probe instrument drives, should be tagged out when the area is accessible. Radiological Protection should hold the tag or approve its release prior to equipment operation. If operational constraints prevent the equipment from being tagged out of service, implement additional controls. These could include remote monitoring and continuous communication with control room, or radiological	"Performed evaluation of requirement to lower boundary dose rate to 2 mrem/hr (the AR does not provide all the information surrounding the requirement of 2 mrem/hr at the boundary). The NSRD Regulations are very prescriptive in the requirements for the boundary placement which is what Bruce Power is required to follow. Requirement is to prevent entry into areas where dose rates exceed 10 mrem/hr and to post hazard warning signs where dose rates exceed 2.5 mrem/hr. The WANO Guidelines allow for a spike up to 200 mrem/hr therefore CNSC Regulations are more conservative. Current boundary requirement is 10 mrem/hr, however, field observations demonstrate that the boundary dose rate is typically undetectable as a result of radiography operations. "Regarding employing portable area gamma meters at the camera body, radiographers already employ the use of Admiral Survey meters and place those meters at the camera body to indicate radiation levels and to confirm retraction of the source." This is considered to be an acceptable deviation from the Guidelines. d. Identification of precursors to unplanned-dose events: Compliant The procedure Radiation Protection Performance Indicators [SEC-RPR-00012] describes the performance indicators used to measure the effectiveness of the Radiation Protection Program. The indicators include low-level radiological events that could be precursors to more significant events.	

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	protection personnel, to ensure personnel in the area are warned of equipment operation and radiation field increases. 4) Radiography Radiography is a task treated as an activity with high radiological risk when performed. The station radiological protection organisation provides an oversight of radiography that is performed anywhere on site, including outside the protected area and in radiography vaults. Evaluate the use of alternative examination methods to avoid radiography when practical. When necessary, perform radiography using the lowest energy source practical or electronic X-ray generators. Operating experience, within and outside the nuclear power industry, has shown that events occur because of weak control of radiography boundaries, as well as radiographer human performance errors. The following training, planning, briefing and radiography controls have been used successfully in the industry to manage the radiological risks associated with radiography. They should be included in station procedures that control these activities. Use training to help personnel fully internalise the risks associated with radiography and provide them with the knowledge necessary to prevent radiography events. Radiography personnel receive nuclear safety culture orientation, as well	In addition, the SCR process described in [BP-PROC-00060] defines Significance Level 3 as "An incident or substandard condition which is not significant by itself, but which has the potential to be more significant or which may be the precursor to a more significant event."	

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	as training on human error prevention tools, such as procedure use and adherence and three-way communication. Their radiation protection training, knowledge and experience should be verified as sufficient and current, along with knowledge of procedures and equipment. Training for radiological protection personnel who assist and provide oversight includes general radiography camera fundamentals and a review of related operating experience. General employee radiation worker training emphasises the high dose risk of radiography as well as requirements to comply with all radiography barriers and postings. Include radiography in the work control scheduling process to ensure that conflicts with other activities are avoided and that effects on plant equipment and alarms are recognised. Radiography plans are developed and approved before these activities begin. These plans take into account the radiation source type and output; exact radiography location and direction of shot (free air or collimated); and assessment of radiation levels in all surrounding areas, including adjacent buildings, roofs and outside areas. The shielding properties of both permanent and temporary equipment and structures used in calculating radiation levels should be validated in the field. Additionally, these plans should address actions that will be taken to evacuate, post and control the affected areas, including the communication methods that will be used.		

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	Conduct briefings for radiographers and other station personnel involved in the radiography activities. Address potential emergent hazards and clearly define the stop work criteria and actions that will be taken if unexpected events occur. Industry experience has shown that radiographers often do not recognise equipment malfunctions as an anomaly that would necessitate stopping work. Briefings should include pertinent industry operating experience and a review of human performance tools that will be used to prevent errors. Also discuss contingencies for anticipated problems such as the radiography source becoming stuck outside the shield. Clearly communicate radiography activities to all station personnel in a manner that is sufficiently clear and unambiguous. This will help to prevent personnel from entering radiography boundaries. Thoroughly search areas affected by radiography to ensure all personnel have been evacuated prior to shots. Establish and post physical boundaries. However, guarding in lieu of a boundary and posting is not allowed. Locked high radiation area ladder guards may be used to prevent workers from ascending ladders that lead to areas restricted by the radiography. This is providing the area has been searched prior to locking and the ladder guards are properly posted for radiography. Boundaries are walked down by a radiographer and radiation protection personnel knowledgeable		

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	of the plant. This ensures that the boundaries are consistent with the radiography plans and that all accessible areas are posted and controlled. Establish controls, such as boundary guards, to prevent unauthorised entry into the boundaries. Surveys are conducted to verify that dose rates created by radiography do not exceed 200 µSv in one hour at radiography boundaries. The radiation level could briefly exceed 2 mR/hr during source deployment and withdrawal, provided this was addressed in the radiography plan. Radiographer instruments and dosimetry must be capable of detecting and properly measuring the radiation emitted. Additionally, the instruments are source-checked to ensure they are operating properly. Controls are in place to ensure that the radiography source is used only in authorised locations and to verify that the camera and guide tube have been properly maintained and are functioning properly. Radiographers have electronic dosimeters with both dose and dose rate alarms supplied by the station. Work stops if equipment malfunctions or unanticipated electronic dosimeter alarms occur. If dose rate alarms are anticipated during source deployment and retraction, ensure they have been discussed and documented during the pre-job job briefing. Consider the use of remote instrumentation to verify that the source is fully retracted and shielded before radiographers approach the camera.		

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	d. Identification of precursors to unplanned-dose events Review radiological events and deficiencies collectively against causes or precursors to high-dose events. Reviews of personnel radiation doses that exceeded administrative dose control levels or federal limits, have identified a number of precursors to these events, including the following: • Compliance weaknesses are identified in administrative controls such as procedures, RWPs, locked high radiation key control and radiological postings; • Radiological surveys are inaccurate or incomplete; • Work controls, procedures and radiation work permits are insufficient; • Radiological protection technicians are insufficiently trained to understand the radiological hazards, to use equipment and processes effectively to protect workers, and to apply industry operating experience; • Radiological protection personnel are not complying with the radiological rules that all workers are expected to follow; • Pre-job briefings are superficial and do not include a clear description of the radiological		

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	conditions and requirements; • Workers or radiation protection technicians are proceeding when faced with unfamiliar or changing situations, rather than contacting their supervisors; • Workers or radiation protection technicians are rationalising or accepting risk; • Supervisors are not being held accountable to coach and reinforce high standards of radiological performance; • Station management does not emphasise the importance of radiation safety or hold workers accountable for following radiological protection rules and procedures. These precursors may indicate a significant problem in the radiological protection programme, even though no personnel have exceeded regulation limits or received unplanned dose.		
IV.C1.	Minimise individual internal dose to keep total exposure well below regulatory limits. Require workers to notify radiological protection supervision when they undergo medical tests or treatments that involve radiation or radioactive material (routine X-rays excluded). Notification should be made before personnel enter the RCA. This precludes such entry from initiating unplanned contamination monitor alarms, adding medical exposure to station primary dosimeters and contaminating office areas with medical	Programmatic: Acceptable Deviation Internal Dose Controls The purpose of the ALARA program [BP-RPP-00044] is "to ensure that occupational radiation exposures, both individually and collectively are maintained As Low As Reasonably Achievable (ALARA)." These radiation exposures are from both external and internal radiation sources.	AD

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	radioisotopes. a. Internal dose investigation Document positive whole-body counts (the presence of licensed radioactivity above background). Initial screening steps should be taken to ensure that contamination is not external on the body or clothing. Record internal dose in the individual's personal dose record, at a level that can be determined accurately given the instrumentation and algorithms used. Evaluate and investigate positive whole-body counts resulting from unplanned intakes or planned intakes of activity higher than anticipated. If the whole-body count is a result of internal contamination, the documentation includes the following: • The quantities and types of radionuclides detected; • A description of the circumstances involved in the occurrence, such as the location of the worker when the intake occurred; • The radiation work permit number; respiratory and engineering controls used on the job; • The number of derived air concentration (DAC)-hours assigned during the job; • An assessment of the cause; and the	Employees undergoing radiopharmaceutical treatment have specific obligations under Section 4.8.1 of the procedure Facility Access and Working Rights [BP-RPP-00018] not to enter a facility and to notify his/her supervisor of the treatment. Approval of the facility HP/AHP or RSO is required before entry to the facility is permitted. a. Internal dose investigation: Acceptable deviation Whole-body counting is a dosimetry methodology described in [SEC-DOS-00039] and subject to the Dosimetry Service Licence (DSL) issued under CNSC Regulatory Standard S-106. Since technical aspects of the methodology, dose assignment, records and quality assurance are all regulated under the DSL, they are not further assessed here. The risk of external contamination causing a false whole-body count is minimized by adherence to the procedure Zoning [BP-RPP-00015], which requires employees to monitor each time they leave a radiological zone to a lower zone. If a contamination monitor indicates that a person is contaminated, the procedure Health Physics Response to a Personnel Contamination Incident [SEC-RPR-00026] applies. It includes specific requirements for cases of suspected internal contamination in Section 4.8.1 and Appendix D, including the information that must be gathered. Section 4.6 of the procedure Dosimetry and Dose Reporting [BP-RPP-00020] provides detailed instructions on how to perform a whole-body count, and on the response to a positive result. In addition, [SEC-DOS-00039] establishes dose verification and investigation levels, above which the possibility of external contamination would be considered.	

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	assigned dose. The extent of the evaluation is commensurate with the quantity of the intake and the reason for the whole-body count. Track and periodically trend positive whole-body counts to identify common causes in multiple occurrences. Evaluate identified common causes for possible corrective actions to improve the radiological control programme. Establish procedures for investigating whole-body contamination monitor and portal monitor alarms to determine if an alarm is due to internally deposited radioactivity or to external contamination. Provide whole-body counts for individuals who alarm these monitors without the presence of external contamination, to accurately assess any internal dose.	The documentation associated with a whole-body count depends on the type of monitoring. If it was a routine count, there will be no specific circumstances, DAC-h, or REP number associated with it. If it was done as special or confirmatory monitoring, as described in [BP-PROC-00280], then that information may be relevant and collected as part of an investigation. However, there is no documented requirement for this specific information to be recorded. [SA-RPR-2013-03] identified this as a gap, and made two recommendations: IDC1: Initiate a DCR to add REP number to Section 5 of FORM-11079. (This recommendation does not actually address the WANO guideline, since the form is only used following a personal contamination event, and not necessarily following a positive whole-body count.) IDC2: Review process to determine if there is a value to determining DAC-hrs from positive WBCs. These recommendations were tracked with AR 28399591-01 and -02. The first was closed with a completion note stating that a DCR had been initiated to revise FORM-11079 accordingly. The second was closed with the completion note: "This acation [sic] is mis-assigned. Dept Mgr RP Programs notified at AMRM 6 Mar 14 that this action as writted [sic] and assigned will not close the gap noted in the WANO guidelines. It asks that for investigations of internal intakes, the number of DACHRs assigned during the job be recorded. This has to be computed at the time of the job based on as found in the field air concentrations and expected time on the tools. To compute after assigned a dose via WBC is not what	

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		they are looking for, though that is an easy answer. 1 mrem internal dose assigned is 1 DACHR. Dept Mgr RP Programs notified and will raise additional actions as required based on field ability to determine DAC." Based on this explanation, this is considered to be an acceptable deviation from the guideline. Internal dose assignments resulting from whole-body counts are among the Radiation Protection Performance Indicators described in [SEC-RPR-00012]. According to Section 7.3 of this procedure, the SFAM for Radiation Protection: "Follows up with events to ensure that the appropriate mitigating actions have been taken and sufficient information is available to assist in assessing the event. "Collects, analyzes, trends and reports the data in a manner consistent with the expectations identified by the CFAM for Safety. "Identifies adverse trends and initiate corrective actions."	
IV.C2.	a. Airborne radioactivity surveys 1) Sample frequency and collection methods Airborne radioactivity surveys are performed to monitor the concentrations of airborne radioactivity associated with nuclear station operation. They are to be performed as follows: • During any work or operation known or suspected to cause airborne radioactivity, such as grinding, welding, burning, cutting, hydrolyzing,	Programmatic: Gap Identification and Control of Airborne Radioactivity a. Airborne Radioactivity Surveys: Compliant 1) Sample frequency and collection methods: Compliant The procedure Airborne Radioactive Particulate Surveys	Gap

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	vacuuming, sweeping and using compressed air or volatiles on contaminated equipment; during waste-compacting operations; and during contaminated insulation removal; • During any work or operation that involves the breach of a radioactive system for which the potential for measurable airborne radioactivity exists; • Prior to or during initial entry into any known or suspected airborne radioactivity area or area with significant loose surface contamination (for example, ≥100,000 dpm/100 cm2), and periodically thereafter; • Containment/drywell entries if conditions are unknown; • Prior to or during initial entry into any high-risk area such as steam generators, reactor cavities, reactor vessels, or radioactive waste tanks, and periodically thereafter; • Based on environmental factors, such as dry and dusty conditions or the drying out of highly contaminated areas, components, and filters; • When the potential for airborne activity exists, such as the discovery of a significant spill or spread of radioactive materials; • Periodically (such as daily) in RCAs with the potential for changes in airborne radioactivity, including the containment or drywell during	[SEC-RPR-00069] provides direction on: - criteria to determine when airborne particulate radioactivity surveys are required; - methods for performing particulate air sampling; - field screening and analysis of particulate air samples; - assessment and response to particulate air sample results; and - documentation of airborne particulate radioactivity surveys. The procedure Tritium Air Monitoring Program [BP-PROC-00917] provides guidance on the placement of tritium air monitors for the purpose of continuous tritium monitoring of generally accessible areas of the station, monitoring for work in progress, and monitoring of areas with potential for leaks. Tritium bioassay is routinely conducted for workers who may be exposed to tritium in air, per Section 4.5 of the procedure Dosimetry and Dose Reporting [BP-RPP-00020]. Section 4.8 of this procedure requires the use of a Personal Air Sampler for measurement of C-14 or transuranic particulates as specified by the REP. These three procedures demonstrate compliance with all of the WANO recommendations in this section. 2) Equipment setup and calibration: Compliant The procedure Use of Portable Radiation Instrumentation [BP-RPP-00012] provides instruction on the use of all portable instrumentation, including that used for air sampling. For each instrument, it provides general specifications, pre-	

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	outages • Any time respiratory protection devices or alternate tracking methods (DAC-hours) are used to control internal radiation dose; • During any work or operation over or near the spent fuel pool when the coolant analysis indicates elevated levels of tritium; • More frequently when analysis of the reactor coolant indicates the presence of significant fuel leaks, which raises the potential to encounter alpha activity. Increases in gamma-emitting fission products such as the cerium, ruthenium, barium, lanthanum and americium, as well as noble gases, can indicate that alpha emitters have been introduced into the coolant. Also, evaluate previous fuel failures and alpha contamination history, because alpha contamination may be trapped in crevices or surface corrosion layers. Obtain a representative sample of the air breathed by personnel in the area. Use low-volume air sampling to determine airborne radioactivity levels for worker protection. Use high-volume air sampling for situations in which airborne radioactivity concentrations need to be determined rapidly; when the work being monitored is not of sufficient duration to support the time requirement for low-volume air samples; or in conjunction with low-volume air samplers to determine peak airborne concentrations. Lapel air	operational checks and operating instructions. It specifies that an instrument not be used if the date on the calibration sticker is in the past. The procedure Use of the Canberra iCAM Alpha/Beta Continuous Air Monitor [SEC-RPR-00070] describes the startup and functional checks of this instrument in Section 4.4. Typical alarm set points are shown in Table 1 of [SEC-RPR-00070]. Preset instrument operating parameters are established by the Instrumentation Health Physicist in collaboration with RP. All radiation protection instrumentation is required to be calibrated at least annually, per Section 4.2.2 of the procedure Radiation Instrumentation Management [BP-PROC-00192]. A CNSC Type II inspection conducted in July 2015 [BRPD-AB-2015-007] found that all 18 tritium-in-air monitors that were observed were properly located, and in working condition, calibrated and labelled per the Tritium Air Monitoring Program [BP-PROC-00917]. 3) Sample analysis and review: Compliant The procedure Airborne Radioactive Particulate Surveys [SEC-RPR-00069] addresses field screening of particulate air samples, subsequent lab analysis (including spectroscopy for radionuclide identification) and actions to be taken if results are above threshold levels. The procedure Source Term Characterization of Radioactive Systems and Areas [SEC-RPR-00073] describes the goals, processes, and records associated with source term	

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	samplers can also be used to obtain representative samples of the worker's breathing zone and are required for work in alpha level 3 areas. When selecting the air sampler location, consider the effect of air flow from plant or temporary ventilation on the sampler's ability to collect a breathing zone air sample. Take air samples during the expected periods of highest concentration, and evaluate them as quickly as possible to determine the need for engineering controls, respirators, area evacuation, area posting, and worker relief from unnecessary respirator use. Use continuous air monitors (CAMs) for situations in which airborne radioactivity levels can fluctuate, and early detection of airborne radioactivity could prevent or minimise radioactivity inhalation. The monitors should also be located near plant systems that could cause rapid increases in airborne radioac- tivity, such as the recombiner, offgas, steam jet air ejector, or other steam-related systems in a BWR and the refuelling floor during refuelling evolutions. Use CAMs with iodine detection capability when removing the reactor head and internals, as well as during the initial opening of BWR steam systems (such as main steam reheaters). Periodically sample and analyse plant liquid systems that could concentrate tritium. Conduct bioassays when significant tritium intake could occur (for example, following entry into a tritiated	characterization. These data are used to establish radionuclide ratios for each system. Results of airborne radioactivity sampling are recorded on [FORM-13422], Particulate Air Sample Analysis Data. Records of the analyses are also entered into the Radiation Hazard Information System in accordance with [BP-RPP-00023]. Section 4.4.7, of [SEC-RPR-00069] states that "The station HP shall periodically (at least monthly) review air sample results for quality control and identification of adverse trends". a. Posting and access control: Gap (Note that this second section "a" is an error in the WANO Guideline.) The procedure Hazards Surveys, Posting, Response and Recording [BP-RPP-00023] specifies in Table 1 that posting is required when the combined concentration of any type of airborne contamination exceeds 1 MPC(a). This is higher than the WANO recommendation of posting at 0.30 DAC. This difference led to Recommendation IDC-9 in [SA-RPR-2013-03] to "Provide technical basis for posting Airborne Radioactivity Area at 1.0 DAC." The recommendation was tracked with AR 28399591-09. The due date for this assignment has been extended to April 31, 2016, to allow time for completion of the technical basis document. Since this issue is being addressed by the corrective action process, it is not considered to be a gap. A Radiological Work Permit is required for all radiological work, which includes work done in an area of airborne	

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	steam atmosphere). 2) Equipment setup and calibration Equipment used for the sampling and monitoring of airborne radioactivity is maintained in good working order, and is periodically checked to verify accuracy. For example, check the proper operation of CAMs periodically by checking for instrument response to a radiation source. Also, monitor the airflow and airborne activity readings periodically while personnel are working in the area. Air sampling equipment with inlet extension hoses, including continuous air monitors, should not be used for quantitative evaluation of airborne radioactivity levels unless the length, diameter, material, layout, and condition of such hoses has been analysed to show that excessive particle deposition will not occur in the extension line. If inlet extension lines are used for quantitative assessments, adjust the alarm setting of the continuous air monitor to account for line deposition. Set CAM alarm levels to alarm consistently at two or three times the background count rate. CAM alarm set points may be raised during periods of high short-lived fission product or radon progeny product concentrations, with the approval of radiological protection supervision. Document set point changes, so that they can be returned to normal when short- lived or natural radioactivity is	contamination, per Section 4.1 of [BP-RPP-00011]. Although areas with airborne contamination in excess of 1 MPC must be posted according to [BP-RPP-00023], there is no documented requirement to enclose or contain the posted area to prevent the spread of contamination. The procedure Contamination Control [BP-RPP-00022] in Section 4.1.7 provides guidance on airborne contamination control, but says only that "Containment enclosures or portable ventilation systems may be set up to prevent spread of airborne contamination during operating and maintenance activities where release of radioactive liquids or gases is likely to occur." In addition, Item C.14 of the ALARA Plan [FORM-11101] on airborne radioactivity mitigation asks the planner to: "Describe what is being done to control tritium in the work area if it is anticipated (e.g., Munters, portable dehumidifiers, trunking, tenting). "Describe how the spread of contamination in the work area will be controlled if airborne particulate is anticipated to be created during this work (e.g., High Efficiency Particulate Air (HEPA) ventilation, tents, containment trunking)." [SA-RPR-2013-03] contained the recommendation IDC-10: "Initiate DCR for BP-RPP-00023 indicating actions should be taken to contain airborne radioactivity areas (upon discovery) through tenting or other means to prevent the spread of airborne and loose surface contamination." This recommendation was captured in AR 28399591-10, which was to initiate such a DCR. The assignment was closed on February 9, 2014, with the note that DCR 28416907 had been initiated. However, the current revision of the	

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	no longer significant. Check alarm capabilities and set points periodically (typically done daily) to ensure proper operation. Calibrate air sampling equipment annually at the very least. During operation, closely monitor air sampler flows and activity readings. Air samplers that exhibit low or rapidly oscillating flow, erratic or off-scale activity readings, indications of air flow leakage around filters or other indications of damage, should be removed from service, repaired and recalibrated. Test counting equipment daily for accuracy and use charts to trend system response. Perform efficiency calibrations with isotopes which correspond to the station radionuclide mix. 3) Sample analysis and review Analyse airborne radioactivity samples as follows: • To rapidly screen air samples, measure each sample with a thin-window Geiger-Mueller (G-M) detector. Alternatively, a more detailed measurement of activity, especially low-level activity, may be made using a G-M detector and a scaler, or a gas flow proportional counter, both of which will detect beta radiation. Screening methods should consider isotopic mix, sample geometry, and count time. If airborne activity is detected above 0.30 DAC, take protective actions to minimise personnel dose while a radionuclide	procedure (R011) was issued September 25, 2014, without the required changes. The DCR is at "Approved" status, with a due date of March 31, 2015. This remains a gap. **Gap 1** This is also a procedural noncompliance, which is addressed under Safety Factor 10, Organization and Administration. b. Work control methods: Compliant 1) Planned internal dose: Compliant Section B of the ALARA planning form [FORM-11101] requires an estimate of internal dose, but is limited to tritium. Items C.12, C.13 and C.14 ask for descriptions of how internal dose will be reduced through PPE, work practices, ventilation, use of remote monitoring and airborne contamination control as referenced above. There is no specific requirement to address quantitatively reduction of internal dose and the effect on external and total dose. The FASA [SA-RPR-2013-03] recommended (IDC-11) that a review be performed of not including an evaluation of planned internal dose, particularly when tritium is not driving prescription of RPPE. Depending on the outcome of the review, either the requirement should be incorporated into governance or the current position should be supported by a technical basis or formal policy statement. The resulting AR 28399591-11 has led to discussion that is still ongoing, with an extended due date of April 29, 2016. Since this issue is being addressed by the corrective action process, it is not considered to be a gap. The follow-up required by RP staff to an apparent case of	

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	analysis is performed. • A radionuclide analysis of the sample is achieved with a high-resolution gamma spectrometer (for example, germanium). Air samples suspected to be greater than 0.30 DAC should be counted using such a system which assesses the types and quantities of radionuclides accurately. • Alpha, transuranic and other hard-to-detect radionuclides, are often significant contributors to dose from airborne radioactivity. Develop and use methods to account for these radionuclides in the assessment of airborne radioactivity. Ratios can be developed based on representative reactor coolant sample activity and waste stream analysis data. Evaluate changes in plant operation that could significantly alter the isotopic mix. For example consider fuel failures since the last waste stream analysis was performed, and the need to resample and reanalyse for alpha and hard-to-detect radionuclides. It is important to use chemistry sample results to anticipate radiological conditions that may impact radiological controls. Record the results of airborne radioactivity surveys. Include details about: • The date and time the air sample was taken; • The purpose and location of the sample; • The applicable RWP;	internal contamination is described in Appendix D of the procedure Radiation Protection Response to a Radiological Event [SEC-RPR-00038]. It includes the direction "If internal contamination is confirmed, put the worker on REMOVAL so that no further radioactive work can be performed until the internal contamination can be evaluated." The required frequency of whole-body counter monitoring is prescribed in Section 4.6 of the procedure Dosimetry Methodology - Whole Body Counting [SEC-DOS-00039]. The frequency is also given in Section 4.6.1 of the procedure Dosimetry and Dose Reporting [BP-RPP-00020], along with instructions on how to perform a whole-body count. The methods used to distinguish between external contamination and internal activity are described in Appendix D of the procedure Health Physics Response to a Personnel Contamination Incident [SEC-RPR-00026]. 2) Engineering controls: Compliant Section 4.5 of the ALARA Program [BP-RPP-00044] notes that "Minimizing dose and controlling contamination is accomplished by reducing the source, applying engineering controls …" In Section 4.5, it goes on to say that "Responsible Managers shall ensure the implementation of the radiological work planning process by: … "3. Identifying the need for engineering controls to reduce exposures and control contamination, such as: " Temporary shielding (described in BP RPP 00036,	

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	• The amount of air sampled; • The results of sample counting; • The serial number of the air sampler and counter used; • The name of the person who obtained and counted the sample. Radiological protection supervision should review air monitoring surveys in a timely manner to verify calculations and identify trends in airborne radioactivity levels. a. Posting and access control Use postings and controls to minimise exposure of personnel to airborne radioactivity. Areas of airborne radioactivity concentration greater than 0.30 DAC, should be conspicuously posted. Require a radiation work permit, work procedure or access permit for entry into an airborne radioactivity area. The posted area should be enclosed or contained within a room, tent, bag, box or other device, to prevent the spread of airborne and loose surface radioactive contamination. b. Work control methods	Management of Temporary Shielding). " Detailed shielding plans are required for reactor face work (e.g., feeder inspections, feeder replacements, damp scrape) where an ALARA Plan is required. " Remote handling tools. " Local ventilation (described in BP RPP 00048, Large Area Containments). " Catch containment (SEC RPR 00065, CATS Devices Field Guide). " Others as required and identified." Section 4.5, Item 3(d) of the procedure Requirements for Planning Radiological Work [BP-RPP-00011] states that ALARA plans shall address "A description of exposure reduction measures to be used during the planned work to keep doses ALARA, including contamination control measures, and airborne radioactivity mitigation techniques." These include internal dose control, airborne radioactivity mitigation and decontamination methods and plans. Guidance on contamination control is provided in [BP-RPP-00022], with emphasis on Control at the Source. This procedure also discusses the use of wetting to control the spread of contamination. 3) Respiratory protection: Compliant Section 2.0, Item 3 of the procedure Selection of Radiation Personal Protective Equipment [BP-RPP-00014] states: "Use of RPPE prescribed in some situations may increase	

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	1) Planned internal dose Establish policies and procedures for planned internal dose. These policies and procedures should utilise engineering controls to reduce airborne radioactivity and minimise internal deposition of radioactive material. A thorough evaluation of control methods, avoided dose and the overall dose to the worker is required prior to approval of planned internal dose. Workers should be informed of their planned internal dose and avoided external dose, as well as the required documentation and approval levels. Have procedures in place which highlight the administrative controls required, for workers with internally deposited radioactivity, to process in and out of the RCA; the frequency of whole-body counts; the methods used to differentiate between external contamination and internal activity; and inhalation versus ingestion. 2) Engineering controls Engineering controls are preferred over the use of respirators to minimise internal dose. Respirators can cause additional stress to workers and increase the risk of injury by interfering with vision, freedom of motion and the ability to communicate. These factors may also contribute to increased dose from external sources. Therefore, engineering controls should be fundamental to work planning and be used as much as possible	external dose by increasing time duration of work in high dose rate areas. If the increase in external dose is likely to be greater than the prevention of internal dose, then RPPE requirements may be modified. Any such deviation from prescribed RPPE shall be approved by the individuals listed below and noted on the Radiological Exposure Permit (REP) and/or in the ALARA plan as required by [BP-RPP-00011], Requirements for Planning Radiological Work: a) AHP for Bruce A or Bruce B. b) Radiation Safety Officer (RSO) for CMLF. c) Approved delegate for either." According to Section 4.5 of the procedure Requirements for Planning Radiological Work [BP-RPP-00011], ALARA Plans must include "A historical exposure analysis of the work to be performed." It goes on to require "A radiological hazard assessment which details the expected radiological conditions for each step of the work, including any expected discovery work and an estimate of the total dose to be received." It must also include measures for internal dose control, including protective clothing. Part of the preparation of the REP, as described in Section 4.7.3 of [SEC-RPR-00015], is to select the appropriate RPPE, including respiratory protection. The procedure Requirements for Respiratory Protection [BP-SM-00030] provides guidance on the use of respiratory protection from both radiological and conventional hazards. It specifies a medical evaluation of employees required to use respiratory protection in Section 4.6, training requirements for such employees in Section 4.7, and fit	

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	to minimise internal dose. Only when further engineering controls are impractical and the use of respirators is shown to minimise total dose, should respirators be considered. Include potential negative post job impacts, such as the need to collect alpha bioassays, or the impact of personnel with internally deposited radionuclides alarming contamination monitors, in the decision on respirator use. The radiological protection group periodically assesses engineering controls being used to control airborne radioactivity. This assessment should include the following: • The use of portable or fixed ventilation devices to reduce or eliminate airborne radioactivity concentrations; • Decontamination and/or repair of the source of airborne radioactivity; • Containment of the source, or the potential source, of airborne radioactivity (for example, use of contamination containments or glove bags); • Performance of the work under water, exposed surfaces being kept wet and the use of fixative agents; • Installation of permanent engineering controls in areas where airborne radioactivity is expected; • Comparison of dose saved when engineering controls are installed.	testing requirements in Section 4.8. It also prescribes the requirements for maintenance, inspection and storage of respiratory equipment in Section 4.9, The procedure Selection of Radiation Personal Protective Equipment [BP-RPP-00014] gives more detail on respiratory protection from radiological hazards. Breathing air is tested in accordance with procedure Breathing Air Safety [BP-SM-00024]. The selection and care of respirators at Bruce Power is documented in the safety manual Requirements for Respiratory Protection [BP-SM-00030]. Employees are required to undergo medical checks every two years, and to use respiratory protective equipment in accordance with the classroom hands-on training. Respiratory protection selection is described in Section 4.4 of [BP-SM-00030], and fit testing and use is described in Section 4.8 of that safety manual. Further direction specific to the selection of respiratory protection from radiological hazards is given in Section 4.5 and Appendix H of the procedure Selection of Radiation Personal Protective Equipment [BP-RPP-00014]. Maintenance of respiratory protection equipment is addressed in procedure [BP-SM-00061].	

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	3) Respiratory protection When engineering controls cannot be used to reduce airborne radioactivity to appropriate levels, the assessment also includes the following: • The total dose with and without respiratory protection; • Past experience on similar tasks, current airborne radio- activity levels and contamination levels; • Radionuclide concentration in fluid systems; • Expected DAC-hours for the job and the number of previous DAC-hours assigned to the worker. Radiological protection supervisors review and document the results of this assessment. Consider the potential negative consequences of intakes. These could include: • Additional administrative controls required for workers with internally deposited radioactivity, to process in and out of the RCA; • The frequency of whole-body counts; • The increased challenge to radiological protection personnel to differentiate between internal activity and external contamination;		

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	• The loss of worker productivity; • The potential newsworthy nature of the event. Issue respirators only to personnel who are trained, fit-tested for the type of respirator worn and medically qualified to wear them. Maintain positive controls for the issue, use and return of respirators, to ensure only qualified personnel wear them. When plant services, or instrument compressed air systems, are used to supply air for respirators, test the air to verify that it meets regulatory requirements, as well as to determine that it is free of radioactivity. Fit, check, test, clean, repair and procure respirators in accor- dance with regulatory requirements and recognised national standards.		
IV.C3.	a. Bioassay frequency 1) Whole-body counting (WBC) Perform a whole-body count of workers suspected of receiving 10 millirem of committed effective dose equivalent (CEDE) internal dose, whether planned or unplanned, to accurately assess the dose received. Investigate positive whole-body counts to determine if the count was the result of external contamination. Do not consider positive whole-body counts that result from external	Programmatic: Compliant Monitoring for Internal Radioactivity a. Bioassay frequency: Compliant 1) Whole-body counting: Compliant Whole-body count (WBC) requirements and frequency are described in Section 4.6.1 of the procedure Dosimetry and	C

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	contamination as an indication of internal dose. Several whole-body counts of a worker may be necessary to determine if the activity was inhaled or ingested, and accurately calculate the internal dose received. In addition, personnel who work in airborne or contaminated areas of the RCA should receive an initial whole-body count prior to the start of work, and a follow-up whole-body count upon termination of employment or prior to leaving to work at another nuclear station. Passive monitoring equipment may be used, as long as both the equipment and method have been evaluated properly. The minimum detectable activity (MDA) level should be adequate to identify potential for internally deposited radionuclides, resulting in additional investigation. 2) Other bioassay Other bioassay techniques can be used to monitor personnel for the internal deposition of radionuclides which cannot be detected using WBC equipment or, when needed, to supplement WBC equipment. Analyse plant water samples periodically for tritium. Also conduct tritium bioassays in areas where personnel may come into contact with plant liquid systems which have a tritium concentration greater than, or equal to, 0.01 microcurie/milliter (for example, following an entry into a tritiated steam atmosphere or during	Dose Reporting [BP-RPP-00020]. Item 1 of this section prescribes the frequency for routine WBCs, which are based on the frequency of required urine samples. Item 2 addresses non-routine counts, which may be required by a REP, or at the initiative of the employee, or as directed by RP staff following an incident. Non-routine counts are also required upon on-boarding and off-boarding, and following a positive count. The process for distinguishing external contamination from internal uptake has been discussed above, under IV.C1(a), Internal dose investigation. 2) Other bioassay: Compliant Section 4.5 of the procedure Dosimetry and Dose Reporting [BP-RPP-00020] contains the requirements for bioassay for tritium in urine. Routine sampling is required on either a 14- or 28-day cycle, depending on the employee's job. Non-routine sampling is required for a variety of reasons, listed in Item 6 of Section 4.5.1. Other special bioassay techniques, fecal sampling and large-volume urine sampling are discussed in Section 4.9 of the procedure. These are performed on a non-routine basis to assess the dose from transuranic radionuclides and from other hard-to-detect radionuclides. b. Whole-body counting equipment: Not assessed 1) Equipment setup, 2) calibration, QC, and 3) software of the whole-body counters are regulated under the Dosimetry Service Licence and Regulatory Standard S-106, and are	

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	or following diving activities). For PWRs, establish programmes for monitoring airborne tritium in areas such as the refuelling floor and inside containment. Also establish random sampling of personnel exposed to tritium in the air, once pre-established thresholds have been exceeded. The capability should exist, either on site or off site, to analyse alpha- and beta-emitting radionuclides, such as transuranics, tritium and strontium/yttrium 90, using “in-vitro” measurements. Perform an analysis when a potential for a 0.1 mSv CEDE intake of these radionuclides is suspected. In addition, these techniques may be used to measure elimination rates of radionuclides from the body. Whole-body counts can be used along with scaling factors to estimate the uptake of non-gamma emitters, such as transuranic radionuclides. Job-specific representative air samples provide an appropriate measurement for developing scaling factors. Multiple whole-body counts can be used to estimate the elimination rates of radionuclides from the body. b. Whole-body counting equipment 1) Equipment setup Use whole-body counting equipment to monitor personnel for radionuclides that emit gamma rays	therefore not assessed as part of this PSR. 4) Passive monitoring equipment: Not assessed The procedure Health Physics Response to a Personnel Contamination Event [SEC-RPR-00026] addresses the possibility that internal contamination may be detected by whole-body contamination or portal monitors, and provides direction on performing a whole-body count when internal contamination is suspected. Doses are not assigned based on readings from contamination or portal monitors. c. Internal Dose Assessment: Not assessed The methodologies used for internal dose assessment are regulated under the Dosimetry Services Licence, and so are not assessed here.	

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	or X-rays. Whole-body counting equipment should be sensitive enough to detect depositions of the radionuclides commonly found at the station, at levels that could result in 0.1mSv of CEDE. Review radionuclides if significant fuel failures are identified. Establish methods to identify and evaluate unidentified peaks in the resulting energy spectrum. Consider including naturally occurring and commonly used nuclear medicine diagnostic radionuclides that may interfere with the interpretation of whole-body counting data. 2) Equipment calibration and quality control Calibrate WBC equipment with the National Institute of Standards and Technology traceable radioactive sources at least annually, or if the WBC equipment is modified or damaged. A phantom should be representative of the geometry a person presents to the detector. Photon energies of the radionuclides used for calibration should span the energy of the gamma/X-rays emitted by the principal radionuclides found at the station. Check each detector in WBC equipment for proper gain (that is, energy/channel) daily during use or whenever environmental conditions change significantly. During WBC operation, check each WBC detector daily for accuracy by using a source from a reproducible location. Use trend charts to monitor		

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	WBC performance. Plot peak centroid, resolution and measured decay-corrected activity for designated sources on the charts to identify adverse trends. Radiological protection supervision reviews the results of all WBC equipment calibrations, checks and initiates corrective actions for any abnormal results. 3) Whole-body counting software Knowledgeable personnel in the radiological protection organisation review software programmes for WBC equipment prior to use. This will ensure: • The correct radionuclides, gamma/X-ray energies, abundance and decay factors are used in the programme library; • Associated action levels are correct; • Formulas used to estimate internal dose are based on the correct models. Perform and document periodic quality control checks. Take measures to prevent unauthorised changes to software programmes. Radiological protection personnel should keep the password or protection mechanism. If software protection is not possible, periodically check system performance to ensure that no unauthorised software changes have		

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	occurred. 4) Passive monitoring equipment Gamma-sensitive whole-body contamination monitors and portal monitors have proven capable of detecting low levels of internal radioactivity (typically less than 1 per cent annual limit of intake) and can help identify suspected internal dose. Prior to the use of these monitors in an internal dosimetry programme, determine their detection capabilities. Demonstrate detection capabilities using a phantom and a radionuclide mix representative of the plant. Repeat this testing whenever the plant radionuclide mix changes significantly. Re-evaluate the use of passive monitoring equipment whenever analysis of the reactor coolant indicates that fuel leaks are present or have increased by a factor of 10. c. Internal dose assessment Base internal dose assessments on: • Radiological and biological parameters; • Regulatory requirements and guidance; • Recognised national standards; • Dosimetric models of the International Council on Radiation Protection and Measurements (ICRP).		

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	Qualified radiological protection supervision should independently review dose assessment calculations to ensure the accuracy of results. Assessments of dose resulting from internally deposited radionuclides, may need to be based on a series of whole-body counts or other bioassay measurements, to determine the worker's actual radionuclide retention pattern. If available, workers need to acknowledge the dose assessment, the accuracy of the information they provided and the significance of the dose received.		
V.C1.	Plan work, including engineering design work, involving radiation dose as far in advance as practical. Optimise the ALARA principles of time, distance, and shielding for each work activity. During the planning stage, avoid unnecessary work, sequence work to minimise dose and identify the lowest dose options for performing the work. System engineers, maintenance planners, outage schedulers, and job supervisors should actively participate in all phases of dose reduction planning to ensure success. Specific steps that have proven useful include the following: • Decontaminate plant components and work areas and evaluate the need for temporary shielding prior to initiating maintenance work in	Programmatic: Gap Preliminary Planning and Scheduling The procedure Requirements for Planning Radiological Work [BP-RPP-00011] "outlines the requirements for planning radiological work at Bruce Power. The purpose of this procedure is to effectively plan work so that radiation exposures are kept As Low As Reasonably Achievable (ALARA) thereby implementing the requirements of BP-RPP-00044, ALARA Program" (Section 1.0). Section 4.4.1 of [BP-RPP-00011] states that "ALARA planning for outages, complex work and large evolutions should occur as early in the planning process as possible to ensure all required ALARA measures, as defined in the ALARA Plan, can be incorporated into the overall work	Gap

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	the affected area. Consider chemical and mechanical decontamination techniques. • Determine needed tools and parts before the work begins, and stage them so delays are minimised. Use power tools (electric or pneumatic) to reduce task performance times wherever possible. Consider the use of special tools (including robotics and remote handling equipment). • Provide support services, including electrical, water, air, and auxiliary lighting and a working environment with comfortable temperature, humidity, and space. • Coordinate the efforts of different groups, such as Operations, Construction, Maintenance, and Radiological Protection, so work can proceed in a systematic, efficient manner. Evaluate the amount of work scheduled in an area to minimise work and work crew interferences. • Minimise the number of workers assigned to a particular job. During outages, to the extent possible, minimise the number of personnel allowed inside containment (PWRs) or the drywell (BWRs), to reduce congestion and improve work efficiency. • Coordinate work by plant area so that work such as scaffolding, insulation, shielding installation and removal is not duplicated for multiple tasks in the same area. Create an integration of scheduled activities to improve	management plan for the work." This aligns with the guidance that work should be planned as far in advance as practical. The procedure Work Coordination Plans [BP-PROC-00771] states in Section 4.0 that "Work Coordination Plans may be developed for work efforts such as tying together large, complex Modifications that require detailed coordination between multiple work groups, or other activities of such a complex nature that detailed coordinated preparation beyond routine Assessing and Planning is necessary to ensure nuclear safety is maintained." This aligns with the guidance that work should be coordinated among multiple work groups involved. [BP-RPP-00011] also states in Section 1.0 that it is "to be used in conjunction with... Work management planning documents..." As described in Section 7.1 of this report, the FASA [SA-RPR-2015-03] led to an action to revise [BP-RPP-00011] to refer to [BP-PROC-00342 Sheet 001] for ALARA planning due dates, to prevent misalignment. The required change was made and the revised procedure issued, and then a month later the change was removed and another revision issued. Consequently, there remains a gap with respect to the required revision of [BP-RPP-00011]. **Gap 1** The guidance provides several work planning considerations that have proven useful in achieving dose reduction. Section 4.1 of [BP-RPP-00011] says that "planning, including scheduling, of work shall take into account personnel, hardware, procedures, supervision and the physical environment aspects of the job. The planning process shall include the anticipation and evaluation of radiation hazards and the selection of appropriate protective measures and dosimetry." Section 4.8 specifically discusses "the means for	

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	coordination. • Schedule system or component flushes to eliminate hot spots and/or reduce general area dose rates prior to work. • Review historical data for previously performed jobs and, where feasible, benchmark industry best performance both in terms of person-hours required, techniques used and dose received. • Review design changes to determine their dose impact from installation, operation and maintenance. • Evaluate engineering controls to reduce airborne activity to minimise internal dose and improve worker efficiency. • Evaluate the use of remote monitoring equipment, including teledosimetry, video monitoring, and two-way audio communication. • For outages, schedule enough time to clean up reactor coolant system activity so that activity will not plate out on piping surfaces and increase work area dose rates. • For outage, develop a water management plan to ensure high activity water is not transferred to systems that would result in additional dose to workers. • For outages, schedule primary system valve maintenance to follow reactor system	transferring tools and equipment required for the job to the work location" when working inside the reactor vault where breathing air is required. The section says to "stage equipment at entrance to a room/area and do not move the equipment until after plugging in for breathing air." [BP-RPP-00011] states that for total estimated dose above 1 person-rem an ALARA Plan is required. In Section 4.5 the requirements for ALARA Plans are further described as follows: "ALARA Plans shall consist of or address the following: a) A job description including the steps involved. b) A historical exposure analysis of the work to be performed. c) A radiological hazard assessment which details the expected radiological conditions for each step of the work, including any expected discovery work and an estimate of the total dose to be received. d) A description of exposure reduction measures to be used during the planned work to keep doses ALARA, including contamination control measures, and airborne radioactivity mitigation techniques. The following areas shall be considered: i) Use of shielding... ii) Training of workers iii) Location of work iv) Scheduled task logic v) Tooling/equipment improvements	

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	cleanup. • Evaluate replacing components rather than repairing them at the job site, based on a cost/benefit analysis. • Schedule or sequence work such that it is performed when systems are full (not drained), to take advantage of lower dose rates (such as for steam generators, tanks, and piping). • For outages, evaluate the need for shielding or other radiological engineering activities based on the total work scope in a certain area. Although the analyses of the individual tasks may not warrant such activities, the consideration of the total scope may change the assessment. • During the planning phase, use just-in-time training, dry runs and training on realistic mock-ups under simulated field conditions to improve work efficiency. Estimate dose based on an accurate prediction of time in the radiological work area, body position relative to the source of radiation and dose rates in that area. Previous dose records for the jobs being performed, either from the station or from other stations, may be useful once adjusted for the scope of the current work and changes in dose rates. Establish a job radiation dose history file to capture this information. If previous dose records	vi) Procedures to be used/required to be developed vii) Contingency plans viii) REPs required and identification of hold points and back-out criteria/conditions ix) Stop work criteria x) OPEX/Lessons learned for similar work xi) ALARA briefing requirements xii) Internal dose control, including protective clothing requirements xiii) Use of remote monitoring, including dosimetry xiv) Airborne radioactivity mitigation/special ventilation requirements xv) Decontamination methods and plans for transport of high dose rate components where applicable xvi) Discussion of high risk activities "Solicitation of input from other applicable work groups, individual workers or Radiation Protection Technicians experienced with the task is advised to allow for a robust and comprehensive ALARA Plan." Table 2 of [BP-RPP-00011] provides the criteria for categorization of radiological work as low, medium or high hazard. According to Section 4.7, the High Hazard Work Plan [FORM-13907] "includes the following: a) A job description including the critical steps involved. b) A OPEX [sic] review of similar work and identified lessons	

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	are not available, estimates can be based on time and dose rates. However, review these estimates carefully to ensure that both accurate person-hours in the RCA and dose rate values have been used. Establish a collective dose action level (in person-Sv) for when a more thorough review is conducted. Typically, this action level is 1 person-rem or less. Some stations have implemented this level of rigor as low as 0.001 person-Sv. Senior managers review tasks expected to exceed 0.05 person-Sv and tasks for which large individual doses could be received in a short time. This review should ensure that sufficient planning and resources have been applied to dose reduction. A station ALARA or dose oversight committee can be used to coordinate resources and establish priorities to achieve outage and on-line dose reduction. These committees, typically composed of department managers and chaired by station senior management, meet on a regular basis. In addition, some utilities have developed fleet ALARA committees chaired by senior department management to provide oversight of fleet ALARA initiatives and dose reduction strategies.	learned to be incorporated into the plan. c) A radiological hazard assessment which details the anticipated radiological conditions for critical steps of the work. d) A description of measures to be used during the planned work to keep doses ALARA, including contamination control measures, and airborne radioactivity mitigation techniques. The following areas shall be considered: i) work pre-requisites ii) monitoring requirements and controls for work, boundaries, areas and materials iii) contingency plans iv) stop work criteria/back-out criteria v) RP controls including: - external dose control measures including use of shielding, remote monitoring, stay times, placement of workers during work, use of equipment/tooling - internal dose control including RPPE requirements, airborne radioactivity mitigation and special ventilation requirements - decontamination methods and management of transport of high dose rate radioactive materials/waste vi) training requirements, including use of mock-up vii) ALARA Briefing requirements viii) oversight requirements including use of Protection Assistances provided by RP."	

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		[BP-RPP-00011] aligns with the guidance in requiring the consideration and documentation of many dose reduction techniques and strategies during work planning. The procedure Dose Estimation for HP Permit Request Processing [SEC-RPR-00019] details "the expectations and process for assigning dose estimates to all work order tasks that meet the definition of radiological work..." (Section 1.0) This aligns with the guidance that during work planning the dose should be estimated based on work duration, distance from the source, dose rates and job history. Past dose history should be available through previous work orders for the job. Table 1 of [BP-RPP-00011] shows the ALARA Plan approvals required according to the total estimated collective dose, including contributions from internal and external exposure. As the total estimated dose increases, so does the required approval level. Above 1 person-rem an ALARA Plan is required. For total estimated dose greater than or equal to 5 person-rem Station ALARA Committee (which includes upper management representation) review and approval is required (in addition to the other approvals also required for medium hazard work). This aligns with the recommendation to establish a collective dose action level above which more thorough work review is required, and that senior management review tasks expected to exceed 0.05 person-Sv (5 person-rem).	
V.C2.	Work supervisors, in coordination with radiological protection personnel, conduct pre-job briefings to inform workers of the specific actions that are planned to reduce dose during the task. Briefings	Programmatic: Gap Work-in-Progress and Postwork Reviews	Gap

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	are also an opportunity for workers to input ideas for reducing dose. Review tasks estimated to exceed the collective dose action level for application of task-specific dose reduction techniques, as described below. • Track task progress daily against both the estimated person-hours or per cent complete and the estimated person-Sv to identify tasks that are at risk of exceeding projections. • Conduct in-progress reviews at pre-established intervals for tasks that exceed the station person-Sv threshold levels. • Set these designated intervals prior to the task and base them on the type of work to be performed, task duration and expected radiological conditions. • The interval can be designated as a per cent of estimated person-Sv, per cent of person-hours, or per cent complete, such as 25, 50, 75 and 100 per cent. • The interval could be established based on other logical decision points in the task. For example, in-progress reviews could be performed after initial shielding installation or after component removal but prior to installation of the new component. If in-progress reviews indicate that the dose estimate may be exceeded, consider whether additional dose reduction techniques can be used.	The procedure Human Performance Tools for Workers [BP-PROC-00617] outlines the requirements for the use of the Pre-Job Briefing Tool. RP Requirements for Pre-Job Briefs are provided in the procedure Executing Radiological Work [BP-RPP-00041], Section 4.2, which states "When radiological work is to be performed, it is essential that the Pre-Job Brief (PJB) includes a discussion on radiological hazards." A PJB is required for all radioactive work - different brief levels are required for different radiological hazard levels. "The purpose of the RP component of the PJB is to inform workers of the conditions of the REP and the specific actions required to reduce dose and control contamination and airborne radioactivity during the work..." [BP-RPP-00041] also requires an ALARA Briefing Form [FORM 13909] for high-hazard work and any work requiring an ALARA Plan (as per [BP-RPP-00011]). "The ALARA Briefing is similar to the RP component of the PJB but the content will be more extensive as it will outline the requirements of the ALARA Plan and/or Radiological HHW Plan and required radiological controls..." Appendix C lists the specific RP requirements for pre-job briefs, including allowing time for questions and comments. Appendix C also lists questions to be asked when reviewing planned radioactive work, and encourages workers to "challenge any concerns or issues that you have by raising them with your Supervisor and RP." The RP requirements for pre-job briefs in [BP-RPP-00041] meet the guidance recommendation that pre-job briefs include dose reduction actions planned for the work, review high dose tasks and allow for workers to provide ideas for dose reduction.	

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	• Also reconsider any techniques that were previously rejected as not resource efficient. • Dose reduction techniques that were used should be reviewed for effectiveness and the cause(s) for the projected overruns determined. • Following in-progress reviews, evaluate the need to adjust the dose estimate up or down to ensure that it remains accurate and challenging. • Communicate dose estimate changes and their bases to affected management, work groups and radiological protection task coverage personnel. • Include these in the outage ALARA report as lessons learned for future outages. • Perform a post task review for all work activities with specific ALARA plans. • As a minimum, for tasks with actual collective dose above an action level or actual doses exceeding an estimate (for example, by 25 %), conduct a formal cause analysis and determine corrective actions. • Most supplemental personnel leave the site shortly after a task is completed or prior to the end of an outage. Post task reviews are held as soon as practical after task completion. • Ask the workers for suggestions on how to reduce dose on future jobs.	The RP Program [BP-PROG-12.05] in Section 4.4 lists Work-in-Progress and Post-Job Reviews as ALARA processes "in place to ensure effective ALARA planning prior to work execution." This documents the high-level commitment to performing work-in-progress and post-job reviews. [BP-RPP-00041] in Section 4.4 says "Work-In-Progress (WIP) reviews shall be performed by the WG Supervisor to ensure that work is progressing as planned. "A daily WIP of radiological activities shall be tracked by the WG Supervisor with the assistance of a Green Qualified worker, if required, against both the estimated person-hours or percent complete and the estimated person-rem to identify jobs that are at risk of exceeding projections and to take appropriate corrective actions..." Section 4.4.1 requires the performance of ALARA work-in-progress reviews for work where the collective dose estimate is greater than 1 person-rem, when 50% of the estimated dose has been accrued and when exposures are anticipated to exceed estimates by more than 25%. "Following an ALARA WIP Review, the requirement to adjust the dose estimate is evaluated to ensure that the dose estimate remains accurate and challenging. Communication of dose estimate changes and their basis to affected management, work groups and workers is required. The WG Supervisor shall include these communications in the PJB or ALARA Briefing and provide details to an HP to include in Outage lessons learned for future radiological jobs." Appendix E of [BP-RPP-00041] provides detailed requirements for ALARA work-in-progress reviews. "Dose reduction techniques that were planned for use are reviewed	

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	• A record of similar work should be kept for future reference. • Repetitive tasks performed on line can be reviewed collectively on a less frequent basis (such as quarterly). ALARA or dose reduction suggestion programmes that recognise and reward workers for practical suggestions to reduce dose have proven effective in generating new ideas. Including dose goals as part of existing incentive programmes has helped some stations achieve additional focus on dose reduction.	for effectiveness by the WG... If an individual's dose or the accumulative WG dose is in excess of the projected amount, the cause(s) of the dose exceedence are determined by conducting an investigation. The findings of the investigation are then reported to the ALARA Committees by the WG Supervisor assisted by an HP and corrective measures shall be taken to reduce any further exposure." The ALARA work-in-progress review requirements provided in [BP-RPP-00041] align with the recommendations made in the WANO guidance. [BP-RPP-00041] in Section 4.6 requires that "a post-job brief is conducted to communicate close-out expectations to workers... During this meeting, workers shall be given the opportunity to feed back observations or suggest improvements to the process." Section 4.7 provides the RP requirements for post-work reviews. A "Post-Work ALARA Review Record shall be performed by the WG Supervisor, with assistance from an HP for radiological work..." when potential collective dose exceeds one person-rem, the total dose received exceeds the total dose estimate by greater than 25%, total dose received by an individual exceeds an RP Action Level, or as selected by RP. "Post-Work ALARA Reviews shall be completed as soon as practical once the work is completed to ensure that contract workers or temporary workers brought in to conduct the radiological work can be involved in the review. "Lessons learned from the Post-Work ALARA Reviews shall be documented... To ensure corrective actions are taken that can be implemented in future radiological work planning for	

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		similar work. "Repetitive jobs performed on-line can be reviewed collectively quarterly." The post-work ALARA review requirements provided in [BP-RPP-00041] align with the recommendations made in the WANO guidance. The ALARA Program [BP-RPP-00044] lists one of the ALARA HP responsibilities as reviewing ALARA suggestions and forwarding them to the Station ALARA Committee for review. The ALARA Program in Section 4.7.1 says that "ALARA initiatives can be submitted by anyone through a Station Condition Record (SCR), by submitting a BIG (Business Improvement Group) Idea or can be a separate project." There is no programmatic inclusion of dose goals as part of an incentive program at Bruce Power. **Gap 1**	
V.C3.	a. Specific jobs Analyse effective dose reduction techniques for continued use and, if appropriate, incorporate them into work procedures or permits for each job. Examples of such techniques are as follows: • Removing sources of radiation, using system flushes, applying temporary shielding, using time-for-decay, plant shutdown or power reduction to eliminate or reduce N-16 and neutron dose rates • Establish formal stop work criteria	Programmatic: Indirect Compliance Radiological Engineering a. Specific Jobs: Indirect Compliance BP procedure Requirements for Planning Radiological Work [BP-RPP-00011] in Section 4.5 states that "ALARA Plans shall address... A description of exposure reduction measures to be used during the planned work to keep doses ALARA..." Considerations specifically listed that are also mentioned in the guidance include: use of shielding; training	IC

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	• Posting low-dose waiting areas, working in the lowest radiation levels, including using best access routes • Performing as much work outside of radiation areas as possible • Providing detailed work procedures that include hold points for radiological protection concurrence before work may proceed • Using photographs, videos, maps, drawings or component flagging to ensure that workers are familiar with the work location, component position and radiation source(s) • Using mock-ups to improve processes • Performing the initial task in the lowest dose-rate area to improve worker efficiency for jobs that repeat the same task in many areas During the task, supervisors and radiological protection personnel make regular observations of work in progress to ensure the dose reduction techniques planned for the task are implemented and to identify ways of further reducing dose. Since workers are the most familiar with the task, they are encouraged to accept responsibility for themselves and their co-workers and to identify opportunities for dose reduction. b. Design changes The cost/benefit analysis of proposed design	of workers; stop work criteria. Section 4.7 of [BP-RPP-00011] states that "High Hazard Work...requires the following additional measures... RP controls including: - external dose control measures including use of shielding, remote monitoring, stay times, placement of workers during work, use of equipment/tooling - internal dose control including RPPE requirements, airborne radioactivity mitigation and special ventilation requirements... - oversight requirements including use of Protection Assistances provided by RP" [BP-RPP-00041], Executing Radiological Work, Appendix C - RP Requirements for Pre-Job Briefs lists "radiological conditions (work area dose rates, low dose waiting areas, tasks or steps where dose rates or radiological conditions may change significantly)" as considerations to be addressed during the pre-job brief. While there is no Radiological Engineering role at Bruce Power (the closest role would be the ALARA Health Physicist), the BP RP Program documentation demonstrates indirect compliance with the intent of the WANO guidance on Radiological Engineering for specific jobs. b. Design Changes: Indirect Compliance The BP ALARA Program [BP-RPP-00044], in Section 4.7.1 states that "in order to allow a cost benefit assessment of dose reduction initiatives, the DM, RP Programs is responsible for deriving and keeping current, a dollar value	

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	changes, plant modifications, and back fits presented to management for approval include the projected dose as well as radioactive waste generation. It also covers disposal costs from installation, operation, and maintenance. Include techniques for minimising radiation dose and radioactive waste generation in each design phase, from conceptual through intermediate and into the final detailed design. During the approval and installation phases, conduct reviews to ensure that dose reduction and radioactive waste minimisation techniques have been incorporated into installation, operation, and maintenance. Train personnel who will perform these reviews in applying dose reduction techniques to design, construction, installation, operation and maintenance. The following are examples of dose reduction considerations for design changes, modifications, and back fits: • Location and orientation of equipment relative to sources of radiation, including piping and cables • Preventive and corrective maintenance of equipment, frequency of repair history (reliability) and use of bolted connections to relocate modules to low-dose areas for repair • Establishment of operational requirements such as frequency of operation and accessibility • Use of high-reliability valve packing • Avoidance of crud traps, such as “dead” legs in	for dose avoided i.e., the cost of a person-rem [person-Sv]. The method for determining this is documented... The dollar value for dose avoided will be approved by the Site ALARA Committee and communicated to the Station ALARA Committees and the Chief Financial Officer." This demonstrates that there is a method in place allowing cost/benefit analysis for proposed design changes in consideration of dose. The program document should be revised to reflect the new RP organization. The responsibility assigned to DM, RP Programs, should be changed to DM, Safety Programs. The RP Program in Section 4.3.1, Facility Design, requires that, "Design changes shall meet the ALARA principle and work towards reducing source term. "The Engineering Department notifies the station or facility AHP of permanent design changes and temporary design changes to review the systems or the station layout as modifications could impact radiation protection." This demonstrates that review of design changes for RP considerations is required. The procedure Source Term Management [BP-RPP-00049] in Section 4.4.2 indicates that the "COMS Design Checklist contains a series of questions pointed towards ensuring the Source Term Reduction has been considered for the (design) change." While the BP RP procedures do not go into specific detail regarding dose reduction considerations to be made for design changes, review of all design changes for RP impact	

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	piping, drain valves and other points where crud collects; or provisions for shielding/flushing of anticipated crud traps • Use of welding techniques that minimise crud traps • Use of low-cobalt or cobalt-free alloys and other material considerations such as corrosion resistance • Use of chemistry control to minimise corrosion and buildup • Use of automated welding equipment for installation • Prefabrication outside radiation areas, including coatings • Application of permanent shielding • Installation of permanent access platforms • Electro polishing or passivation of components in contact with the RCS • Impact of design changes on decommissioning • Use of operating experience to eliminate problems identified at other utilities Identify and analyse systems or components in higher dose rate areas that require rework, to determine if insufficient maintenance or improper design or materials are involved. Complete design	is required, implying compliance with the guidance. c. Radiation Source Term Control: Indirect Compliance The ALARA Program [BP-RPP-00044] discusses a source term reduction program consisting of, but not limited to: "1. Hot spot identification and removal. 2. Cobalt reduction in reactor system components. 3. Source term characterization, monitoring and chemistry control. 4. Source term removal, including H 3. 5. Leak reduction. 6. Identification and removal of failed fuel. 7. Others as identified (e.g. Zinc injection)" (Section 4.7.2). BP also has a Source Term Management procedure [BP-RPP-00049], which "establishes the requirements and responsibilities for the effective implementation of the Source Term Management Program. The objective of the Source Term Management Program is to ensure that materials selection, plant operation, maintenance activities, and chemistry strategies during normal operations, shutdowns, and start-ups are managed to the extent practical to reduce the radiation source term. The Source Term Management Program shall be implemented through a Source Term Management Team. "The commitment to reduce source term must be supported by all departments within the company. The benefits of such	

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	change planning sufficiently in advance of implementation to minimise time spent in radiological work areas. Obtain Maintenance and Engineering involvement in reducing the frequency of rework for these systems or components. c. Radiation Source Term Control The control of radiation sources in the plant is a cooperative effort among Chemistry, Engineering, Operations, Maintenance, Work Management and Radiological Protection. The success or failure of this team can be directly measured by radiation levels and changes in the plant. In many cases, valve or valve part replacement cannot be justified solely for the reason of cobalt replacement. However, pursue a cobalt-replacement programme such that low-cobalt components are available when other reasons dictate the need to replace valves that contain high-cobalt alloys. Include the following elements in a cobalt replacement programme: - Identify components that are potentially significant cobalt contributors to the reactor coolant system and thus warrant replacement of the high-cobalt material. - For each of these components identify suitable qualified replacement cobalt-free or low-cobalt alloys.	efforts could be significant, serving to reduce overall occupational radiation dose incurred by the plant staff and thereby increasing flexibility in the use of personnel as well as public benefit through reduced emissions" (Section 1.0). Section 4.2 of [BP-RPP-00049] discusses the Source Term Management Team, which includes members from RP, Chemistry, Engineering, Maintenance and Operations (Work Management and other work groups are also mentioned "as required"). "The responsibility of the Source Term Management Team shall be to evaluate, prioritize, track and communicate Source Term Reduction Initiatives consistent with other business priorities" (Section 4.2.3). Section 4.3.2 of [BP-RPP-00049] lists the source term reduction initiatives, including but not limited to: "- pH Control of the Primary Heat Transport (PHT) System - Oxidizing Antimony Removal Process - PHT Purification System Performance - Reducing Fuelling Machines Source Term Contribution - Source Term Management by Decontamination - Hot Spot Removal - Emergency Coolant Injection (ECI) Crud Removal - Boiler Hot Spot Removal Program - Improve Maintenance Area Test Facility (MATF) Filtering for Fuelling Machine Heads - Maintain inventory of Stellite components in active systems - Investigate additional filter opportunities for all applicable	

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	- Process design change paperwork ahead of time to allow replacement whenever the opportunity arises. - For cases in which a component replacement is most likely, obtain a cobalt-free replacement so it is available for use when the opportunity arises. For PWRs minimise nickel to reduce cobalt-58. - Develop welding and maintenance procedures, as well as the training needed, to repair and maintain special cobalt-free components. - Issue instructions to appropriate procurement, design and maintenance personnel to ensure cobalt replacement will be performed whenever the opportunity arises. - Periodically update the programme to reflect new information on qualified low-cobalt replacement options. • Generic techniques - Optimise purification system effectiveness (for example, reactor water clean-up, let down and purification). - Establish policies and practices to ensure the integrity of all reload fuel assemblies. - Test and seek the root causes of fuel failures. - Maximise the effectiveness of outage shutdown reactor coolant system clean up. - Evaluate the use of specialised resins and the	systems - Source Term Management by Decontamination. - Source Term Management by Hot Conditioning." The Source Term Management procedure also discusses methods of preventing the introduction of new source term in Section 4.3.4: "- Reducing ingress of cobalt and antimony during maintenance and outages - Reducing ingress of cobalt due to Stellite components with non Stellite materials i.e., Fuelling Machine. - Reduce frequency and severity of unplanned crud bursts via optimized purification. - Removal of Failed Fuel as quickly as possible." Section 4.3.5 requires the "removal of newly discovered source term as early as possible." Finally, Section 4.3 of [BP-RPP-00049] discusses several points regarding the source term management strategy. The final strategy item listed is "analyzing industry trends and Operating Experience (OPEX) to determine changes to the program as required." The BP RP Program and associated procedures document that source term management is intended to be a cooperative effort among several work groups and that industry experience is examined to evaluate potential source term reduction methods. Cobalt contributing components are tracked, and while the specific generic techniques listed in the guidance are not all mentioned in BP documentation, the	

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	addition of auxiliary pumps to increase purification flow after reactor coolant pumps are secured. - Perform chemical decontamination of the primary system or subsystems. - Track and trend the build-up of small radiation sources (hot spots) and take action to reduce or remove significant hot spots. - Minimise cobalt input into plant systems by using temporary pipe dams and cleaning interior surfaces thoroughly following maintenance on valve seats. - Consider assessing component cleanliness by monitoring for trace contaminants using X-ray fluorescence or other methods for measuring trace quantities of metals. - Optimise reactor coolant chemistry. - In BWRs, maintain hydrogen availability and consider the use of depleted zinc injection and noble metals with moderate hydrogen addition. - Evaluate the potential impact of zinc injection on the ability to chemically decontaminate piping and the combined effects of these chemicals and hydrogen water chemistry. - In BWRs, control cycling of hydrogen addition. Maximise clean up flow when securing hydrogen addition and during start-up. - Reduce iron concentration during long- and	BP RP Program and associated procedures indirectly comply with the guidance. A CNSC Type II compliance inspection in August 2014 led to a recommendation [BRPD-AB-2014-010-R2] to "implement planned enhancements to databases that support the ALARA program." Bruce Power agreed to consider the recommendation (see Section 7.3 of this report.)	

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	short-path clean up. - In PWRs, use submicron filtration and consider the use of depleted zinc injection. - For large components or steam generator replacements, consider materials low in nickel and/or the use of electro polishing and passivation of metals. - Reduce dose rates on the refuelling floor by maximising spent fuel pool clean up. - Evaluate optimised resin types and flow rates to enhance clean up capabilities. In addition, station and corporate personnel collect and review industry radiation dose reduction techniques for applicability. Information sources include; WANO Significant Operating Experience Reports (SOERs), WANO Significant Event Reports (SERs), trade publications and industry seminars and meetings. Trend source term and analyse its impact on station collective dose at least each operating cycle.		
V.C4.	Establish radiation dose goals to involve all station groups in reducing short and long-term collective radiation exposure. Senior management support is necessary to ensure that resources are available to meet these goals and that responsibility for meeting dose goals is assigned to appropriate departments and individuals.	Programmatic: Compliant Effectiveness: Compliant Radiation Dose Goals	C

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	For example, dose goals for major outage projects such as steam generator inspection work may be assigned to the steam generator high-impact team leader or project manager. Establish a long-term station dose reduction goal with an action plan to focus the organisation on achieving top performance against utility or industry goals. Review and update long-term dose reduction plans at least annually to ensure that the proper focus is maintained on strategic ALARA planning and station dose reduction. Long- term dose reduction plans should contain an overall executive summary with goals. The plan should identify the ownership of initiatives, recent accomplishments for dose reduction and the approval process for management commitment. Typically, initiatives will be approved by the ALARA Committee, the plant manager and then the vice president. Identify previous initiatives (both source term and ALARA) for the last two years. The dose history and projected goals of each initiative should be discussed with plant data comparisons to similar plants. Include a source term reduction section in long-term dose reduction plans. Consider cobalt reduction, including chemistry controls. Subsections should be used to discuss initiatives such as chemistry, operations, shutdown, maintenance (foreign material exclusion) and so	The BP RP Program [BP-PROG-12.05] in Section 4.1.4 discusses dose goals: "ALARA Committees review performance against dose targets and goals in accordance with BP-RPP-00044. Their objective is to drive performance to be better than target." Section 4.4 of the RP Program discusses the ALARA Program: "The Bruce Power ALARA Program, BP-RPP-00044, identifies planning strategies to control dose and minimize exposure As Low As Reasonably Achievable at Bruce Power to meet the requirements outlined in CNSC Regulatory Guide G-129, Keeping Radiation Exposures and Doses 'As Low as Reasonably Achievable (ALARA)...' This includes a 5 Year Dose Reduction Plan and processes for establishing dose goals and targets consistent with the 5 year dose reduction plan." The BP ALARA Program [BP-RPP-00044] in Section 4.1 describes management of the program: "The Site ALARA Committee provides oversight of the Bruce Power ALARA Program. The Site ALARA Committee is chaired by the Chief Nuclear Officer (CNO) and membership includes Station Senior Vice Presidents (SVPs), SVP of Outages and Maintenance, Vice President of Nuclear Operations Support, DM, Safety Programs and Responsible Managers. The Site ALARA Committee meets at least quarterly. "Station ALARA Committees provide oversight of the ALARA Program for their facility. The Station ALARA Committee is chaired by the Plant Manager and membership includes senior management representation from each of the major departments that either receives dose or impact radiation	

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	forth. Typically, long-term dose reduction plans are developed for a five-year period. Develop five-year plan with dose reduction items and expected results. This plan should be integrated with site processes such as the business plan, outage plans, and the corrective action programme. Senior management reviews and approves scope changes to the five-year plan. Radiation dose goals are used as a management tool for involving all station groups in actively reducing radiation dose and provide a means of assessing the effectiveness of radiation dose reduction actions. The challenge is to perform the needed work while maintaining dose ALARA. Approach scope reduction to achieve dose goals with caution, as elimination of necessary work may ultimately increase dose if equipment failures result. In addition, always consider nuclear safety when evaluating the option of work scope reduction. Subdivide annual and outage dose goals into goals for each major plant group and major outage evolution. Set goals with the input from those responsible for performing the work. This will ensure members commitment to meeting them. Establish challenging goals. Station best performance and industry best performance for major repetitive tasks can provide the basis for	exposures and radiation exposure planning... The Station ALARA Committee meets at least monthly and more frequently as required by outage schedules. Areas to be discussed at the Station ALARA Committee meeting include, but are not limited to: ALARA Plan reviews, 5 Year Dose Reduction Plan and 5 Year Dose Reduction Plan action reviews. "Station ALARA Sub Committees, comprised of Section Managers (or lower) from the same departments as the Station ALARA Committee, work to provide oversight, approval and support implementation of ALARA for their facility. The ALARA Sub Committee provides a forum for line ownership of dose, working level input and approval of ALARA Plans for their facility and support for implementation of ALARA initiatives. “All ALARA Committees are required to have Terms of Reference to define the following: 1. Chair. 2. Membership (name and position). 3. Quorum. 4. Meeting frequency. 5. Roles of members. 6. Required meeting agenda items. 7. Owner of agenda, actions, responsibilities for minutes and timelines for minute distribution.” Section 4.2 of the ALARA Program describes the 5 Year Dose Reduction Plan:	

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	challenging goals. Each major goal should require an action plan and be assigned to each work group to reduce exposure. Micro-planning is a technique used to plan tasks where collective dose is expected to be low in some cases at 0.1 mSv. Management approves the goals and the action plans. Ensure that the outage dose goal and the outage ALARA dose projection based on the total dose projected for each outage RWP are in agreement. If a significant difference exists, adjust the outage goal or perform a gap analysis to identify the actions needed to achieve the outage dose goal. Monitor progress toward the effective implementation of action plans and achievement of ALARA goals on a daily basis. Formally provide station status weekly during normal operations and daily or per shift during outages. A graph of projected daily outage dose and work hours tracked against actual dose and work hours is a useful indicator. The success or failure to meet a goal should be readily visible to all personnel, to help instil ownership and accountability at both the supervisor and worker levels. Conduct annual and outage radiological performance critiques. This review can determine if original dose estimates were accurate, if the goal was challenging and most of the actions taken to reduce dose were effective. In addition, identify actions for improvement and assign them to a responsible individual or department.	"The 5 Year Dose Reduction Plan summarizes current activities being utilized for dose reduction and provides senior management a road map for future exposure reduction initiatives required for Bruce Power to achieve excellence in Collective Radiation Exposure (CRE). "Preparation of the 5 Year Dose Reduction Plan is responsibility of the Responsible Manager for each Station taking the following into consideration: 1. The 5 Year Equipment Life Cycle Engineering (ELCE) Plan for inspection and maintenance of all major reactor components (i.e., feeders, fuel channels, boilers, reactor system heat exchangers), as well as, valves, mechanical, and rotating equipment. The 5 Year Dose Reduction Plan must take into consideration the dose consequences of the planned work and shall provide sufficient detail to allow dose estimations based on past performance for similar maintenance campaigns. 2. The 5 Year outage schedule produced by the Outages and Maintenance Organization which will meet the inspection and maintenance requirement identified by the ELCE Plan. 3. An examination of past dose performance to planned operation and maintenance activities to project dose performance with and without dose reduction initiatives. By examining trends in performance and station conditions, the 5 Year Dose Reduction Plan helps identify focus areas for new dose reduction efforts. 4. Any dose reduction initiatives and other business objectives (e.g., top World Association of Nuclear Operators (WANO) quartile for collective radiation exposure).	

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	Guidelines for managing work scope changes include a review of possible radiological consequences. Prior to approving major work scope changes, station management considers the radiological consequences in the decision process. Where the work scope is changed, causing the annual or outage radiation exposure goal to be unachievable or achieved too easily, revise the goals. Using the above information, plant and corporate management personnel are provided with a periodic (quarterly or at least semiannually) summary of radiation dose reduction performance. This summary includes performance measures such as the following: • identification of problems and needed improvements to achieve or continue to meet the industry collective radiation dose goals • a list of actual dose performance compared to goals • a comparison of station collective dose with other stations of the same type. This comparison may include an analysis of similarities and differences, because radiation dose varies among plants of similar design as a function of operational history, plant age, amount of outage and repair work and plant radiation levels. • an estimate of the amount of collective dose saved by the radiation dose reduction	"The 5 Year Dose Reduction Plan is reviewed and approved by the Station ALARA Committee and is implemented by the Plant Manager. The Site ALARA Committee provides oversight on the implementation of the 5 Year Dose Reduction Plans. "Through the calendar year progress of approved ALARA dose reduction initiatives will be reviewed against the 5 Year Dose Reduction Plan by the Station and Site ALARA Committees and their status tracked... "The 5 Year Dose Reduction Plan is required to be revised annually based on updated ECLE Plans, outage schedules and new initiatives and may require updating prior to the one year if there are significant changes to either inputs throughout the year." Section 4.3 of the ALARA Program discusses establishing collective radiation estimates and dose goals: "In order to improve performance in CRE, dose goals and targets are established and performance against these measured at various levels of the organization. "Business plan dose targets are prepared by the Responsible Manager and approved and by the Station ALARA Committee and the CNO and are based on the 5 Year Dose Reduction Plans, approved dose reduction initiatives and corporate objectives (e.g., WANO median or first quartile performance). "To achieve the business plan goal, Plant Managers shall ensure that the approved dose reduction initiatives are implemented at their facilities/projects. Responsible Managers shall perform a gap analysis to identify factors that	

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	programme • a comparison of actual dose performance against station, utility and industry long-term goals • if major repairs or modifications were made, an assessment of station performance compared to other stations performing similar repairs or modifications • source term trends, effects on station collective dose and the status of source term reduction initiatives.	affect their facility/project's ability to meet the business plan goal and present these gaps at Station ALARA Committee meetings to develop action plans to address the identified gaps. "Lower level dose targets are established to provide focus and ownership of dose by work groups performing radiological work and are consistent with the business plan dose target. These lower level dose targets include outage, on line, monthly, work group level and work program level targets. Dose targets are reviewed, approved and tracked at Station ALARA Sub Committee meetings... "These dose estimates will be reviewed on an ongoing basis by Line Management, ALARA Health Physicists and RP Assessors in order to identify gaps between the estimates and the station business plan dose targets, the need for further dose control efforts, and improvements to the dose estimation process." Bruce Power evaluated their RP Program and performance against a CANDU RP benchmarking report and recorded their findings in a FASA [SA-RPR-2013-02]. This FASA identified three gaps against performance at other CANDU power plants with respect to challenging dose goals: PNGS GP-4: "… a gap exists in that goals set at Bruce do not appear to be challenging in a manner that would require groups to develop initiatives to meet or exceed those goals." CNE GP-3: "Challenges to reduce dose to well below budget are not apparent, and dose targets can sometimes be achieved without application of ALARA initiatives." EXELON GP-12: "Dose goals set for organizations and high	

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		exposure work do not appear to be challenging. Dose budgets appear to be dose estimates as opposed to challenging goals." Improvements with respect to challenging dose goals were made after this FASA, and Section 4.0 of SEC-RPR-00012 states that the setting of challenging targets and goals is critical in maintaining a robust RP Program. **Clause V.C4 of t**he guideline suggests that long-term dose reduction plans should be reviewed and updated at least annually. The Bruce B ALARA Committee TOR indicates that the 5 year dose reduction plan is produced annually. Plans should contain: overall executive summary with goals; ownership of initiatives; recent accomplishments; approval process; previous initiatives for the last two years; dose history and projected goals of each initiative; plant data comparisons to similar plants; and a source term reduction section. A 5 Year Dose Reduction Plan is required at Bruce B, and considerations that go into preparing the plan are listed in Section 4.2 of [BP-RPP-00044] no specific description of the required contents of the plan is provided. The Bruce B ALARA Committee TOR indicates that members are responsible to support the development and approval of the plan. The most recent 5 Year Dose Reduction Plan was issued by Bruce B in May 2016, and contains: scheduled outage days; outage ALARA initiatives; projected dose estimates; consideration of OPEX from similar stations; consideration of unit to unit source term. A discussion of the assumptions and potential dose reduction initiatives for future implementation is also included. While the requirements for the 5 year dose reduction plan provided in [BP-RPP-00044] and the details provided in the	

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		Bruce B dose reduction plan do not meet the recommendations exactly, the intent of the recommendation is met. While dose goals must be established, the programmatic emphasis is on dose goals being achievable, with no mention of setting challenging goals. However, following a FASA [SA-RPR-2014-02] that identified three gaps against performance at other CANDU power plants, improvements with respect to challenging dose goals were made. Annually, the Bruce B dose goals are documented in a memorandum by the Bruce B Radiation and Industrial Safety Manager, sent to the Executive Vice President and Chief Nuclear Officer. These memos demonstrate challenging dose goals through progressive reduction in dose targets based on outage scope. In addition, CNSC has recommended [BRPD-AB-2014-010-R3] that Bruce Power "develop and implement additional dose reduction measures to achieve their business goal of achieving industry best Collective Radiation Exposure performance." Bruce Power accepted the recommendation (see Section 7.3 of this report), and has since achieved top ranked status for CRE in North America. There is no specific documented requirement to provide station dose status weekly during normal operations and daily during outages. However, the following dose information is provided: • Via the RP web page - current year to date dose and dose per unit • Via the Radiation Information System - personal	

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		individual dose status • The Site ALARA Committee TOR indicates that that committee reviews dose status monthly • The Bruce B ALARA Committee TOR indicates that committee members are responsible for producing planned outage dose performance reports • Daily outage dose performance emails are sent to RP personnel • A detailed outage dose performance overview report is prepared and communicated following an outage • Dose status against the YTD target is reported daily in the Plant Condition Report RP practices that are not documented in RP Program governance have been identified as a gap, as discussed in Section 5.6. Independent Oversight Quarterly Reports issued for Q1 and Q3 of 2015 identified issues with ALARA accountability. Corrective actions are in progress (see Section 7.2.1 of this Report.) The CNSC Regulatory Oversight Report for Canadian Nuclear Power Plants: 2014 noted that Bruce Power's ALARA program is well documented and mature (see Section 7.3 of this report.)	
VI.C1.	a. Area, equipment, material, and tools Use contamination controls for areas, equipment, materials, tools, and other items if contamination	Programmatic: Compliant	C

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	levels exceed the following: • Beta-gamma - Removable: 1,000 dpm/100 cm2 - Total (fixed plus removable): 5,000 dpm/100 cm2 • Alpha - Removable: 20 dpm/100 cm2 - Total (fixed plus removable): 300 dpm/100 cm2 These control levels are low enough to prevent the spread of contamination to clean areas and are considerably less than the levels that would cause significant personal skin dose. b. Protective clothing and equipment Remove protective clothing with fixed contamination above a predetermined action level from use or dispose of it as radioactive waste. Determine the fixed contamination action level (both beta and gamma) based on the potential for contamination leaching and for the release of discrete radioactive particles from the protective clothing. Also consider the number of personnel contamination occurrences that are attributed to protective clothing. The use of gamma-sensitive instrumentation to monitor protective clothing is more effective in identifying cobalt-60 discrete radioactive particles than thin-window G-M	a. Area, equipment, material and tools: Compliant BP-RPP-00022, Contamination Control, Section 4.1.1, provides the contamination control limits for clean areas, materials, and tools used in clean areas of the zoned station at BP. The values provided are in direct alignment with those recommended in the WANO guidance. b. Protective clothing and equipment: Gap BP uses a variety of RPPE, some of which is laundered, some of which is disposable (as per procedure Selection of RPPE [BP-RPP-00014]). After use for contamination work, RPPE is either handled in accordance with Waste Management procedures (which is outside of the scope of this assessment), or surveyed and sent to the on-site laundry facility. The procedure Hazards Surveys, Posting, Response and Recording [BP-RPP-00023] in Section 4.4.1.5 details requirements for surveying and labeling used plastic suits: a loose contamination check is required using a Masslinn and a pancake meter. A direct survey of the bag containing the suit is also required using a gamma meter (in alignment with the guidance). The decontamination procedure, [BP-RPP-00007] Appendix D identifies steps to be taken if clothing is contaminated. If after decontamination attempts, there is still fixed contamination on the clothing then the procedure instructs that it be sent for laundering or disposal. While it is not stated that this applies to RPPE, it is implied. The Plastics Laundry procedure [B-SMP-78150-00003]	

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	detectors. Decontaminate respiratory protection equipment to less than 1,000 dpm/100 cm2 of loose contamination prior to reuse. Significant fixed contamination (for example, above 5,000 ncpm beta-gamma on a frisker) should require removal of respiratory equipment from service. c. Aggregate quantities of non-bulk materials If individual items have been manually surveyed using a beta-sensitive monitor and placed together to form an aggregate of these materials (for example, a bag of trash or collections of bags of trash), survey them in a gamma- sensitive tool monitor before unconditionally releasing them from the RCA. If the aggregate is too large to be placed in the tool monitor and it cannot be separated into smaller quantities that can fit, survey the aggregate quantity for detectable gamma radiation levels with a gamma-sensitive instrument that is capable of measuring in the micro-R range in a low background area.	provides contamination levels above which plastic suits must be sent for decontamination. Section 4.4.9 discusses segregation of suits for washing, and states: “IF any suits greater than 10,000 nCi prior to washing, THEN DECONTAMINATE.” Sections 4.10.7 and 4.10.8, respectively state that after wash: “ENSURE all suits being released from plastics Laundry Facility are less than 650 nCi.” and “IF any suits are over 650 nCi, THEN SEND for decontamination.” According to [SA-RPR-2013-03], "NK37-SMP-78140, Rev 001, step 4.6.2 and CMF management allow 'NO RESIDUAL' contamination (fixed or loose) on respirators." This aligns with, and in fact exceeds, the guidance on decontamination of respiratory protection. c. Aggregate quantities of non-bulk materials: Not assessed. The segregation and handling of waste materials is outside the scope of this assessment.	
VI.C2.	a. Automatic contamination monitors Automatic whole-body contamination monitors are, in most applications, superior to manual frisking. The whole-body monitors are particularly useful during surveying for discrete radioactive particles, because of the difficulty of detecting	Programmatic: Gap a. Automatic contamination monitors: Gap [BP-RPP-00015], Zoning, Section 4.1.3: "All personnel shall monitor surfaces of clothing or body which have been	Gap

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	particles by hand frisking. Use whole-body contamination monitors at the exits from the primary RCA. Beta contamination monitors should detect levels at the average beta energy of the station radionuclide mix equivalent to 5,000 dpm at a distance from the detector equivalent to the location of the individual being monitored. Based on the configuration of the whole-body contamination monitor, the detector location, and the body part being monitored, this distance may be on contact with the grating above the foot detector and up to 3 inches from some other detectors. Establish alarm set points as low as practical, considering the presence of difficult-to-detect isotopes in the station radionuclide mix. At least daily, perform a response check on each detector, using a source with activity at the desired set point for the alarm and reasonably approximating the station isotopic mix. If a site chooses to response-check its RCA release instrumentation at a frequency other than “every detector, every day,” the position should be well documented and include at least the following elements: • Instrument type and the location. Testing for both trains of detectors should be documented for instrumentation with dual detection capabilities (such as gas flow proportional detectors and gamma scintillation detectors). • Performance of deliberate failure tests to	exposed to atmosphere of Zoned Area by using the personnel whole body contamination monitors when entering Zone 1 or Public Domain from Zone 2." Section 4.2 makes reference to whole body monitors at the entrance to Zone 2 from a higher numbered zone. Section 4.5 makes reference to whole body monitors at the entrance to Zone 1 or Public Domain. Throughout the procedure whole body monitors are also mentioned at the exit from Zone 2 to the unzoned area, entrance to Zone 2 coffee shops, and close to work locations during outages. This aligns with WANO guidance regarding placement of whole body monitors at the exit from the primary radiologically controlled area. [BP-PROC-00037], Calibration and Maintenance of Fixed Contamination Monitors establishes the alarm set points and testing frequency for fixed contamination monitors, including whole body monitors. As per Appendix B, the alarm setpoints for Zone 2 to 1 boundary whole body monitors are 4.5 nCi (9990 dpm) of Tc-99 at 1.3 cm for foot detectors and 7.5 nCi (16,650 dpm) of Tc-99 at 5 cm for hand and body detectors. In a technical basis document written in 2005, “Radiation Protection Alarm Set-points implemented at Bruce Power in comparison with industry best practices and International Standards”, the basis for Bruce Power’s whole-body monitor alarm set points is established. Bruce Power interprets the 5000 dpm recommendation as meaning that a whole-body contamination monitor “should be able of detecting … 5000 dpm/100cm^2 of ^{137}Cs at 1 cm with a 95% DCL [Detection Confidence Level] and FAR [False Alarm Rate] of <0.01%.” The technical basis document describes how the established WBM set points used at Bruce Power	

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	verify an instrument will remove itself from service prior to becoming ineffective • A formal process to evaluate and document instrumentation hardware or software modifications against initial testing, to ensure the monitor continues to function as expected • Testing to document as-found and as-left conditions to determine if the position should be reevaluated Periodically, whole-body contamination monitors should be challenged in the normal operating mode using a smear source representative of the station nuclide mix to determine their reliability and sensitivity. If the monitor does not have the ability to account for radon, have procedures in place to evaluate alarms for short-lived or natural radioactivity. Install gamma-sensitive portal monitors at the RCA exit to increase the likelihood of detecting contamination primarily composed of activated corrosion products that has proven difficult to detect with many types of automatic whole-body contamination monitors. Use portal monitors in a pause mode, and optimise their detection capability. Establish the alarm set point as low as practical, considering ambient background radiation, the negative consequences of false-positive alarms and reasonable egress times. Portal monitors located at the RCA exit should have alarm set points that correspond to	are equivalent to the guideline, based on their interpretation given above. The beta energy of Tc-99 is representative of the station radionuclide mix, which is dominated by Co-60. The FASA [SA-RPR-2013-03] identified a discrepancy between the RP program and the guidance with respect to whole body monitor alarm set points. AR 28399592-03 was raised to evaluate the whole body monitor alarm set points with respect to the WANO guidelines. The AR was closed in November 2014 to DCR 28470411 to revise [BP-PROC-00037]. The due date for the DCR is October 12, 2018; however, the procedure was revised to R005 in September 2015 without addressing the request to evaluate the WBM alarm set points. Consequently, there is still a gap. Whole-body alarm set points have not been revaluated or confirmed since 2005. **Gap 1** This is also a procedural noncompliance, which is addressed under Safety Factor 10, Organization and Administration. In addition, the CNSC Type II inspection on Radiation Hazard Control in 2015 led to a recommendation [BRPD-AB-2015-007-R8] that Bruce Power "periodically review and confirm the technical basis for alarm set points and source check frequency of fixed contamination monitors remains consistent with industry best practice. CNSC staff further recommends that this periodic review be documented as a re-confirmation of the existing 2005 report (Radiation Protection Alarm Set-points implemented at Bruce Power in comparison with industry best practices and International Standards) or an updated report be generated as appropriate, and that alarm set points and source check frequencies be updated in governance as appropriate pending the results of such	

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	1111-1296 Bq (30-35 nanocuries) at Co-60 or about 2778-2963 Bq (75-80 nanocuries) of Cs-137. Gamma-sensitive portal monitors are not needed at the RCA exit if the whole-body contamination monitors incorporate a plastic scintillator or other detector capable of monitoring gamma radiation. At least each day an instrument is in use, perform a response check using a radioactive source with an activity appropriate for the alarm set point. Install gamma-sensitive portal monitors at the protected area exit as a final barrier, to increase the likelihood of detecting contamination that may have been inadvertently released from the RCA. Alarm set points should be based on station-specific isotopic mix and environment. If contamination monitor alarm set points are standardised across a multi-site fleet, use the set points from the station with the most limiting radionuclide mix, rather than an average among the sites. b. Hand frisking techniques The detectable quantity for a direct frisk with a thin-window Geiger-Mueller detector is nominally 100 counts per minute (cpm) above background with the background reading less than 300 cpm (a background reading of less than 200 cpm should be used if surveying for release of personnel). A minimally acceptable whole-body frisk requires	periodic reviews." Bruce Power acknowledged the recommendation in [NK29-CORR-00531-12856] and referenced actions arising from the FASA, including the DCR mentioned above. [BP-PROC-00037], Appendix B also provides the alarm check test frequency for fixed contamination monitors. For Zone 2 to 1 boundaries, whole body monitor alarm checks are required bi-weekly, rather than daily as suggested by the WANO guidance. A draft report [B-REP-03400-28MAR2013], “Review of Alarm Set-point Checks of Zone 2/1 Fixed Radiological Instrumentation” states that “discussions and document reviews suggest that the alarm test frequency of Zone 2-1 monitors has remained at bi-weekly since 2001 … There has been no change in Bruce Power practices of alarm testing these instruments to conform to changing INPO and WANO guidance, and documented justification for the current test frequency or for not meeting the current WANO or INPO guidance could not be located.” However, the draft document concludes, “simply deciding to implement daily alarm tests is probably not practical with the current staffing and furthermore may not be justified…” Section 6.0 of the draft report provides a justification for no immediate changes to WBM alarm test frequency: “Based on the experienced low potential for contamination at Zone 2/1 boundaries, combined with a low frequency of WBM detector alarm failures … there is no need for immediate change in the current test program, while further evaluation is conducted to develop and justify possible future changes in the alarm test frequency.” [SA-RPR-2013-03] notes, "justification of this less frequent testing has been drafted but has not yet been completed."	

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	two or three minutes. If background count rates below 300 cpm cannot be reasonably achieved at the desired monitoring location, frisk to check for gross contamination and perform a final frisk at a more remote location with acceptable background levels. Shielded frisking booths may be provided in high- background areas. Hand frisking should not be used for the release of personnel from the station without specific approval of the radiological protection manager, because of process difficulties and sensitivity. c. Contamination areas and radiologically controlled areas All personnel perform, as a minimum, a hand-and-foot frisk as soon as practical on exiting a contaminated area. When personnel exit a highly contaminated area (for example, greater than 100,000 dpm/100 cm2) or a discrete radioactive particle area, a whole-body frisk is done as soon as possible. In addition, a whole-body frisk using the whole- body contamination monitor or a frisker is performed before personnel put on any clothing not worn in the contaminated area. This ensures clothing does not lessen the sensitivity of the frisking process by shielding beta radiation. All persons, regardless of whether they entered a contaminated area, should monitor themselves for contamination with a whole- body contamination monitor prior to exiting the RCA.	There is a discrepancy between the RP program and the guidance with respect to whole body monitor test frequency. This gap was noted by the CNSC during an inspection that took place in July, 2012 [NK21-CORR-00531-09833]: "Bruce Power's alarm check frequencies for monitoring equipment at the Zone 2-1 boundary do not meet industry guidance" (Section 4.5.2). AR 28399592-04 was raised to evaluate the response test frequency of Zone 2 to 1 release instrumentation with respect to WANO guidelines. The AR was closed in November 2014 to DCR 28470415, and that DCR is at "Approved" status with a due date of August 11, 2015. There is a note in the DCR dated October 16, 2015, saying "Not evaluated during Revision 005." Consequently, there is still a gap. **Gap 2** This also shows a procedural noncompliance, which is addressed under Safety Factor 10, Organization and Administration. [BP-PROC-00037], Appendix B also provides the alarm check source to be used. For Zone 2 to 1 boundary whole body monitors, 2.7 nCi Cs-137 check sources are required. The technical basis document written in 2005, “Radiation Protection Alarm Set-points implemented at Bruce Power in comparison with industry best practices and International Standards” states: “the nuclide used in the calibration of all radiation protection instrumentation must be representative of the nuclides one would expect to encounter in that facility … with respect to beta sensitive WBCMs [whole-body contamination monitors] the nuclide of choice is ^{99}Tc … in the case of gamma sensitive equipment 137Cs is chosen as a calibration nuclide due to its … radiation emissions which are representative of commonly encountered radionuclides in an operating nuclear power plant.”	

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	It may not be practical to install whole-body contamination monitors and gamma-sensitive portal monitors at satellite RCAs, such as warehouses or radioactive material storage facilities. In these instances, personnel perform a survey using a whole-body contamination monitor or a hand-and- foot frisk upon leaving the satellite RCA and proceed to the nearest whole-body contamination monitor and gamma-sensitive portal monitor. Contamination monitoring requirements are clearly posted at the exit from satellite RCAs. Exiting any posted RCA or radioactive material storage area (RMA) requires personnel to monitor for contamination as specified above, with the following exceptions: • If the area is an RCA only because of dose rates and there are no radioactive material storage containers or contamination sources in the area, contamination monitoring is not required. • Personnel and material monitoring requirements for independent spent fuel storage installations (ISFSIs) should be the same as the primary RCA while fuel loading activities are in progress. After individual campaigns have been completed, ISFSI areas are exempt from monitoring because the contamination source is sealed within the certified container. • On a temporary basis, a satellite area posted as an RCA or RMA may be released from	[SA-RPR-2013-03] notes that "Cs-137 is used for the alarm tests and is not representative of the station isotopic mix as it has a higher energy beta than Co-60. Tc-99 sources have been obtained for these alarm test applications, but have not been placed into use." Use of a response check source that approximates the station isotopic mix is not required in the procedure. There is a discrepancy against the guidance with respect to using a check source that approximates the station isotopic mix. AR 28399592-05 was raised to evaluate the use of a response check source that approximates the station isotopic mix (including consideration of using Tc-99 vs. use of Cs-137). The AR was closed in November 2014 to DCR 28470398, and that DCR is at "Approved" status with a due date of April 22, 2015. There is a note in the DCR dated October 16, 2015, saying "Not evaluated during Revision 005." Consequently, there is still a gap. **Gap 3** This also shows a procedural noncompliance, which is addressed under Safety Factor 10, Organization and Administration. There is no programmatic requirement to perform routine tests to challenge whole-body contamination monitors using a smear source representative of the station nuclide mix to determine the reliability and sensitivity. This constitutes a gap against the guidance regarding performance of periodic monitor challenges. **Gap 4** [SEC-RPR-00026], Health Physics Response to a Personnel Contamination Incident, Section 4.2, item 5 b and Section 4.3 provide guidance on evaluating alarms for radon or short-lived contamination. This is in alignment with the guidance. [BP-RPP-00015] indicates that gamma sensitive portal monitors are present at the Bruce B guardhouse, but not at the immediate exit from the controlled Zone 2 area. Section	

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	the need for contamination monitoring on each exit from the area. However, there must be no open contaminated areas or material, radiation protection coverage must be provided, and a sufficient survey of the area must be periodically performed (for example, each shift) to ensure no contamination is present. Provide equivalent contamination monitoring capability, as at the RCA exit, for personnel entering non-RCA clean areas inside the RCA where eating and drinking are allowed. For example, provide a whole-body contamination monitor and gamma tool monitor equivalent to those used at the RCA exit. d. Personnel Contamination Event A personnel contamination event is when an individual is contaminated greater than or equal to 100 counts per minute above background on the skin, clothing, or modesty garment, glasses, lanyard, shoes or hardhat. The highest contact frisker reading should be used to classify the personnel contamination event.	4.5 requires that personnel use a gamma sensitive portal monitor prior to entering Zone 1 or the Public Domain, but there is no programmatic requirement to have.portal monitors and/or gamma sensitive detectors in whole body monitors in place at all Zone 2 exit locations. This is a gap against the guidance regarding placement of gamma sensitive whole body detection capability at the exit from the controlled area. However, whole-body monitors with gamma detection and measurement capability are in place at all Zone 2 to 1 exits at Bruce B, so the requirement is met in practice. The CNSC Type II inspection on Radiation Hazard Control in 2015 led to a recommendation [BRPD-AB-2015-007-R3] that Bruce Power "identify the numbers and locations of available whole body monitors required to provide adequate coverage in the stations and to develop and implement a corrective action plan to ensure this minimum adequate level of coverage is achieved and sustained." Corrective actions are in progress under AR 28527104, as discussed in Section 7.3 of this report. The WANO guideline recommends a gamma portal monitor alarm set-point of 75-80 nCi Cs-137. [BP-PROC-00037] indicates that the portal monitor alarm set point (in Appendix B) is 200 nCi Cs-137 for the sum channel and equal or lower for individual detectors. The technical basis document written in 2005, “Radiation Protection Alarm Set-points implemented at Bruce Power in comparison with industry best practices and International Standards” states: “With respect to SAMs [Small Article Monitors] and Portals [portal monitors], it is reasonable to lower Portal Alarm set-points to around 100 nCi. Statistical error and reproducibility effects would provide an acceptable tolerance of +/- 20%.	

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		Therefore, an alarm set-point of 80 nCi ^{137}Cs on a Portal Monitor is in the same vicinity as a value of 120 nCi ^{137}Cs." [SA-RPR-2013-03] notes that the alarm set points are "200 nCi of Cs-137, rather than Co-60, which would be representative of the station mix of gamma emitting radionuclides. The alarm level of 200 nCi is more than twice the level recommended by WANO." This is a discrepancy against the guidance regarding portal monitor alarm set points. AR 28399592-08 was raised to evaluate the security exit portal monitor alarm set points to achieve WANO guideline levels. The AR also mentions creation of a portal monitor alarm set point technical basis document. The AR was closed in November 2014 to DCR 28470421, and that DCR is at "Approved" status with a due date of August 10, 2015. There is a note in the DCR dated October 16, 2015, saying "Not evaluated during Revision 005." Consequently, there is still a gap. **Gap 5** This also shows a procedural noncompliance, which is addressed under Safety Factor 10, Organization and Administration. The CNSC Type II inspection on Radiation Hazard Control in 2015 led to an Action Item [BRPD-AB-2015-007-AN1] that Bruce Power "develop and implement a corrective action plan to ensure that all RP instrumentation is calibrated at the required frequency and a calibration label is affixed prior to the equipment being placed in service." Corrective actions are in progress under AR 28527104, as discussed in Section 7.3 of this report. b. Hand frisking techniques: Compliant [BP-RPP-00015], Section 4.1.3: "Personnel shall not use	

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		unmonitored exits to exit Zoned Area except in emergency situations...If personnel whole body monitors are not available, this monitoring may be accomplished by other means approved by the AHP." Release of personnel by any means other than use of a whole body monitor (including hand frisking) would require the approval of the AHP. [BP-RPP-00022], Section 4.1.5.12 provides detailed guidance on performing manual whole body frisks, and directs the use of a whole body monitor as a follow-up. This is in alignment with the WANO guidance. The CNSC Type II inspection on Radiation Hazard Control in 2015 led to a recommendation [BRPD-AB-2015-007-R5] that Bruce Power "enhance the current alpha frisking requirements by conducting frisking at the exit of all alpha level 3 areas and not only areas with less than 50:1 ratios to ensure that potential alpha hazards from all alpha level 3 areas are identified." The Bruce Power response was to initiate DCR 28524606 for [SEC-RPR-00016] with a due date of October 28, 2016. c. Contamination areas and radiologically controlled areas: Indirect compliance [BP-RPP-00022], Contamination Control, Section 4.3.3 describes the process required for exiting a contamination control area (CCA). The requirement includes a minimum hand and foot frisk followed as soon as practical by monitoring in the nearest whole body monitor, in alignment with the guidance. The BP RP Program does not define "highly contaminated areas", however, [BP-RPP-00022],	

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		Section 4.3.3 would cover highly contaminated areas as a specific type of CCA. Appendix C describes Hot Particle Area Control, including step 6 which lists the requirements for exiting a hot particle area (HPA) CCA. All personnel leaving CCA after working in a Hot Particle Area CCA are to undergo a whole body survey prior to proceeding to the whole body monitor." [BP-RPP-00022], Section 4.1.2, 8: "Personnel shall monitor themselves in WBM as soon as possible at the nearest monitor upon exiting a CCA and shall WBM for contamination prior to donning any additional personnel clothing (such as coats) not worn inside CCA." [BP-RPP-00015], Zoning, Section 4.1.3: "All personnel shall monitor surfaces of clothing or body which have been exposed to atmosphere of Zoned Area by using the personnel whole body contamination monitors when entering Zone 1 or Public Domain from Zone 2." There is no reference to satellite RCAs at BP, however clear monitoring requirements are provided for movement between zones. There are no exceptions to monitoring requirements in moving between zones at BP. [BP-RPP-00015], Zoning, Section 4.1.8: "Personnel shall monitor themselves and materials for contamination when entering areas where additional monitoring is required by the AHP, e.g., coffee shops, change rooms, and main control room." Section 4.6 provides more detailed requirements for entering a Zone 2 coffee shop or the Zone 2 Main Control Room. The type of monitors used is not specifically mentioned, however the requirements include monitoring all	

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		items and the whole body using the monitors provided. d. Personnel contamination event: Compliant The definition of a Personal Contamination Event (PCE) provided in the RP Lexicon is in alignment with the guidance. [BP-RPP-LEXICON], Section 1.2.180: "Personal Contamination Event contamination of skin, hair, clothing, or items worn by alpha (α) contamination or beta (β) contamination that is greater than or equal to 100 net cpm as measured by a pancake-type contamination meter on slow response in a general background not exceeding 300 cpm (β/γ). For the purpose of tracking, trending, and identification of corrective actions, personal contamination events are categorized as: 1. Contamination of skin, personal clothing (including scrubs or modesty garments), or personal items. 2. Contamination of protective clothing. "Category 1, above, is further subdivided into: a) Action Level 1 event: events where detected contamination was greater than or equal to 100 net cpm and less than 5000 net cpm. b) Action Level 2 event: events where detected contamination was greater than or equal to 5001 net cpm and less than 50,000 net cpm. c) Action Level 3 event: events where detected contamination was greater than or equal to 50,000 net cpm.	

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		"These are based on EPRI standards."	
VI.C3.	a. Area contamination control 1) Source minimisation • Control the sources of radioactive contamination to minimise the number and extent of contaminated areas. • Identify radioactive system leaks and enter them into the station work control system for repair, with priority given to leaks that spread contamination. • Use drip pans, containment devices, or drain hoses to divert or collect leakage whenever the leak cannot be repaired quickly. • Track and inspect these devices periodically (for example, monthly) to ensure effective protection against the spread of contamination and timely removal after repair of the leaking components. Prepare work sites to minimise the spread of contamination during work while also reducing the generation of radwaste. Planning includes contamination control measures such as the use of plastic, washable sheets or absorbent material and the use of strippable coatings, containments or bottles to collect radioactive material leakage. Train workers to ensure they are proficient in using contamination control devices. Maintain the	Programmatic: Gap a. Area contamination control: Gap 1) Source minimisation - Gap The procedure New Work Initiation [BP-PROC-00327] requires that leaks be identified and characterized and entered into the work management system. [BP-PROC-00328], Work Prioritization and Approval, provides guidance on the prioritization of work. [SEC-RPR-00065], CATS Devices Field Guide, describes the use of "Control at the Source" devices, used to contain and prevent the spread of contamination as an augmentation to good work practices. [BP-RPP-00022], Contamination Control, Section 4.1.3, 3: "CATS devices shall be inspected upon installation, should be formally tracked (catalogued), periodically inspected (e.g., on a quarterly basis), and be promptly removed when no longer required." [BP-RPP-00022] "describes the Radiation Protection (RP) work practices, measures, and techniques used to control radioactive contamination at the source, including Discrete Radioactive Particles (DRPs) to prevent contamination spreading to workers, equipment and areas between work locations and maintain exposures As Low as Reasonably Achievable (ALARA)." The procedure includes instruction on:	Gap

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	integrity of floor coatings to facilitate decontamination of areas after work is completed. Avoid the use of materials that attract radioactive particles or that have been known to accumulate contamination, such as cloth chairs and carpet in the RCA. If these materials must be used, survey them frequently to ensure contamination levels are not building up above appropriate levels. Provide specific contamination control guidance for repetitive evolutions such as filling and venting contaminated systems and installing temporary instrumentation during in-service testing. Document guidance in plant procedures, job aids and radiation work permits to minimise the chance of spills during these repetitive evolutions. For frequently performed fill-and- vent evolutions, consider modifications to eliminate the use of temporary hoses routed to floor drains or to ducts that create a high potential for the spread of contamination. Store material with loose or fixed contamination in areas protected from inclement weather, water leaks, extreme temperatures, fire hazards, and other environmental conditions that could degrade the material or storage container and spread contamination. Investigate spills caused by improper maintenance, surveillance testing, and operational evolutions. Use the station corrective action programme to document spills. Take appropriate	- preparation of work sites and inclusion of contamination control in work planning; - containment and cleaning of spills; - decontamination following repair or containment of leaks; - use of containment enclosures. Although [BP-RPP-00022] provides guidance on ways to help control contamination, the use of CCAs and CATS, and maintaining the integrity of floor coatings, there is no requirement to train personnel in the use of contamination control devices. There is also no requirement for training in CATS in the training document for RP Techs, [TQD-00046]. Included in the RP Tech training for the spring session of 2015 was 'Contain at the Source (CATS): Set-up, Use and Removal' training. In this case, changes in the training program are not supported by updated RP Program documentation. RP practices that are not documented in RP Program governance is discussed in Section 5.6. The Independent Oversight Quarterly Report for 2015-Q2 identified inconsistent enforcement of radiation protection and work practices as leading to poor practices and the potential of loose contamination spread. Corrective actions are in progress as described in Section 7.2.1 of this report. [BP-RPP-00005], Routine Radiological Survey, Sections 4.5.1 and 4.5.3 provide direction regarding the routine survey of vinyl and cloth chairs for radioactive contamination. There is no procedural restriction on the use of vinyl or cloth chairs within Zones 2 and 3. This is a gap against the guidance recommendation to avoid the use of materials that can accumulate contamination in the radiologically controlled	

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	corrective actions, such as establishing procedure revisions, process changes, plant modifications, and task-specific training, as well as correcting improper work practices, to prevent recurrence of spills. Clean work areas and survey them for contamination after each job. Contain and clean spills or leaks that spread radioactive contamination as soon as practical. After fixing or containing leaks, decontaminate component rooms and cubicles to allow personnel to access them without wearing protective clothing. The use of containment enclosures (for example, glove bags or tented enclosures) can reduce post maintenance decontamination efforts, in addition to eliminating airborne contamination. Evaluate the dose received and resources needed to install and remove containment enclosures against other contamination controls. 2) Survey frequency Survey for beta/gamma radioactive contamination at a frequency appropriate for the conditions and activities conducted in a given area. The frequency and the extent of the survey are based on historical data, the potential for change and the need for reducing dose to radiological protection technicians. Surveys need not be performed in areas that are accessed infrequently. Conversely, personnel should not be allowed to enter until	area. **Gap 1** [SEC-RPR-00015], Radiation Exposure Permits, provides direction on the preparation of REPs, including specific contamination control guidance. As noted in [SA-RPR-2013-03], "Contrary to the WANO guidance, no reference for implementing system changes to minimize the potential for contamination spread could be found in BP governance... Perform a review of frequently performed fill and vent evolutions and determine if modifications are appropriate to eliminate the use of temporary hoses routed to floor drains or ducts." This documents a discrepancy against the guidance regarding consideration of modifications to eliminate the use of temporary hoses to drains or ducts. AR 28399592-17 was raised to document the corresponding recommendation. A review was conducted, and found no specific circumstances for this change to be made. The AR was closed in June 2015, and DCR 28501604 was created to capture a recommendation that [BP-RPP-00022], Section 4.1.3, be revised to include the statement "Where CATS devices are frequently used in fill and vent evolutions, consider modifications to eliminate the use of temporary hoses routed to floor drains or to ducts that create a high potential for the spread of contamination." The due date of the DCR is June 1, 2016. The CNSC Type II inspection on Radiation Hazard Control in 2015 led to a recommendation [BRPD-AB-2015-007-R1] that Bruce Power "ensure consistent use of temporary drain lines, secured in place to align with station floor drains." The Bruce Power response was to initiate AR 28524423 with a due date	

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	these areas are surveyed. Examples of survey frequency are as follows: • weekly in contaminated areas accessed frequently or in areas where radioactive materials are handled or stored • When necessary to control entry or work where contamination boundaries are located in areas of high dose rates • During initial entry into areas entered infrequently that contain known or suspected contamination areas and periodically thereafter to determine if conditions have changed • At least daily at contamination area control points, change areas, and step-off pads when in use • At least daily at RCA exit points • During work that involves the opening of any radioactive system; and during welding, burning, or grinding on surfaces with loose or fixed contamination • Following area decontamination to ensure that removable levels are less than 1,000 dpm/100cm^2 • Any time contamination conditions are subject to significant or rapid change in a work area • Routinely in areas outside the RCA (offices, shops, storage areas, and eating areas) on a rotating basis. If contamination is found in these areas, perform additional surveys to ensure that	of October 31, 2016. As noted in [SA-RPR-2013-03], "Contrary to the WANO guidance, no reference specifically requiring that RAM be stored in locations protected from inclement weather could be found... Incorporate a statement in [BP-RPP-00022] that prohibits storing material, with loose or fixed contamination, in an area where it may be exposed to water." This identified an apparent discrepancy against the guidance regarding storage of contaminated material in areas protected from adverse environmental conditions. AR 28399592-18 was raised to document the corresponding recommendation. Since Zones 2 and 3 are exclusively indoors, there is little risk of wetting in those zones due to inclement weather. The Zoning procedure leaves open the possibility of AHP approval for storage of contained radioactive material in the Unzoned Area, which could be outdoors. However, if approved radioactive material is stored in unzoned area, it would be contained (typically in seacan or drum), and thus would be protected from inclement weather. The AR was closed in February 2014 to DCR 28416912. The DCR is at "Approved" status with a past due date of March 31, 2015. This is a procedural noncompliance, which is addressed under Safety Factor 10, Organization and Administration. [BP-PROC-00059], Event Response and Reporting, and [BP-PROC-00060], SCR Process, describe the use of the corrective action program to document adverse conditions and initiate investigations. The requirements to clean work areas and survey for contamination after each job, contain and clean spills or leaks	

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	no additional contamination is outside controlled areas. Sample locations should not be restricted to general walkways for routine surveys. Obtain samples from out-of- the-way locations and equipment, as well as from potential sources of contamination, to ensure a complete assessment of the area. A representative number of smears should be checked for alpha activity. Take periodic samples from primary sample sinks and in the reactor cavity following drain-down after refuelling. Conduct periodical surveys on contamination areas that have the potential for highly radioactive particles. Base survey frequency on the potential for worker contamination on contamination history, current survey results, trends and on the dose expended to perform these surveys. Areas directly adjacent to discrete radioactive particle areas should also be surveyed periodically during work and at a lesser frequency when work is not being performed. Standard dry-smear techniques are not sufficient to collect particles because particles frequently will not adhere to the smear. The most effective survey method is to use large-area smears taken with tape, oil-impregnated cloth, tacky rollers or similar devices. Document and retain the results of contamination surveys taken to assess the level of worker protection. Radiological protection supervisors	as soon as practical, decontaminate following repair or containment of a leak and use containment enclosures are provided in:[BP-RPP-00022], Contamination Control; [BP-RPP-00041], Executing Radiological Work; [SEC-RPR-00065], CATS Devices Field Guide; and [BP-RPP-00048], Large Area Containments (Tents). [BP-RPP-00048], Section 4.3.3, item 2 requires that a Health Physicist "Evaluate use of large area containments in areas where high levels of radioactive contamination or radiation fields exist against added radiation exposure involved during installation and removal of containments." 2) Survey frequency - Compliant [BP-RPP-00005], Routine Radiological Survey, states: "4.5 Sample locations should not be restricted to general walkways, obtain samples from out of the way locations and equipment as well as from potential sources of contamination (e.g., in offices, take samples of computer keyboards, work surfaces, coffee/vending machine in cafeterias) such that a complete assessment of the area is performed." Section 4.5.1 of [BP-RPP-00005] prescribes routine survey frequencies of at least once every 3 days for Zone 1, Zone 2 coffee shops and main control room. Section 4.5.3 states that the routine survey frequency required for Zone 2/3 areas and the Unzoned Area is "variable and dependent on traffic flow, historical survey data and risk associated with encountering a radiological hazard." Section 4.2 assigns responsibility to the Department Manager (DM), RP&IS to develop and maintain their respective station's routine survey	

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	review contamination survey results to ensure that all required surveys are performed and that documentation is accurate and complete. Trends in contamination levels that require further investigation are also identified. 3) Contamination area posting and work control Whenever practical, post contamination survey information in the form of maps, signs or stickers conspicuously in or near work areas. For work in areas with known discrete radioactive particles, consider additional precautions. Such precautions include special posting, increased contamination monitoring, the segregation of material from the area, and the use of buffer zones to prevent the spread of particles. Unless the area is bounded by walls and doors, a tent, or containment, the area should be clearly marked with an appropriate combination of yellow and magenta rope, signs, gates or boundary tape to signify the presence of radioactive contamination. Areas such as sample sinks, pump bases, and other small areas that surround equipment may require alternate methods of marking the presence of radioactive contamination. Workers must be able to determine the boundaries of the contamination area. Ensure the integrity of boundaries by prohibiting personnel from reaching across or passing material over boundaries. Secure cords	program. The CNSC Type II inspection on Radiation Hazard Control in 2015 led to a recommendation [BRPD-AB-2015-007-R6] that Bruce Power "enhance the current required frequency of routine surveys at Zone 1 lunchrooms, Zone 2 coffee shops, and main control room to align with industry standards (e.g. daily surveys)." The Bruce Power response was to initiate DCR 28524609 on BP-RPP-00005 with a due date of November 18, 2016. [BP-RPP-00023], Hazard Surveys, Posting, Response and Reporting, and [BP-RPP-00041], Executing Radiological Work, require that radiological surveys be performed as general workplace and entry surveys at boundaries where high dose rates and/or contamination are anticipated. [BP-RPP-00023] also requires surveys during work that involves opening a radioactive system, following area decontamination, and when there is significant or rapid change. [BP-RPP-00041] also requires that surveys be performed during initial entry into areas entered infrequently as part of their workplace surveys. [SEC-RPR-00046] documents the requirements for "Routine Surveys Outside the Protected Area". [BP-RPP-00005] indicates in Section 4.2 that "Authorized Health Physicist/Radiation Safety Officer (AHP/RSO) shall be consulted to provide input regarding routine alpha surveys in their respective areas of responsibility. Routine alpha surveys shall be performed in support of ongoing alpha monitoring and characterization program." Guidance on the	

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	and hoses that penetrate boundaries and by restricting material from encroaching on boundaries. A person with an open wound should not be allowed access into a contaminated area unless the wound has been covered to prevent contamination from entering the body through the wound. Radiological protection per- sonnel should be informed immediately of any wound or other injury occurring in a contaminated area so the injury can be checked for contamination. Since the radiation dose from contamination is usually insignificant, actions necessary to provide prompt emergency medical attention MUST NOT be delayed by attempts to monitor for contamination. 4) Protective clothing requirements Include protective clothing requirements as well as other protective and precautionary radiological measures, in a radiological work procedure or permit. Personnel entering contaminated areas should wear protective clothing, as follows: • Protective clothing is worn based on the contamination levels and the type of work to be performed. A complete set of protective clothing normally consists of a head cover, coveralls, gloves, booties and rubber or cloth overshoes. Cotton liners can be worn underneath rubber gloves for comfort, but they should not be considered protection from contamination. If a	performance of alpha surveys is provided in Alpha Monitoring Procedure [SEC-RPR-00016]. [BP-RPP-00023] provides direction on performing loose contamination surveys, but does not specifically address the special case of discrete radioactive particles (DRPs). It does, however, include the use of a Masslinn mop or cloth for large-area surveys, and this technique is consistent with the WANO guidance. The procedure Contamination Control [BP-RPP-00022] in Section 4.1.5.3 also prescribes the use of Masslinn for DRP surveys. These procedures adequately address the WANO guidance regarding DRPs. [BP-RPP-00005], Section 4.8 requires that the "Qualified Surveyor shall record routine survey results on routine survey check sheet(s), update Radiation Danger Signs and enter into RHIS Radiological Log. "RP FLM shall: 1. Review and verify routine survey check sheet(s). 2. Set status in RHIS to 'Verified'. 3. Initiate follow-up action to survey results" This documents requirements for recording survey results, review and follow-up. 3) Contamination area posting and work control - Compliant [BP-RPP-00023], Hazards Surveys, Posting, Response and Records, Section 4.4.1, provides detailed guidance on posting survey results. Section 4.2.1.1 of [BP-RPP-00022] describes the minimum	

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	respirator is worn, the head cover should not interfere with the seal between the face of the worker and the respirator. • Some plants use types of protective clothing such as scrubs instead of more traditional protective clothing coveralls in areas with lower contamination levels. Regardless of the style of clothing worn, if used as protective clothing to reduce the risk of a worker becoming contaminated, the clothing needs to be designated and controlled in the same manner as traditional protective clothing. This control includes removal at the step-off pad at the exit from the contaminated area. Scrubs used as protective clothing should not be worn outside the RCA, because of the buildup of low-level fixed contamination. Also, scrubs with low-level fixed contamination should not be stored outside the RCA in an uncontrolled area. • When scrubs are not considered protective clothing—such as when used as a modesty garment under other protective clothing or when worn as street clothing in areas where personal street clothing and partial protective clothing such as gloves or shoe covers are authorised—it may be acceptable for personnel to exit the contaminated area without removing the scrubs at the step-off pad. • If personnel are working in a contaminated area with significant removable contamination (for example, in excess of 100,000 dpm/100 cm2),	requirements for a contamination control area, including a hot particle area. Appendix C provides additional guidance for hot particle areas. Together, these adequately address the WANO guidance. [BP-RPP-00007], Decontamination, Section 4.1.2.2: "In cases of severe injury, medical attention shall take precedence over personal decontamination." Section 4.1.2.3 says "Personnel with open wounds shall not perform radiological work involving contamination unless wound is covered with an adhesive compress type dressing and they exercise extra caution when performing work." These requirements directly address the guideline. Further requirements are provided in the procedure Health Physics Response to a Personnel Contamination Incident [SEC-RPR-00026], which also align with the guidance. 4) Protective clothing requirements - Compliant Protective clothing requirements and other protective measures are provided on the REP, as described in [SEC-RPR-00015], Radiation Exposure Permits. [BP-RPP-00014], Selection of Radiation Personal Protective Equipment documents "the requirements to be used to select and use Radiation Personal Protective Equipment (RPPE) when required to perform radiological work at Bruce Power... RPPE is worn to prevent personal radiological contamination and internal uptake, and to limit the spread of radiological contamination at Bruce Power facilities" (Section 1.0). The procedure provides guidance on the selection of the appropriate RPPE based on the contamination levels and type of work to be performed. The procedure also describes	

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	additional protective clothing may be required. If work involving wet or greasy materials is expected or encountered, non- permeable coveralls or aprons should be used in addition to a full set of regular protective clothing, to protect personnel from wet materials. • A step-off pad is provided at the exit of a contaminated area where protective clothing is removed before personnel exit the area. This step- off pad is on the clean side of the contaminated area exit. In areas where more than one set of pro- tective clothing is used, additional step-off pads may be used to prevent the spread of contamination. Placing receptacles on the contaminated side at step-off pads for segregating reusable protective clothing and trash reduces the potential for the spread of contamination. • The number of layers and type of protective clothing may be adjusted based on other industrial safety risks, such as heat stress. The goal should always be to optimise worker protection and to prevent the worker from becoming contaminated. A reduction in protective clothing requirements for industrial safety reasons warrants compensatory actions to further reduce or contain work area contamination. The effectiveness of protective clothing is greatly reduced when dampened from perspiration or moisture from the work environment. Precautions, such as the use of air chillers and dehumidifiers, should be used to control these factors.	the various RPPE ensembles approved for use at Bruce Power. [SEC-RPR-00015] requires that RPPE requirements be considered based on the work conditions and hazards and described in the REP. This is in alignment with the guidance. Scrubs are not listed in [BP-RPP-00014] for use as protective clothing at Bruce Power. [BP-RPP-00014] and [SEC-RPR-00015] detail the requirement and selection of appropriate RPPE based on the working conditions anticipated, including: highly contaminated areas, work involving wet or greasy materials, and other industrial safety considerations such as heat stress. Appendix Q of [BP-RPP-00014] provides information on the heat balance and ergonomic effects of air supplied plastic suits. [BP-RPP-00022], Contamination Control, described the required layout for Contamination Control Areas, which includes the use of step-off pads and receptacles for segregating reusable protective clothing and waste. 5) Radiologically controlled area posting and work control - Acceptable deviation [BP-RPP-00015], Zoning, Section 4.1.6 requires that "Zone boundaries must be clearly marked." [BP-RPP-00023], Hazards Surveys, Posting, Response and Recording, 2.1.3: "A sign indicating the presence of radioactive material(s) is required on an area, room or enclosure that is used to store or otherwise hold radioactive	

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	Alternatively, frequent changes of protective clothing may be required. 5) Radiologically controlled area posting and work control. Controls for the RCA include the following: • The area is marked conspicuously. • Personnel normally are not allowed to eat, drink, smoke and chew in the RCA. If necessary, techniques for providing water to personnel can be used if precautions including contamination control and monitoring are taken to minimise the potential to ingest radioactivity. • Each entry into the RCA is controlled by a radiation work or access permit. • Personnel normally are not allowed to exit a contaminated area and traverse the RCA in potentially contaminated protective clothing. • Uncontaminated areas within the RCA should be kept as clean as practical. • When a significant fraction of smears from an area indicates loose contamination above a designated administrative control level, the area is cleaned. • The extent and status of station contaminated areas are tracked, and periodic reports are sent to management.	materials, except where the location has already been posted with a sign for radiation, surface contamination, or airborne contamination hazards." [BP-RPP-00015], Section 4.1.20 identifies that personnel are not normally permitted to eat, drink, chew or smoke in Zones 2 or 3, or Unzoned Areas. Exceptions to this must be approved by the AHP. There are designated locations for consumption of fluids in Zone 2, as approved by the AHP. [BP-RPP-00011], Requirements for Planning Radiological Work, Section 4.1: "An approved [FORM-11106], Radiological Exposure Permit (REP), is required to be issued for all radiological work." [BP-RPP-00018], Facility Access and Working Rights, does not require the use of a REP for each entry into the zoned area. While this does not align with the guidance this is an acceptable deviation based on the fundamental differences between the BP station layout and that of a typical PWR/BWR. [BP-RPP-00022], Contamination Control, in Section 4.3.3 documents the requirement to remove potentially contaminated PPE prior to exiting a CCA. Section 4.1.10 requires that "uncontaminated areas should be kept as clean as practical... Administrative control levels should be used to minimize loose contamination build-up in clean areas..." Section 4.1.11 requires that "Details of CCA, such as location, size, required in-service date, work to be done, and name and phone number of CCA User shall be identified in Rubber Area Management (RAM) database which is	

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	b. Discrete radioactive particles Discrete radioactive particles (referred to as DRPs or “particles” hereafter) are small, loose, highly radioactive particles that are very transportable because of their small size and electrostatic charge. Particles originating from irradiated fuel emit high-energy betas and low-yield photons, resulting in high beta dose rates. Particles originating from activated corrosion products emit low-energybetas and high- yield, high-energy gammas, resulting in high gamma dose rates. Evaluate technical and operational considerations and develop a failed fuel action plan or procedure for operating with the defective fuel. This plan or procedure should include the added potential for the production of DRPs. Minimise the generation and spread of particles during maintenance activities that involve the opening of primary systems. Proven techniques for reducing DRPs during in- place valve seat maintenance include installation of dams in valves and piping prior to maintenance and then vacuuming the inside of the valve after maintenance and wiping the inside of the valve with a wet towel. Techniques such as X-ray fluorescence can be used to determine cleanliness more accurately than visual inspection. Carefully monitor refuelling equipment used at	maintained and updated by RP and CvM staff." While the terminology at BP has changed from "Rubber Area" to "Contamination Control Area", the name of the corresponding management database has not changed; this could lead to confusion. Section 4.2.6 of [SEC-RPR-00025], RP Field Inspection Oversight, requires weekly inspections and in-depth audits of CCAs every two months. b. Discrete radioactive particles: Indirect Compliance [BP-RPP-00022] Contamination Control includes specific instruction regarding DRPs (Discrete Radioactive Particles), of which "hot particles" are a specific type. Appendix C of [BP-RPP-00022] "Hot Particle Area Control" includes specific direction regarding DRPs. Excerpts from [BP-RPP-00022] that provide evidence of the RP Program documentation alignment with the guidelines are provided below: Appendix C: "When assessing whether work requires a CCA, CCCA, or HPA consideration shall be given to the generation of hot particles and where necessary the controls identified in this Appendix shall be applied and outlined in the REP." Appendix C, Part 1 addresses "activities/areas have been identified to have a high probability/known to generate hot particles." Direction is provided on the evaluation and posting of such activities/areas. Section 4.1.5.4 provides a list of techniques that "should be used to minimize generation and spread of DRPs [Discrete	

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	other facilities before allowing its entry into the plant. After use, clean and carefully monitor the equipment before it is allowed to cross the plane of the pool edge. When particles are known to be in the fuel pool, use submicron underwater filters and fuel pool skimmers to reduce the concentration of particles both in the pool and attached to the pool walls at the water surface. The use of underwater vacuum cleaners has proven effective in reducing particles in spent fuel pools and flooded reactor cavities. Entry into areas with known or a high potential for DRPs requires specific radiation work permits and increased radiological protection controls, including additional protective clothing. Outer protective clothing layers should be either discarded after use or handled separately to avoid cross-contamination of other less-contaminated clothing. In addition to their normal task coverage functions, radiological protection technicians' responsibilities for work in an area with a high potential for DRPs include the following: • Establishing stay times in the work area based on the potential for significant exposure from DRPs. • Surveying materials and equipment for the presence of DRPs before use by workers. • Periodically surveying workers in the area based on the potential for significant exposure	Radioactive Particles] with maintenance and opening of primary systems." Including that "equipment from other facilities should be surveyed and monitored for DRPs prior to the equipment being used in the Bruce Power Facility, when possible." Section 4.1.5 and Appendix C address increased RP controls required for work when DRPs are possible/anticipated, including: an appropriate REP, additional protective clothing, removal of protective clothing (assistance doing so as required), stay times, surveying personnel at appropriate frequency, clearly identifying material removed from HPAs (including use of coloured bags), prohibiting opening of bags except in specially equipped areas, whole body frisking, whole body monitoring, and capture of DRPs for analysis. Section 4.1.9 provides direction for handling contaminated equipment, which shall be "decontaminated as soon as possible, or contained, sealed and labeled and moved out of CCA as soon as possible." While the procedure does not specifically mention wiping down respirators to remove DRPs, the intent of the recommendation is met through direction on the handling of contaminated equipment. [SA-RPR-2013-03], Review of RP Program against WANO RP Guidelines: "Procedures do not contain processes for identifying DRPs and Nuclear Energy Workers (NEW) are not trained on processes for identifying DRPs... Initiate TCR (Training Change Request) to develop and provide training for workers who perform radiological work as appropriate, on techniques for identifying DRPs." There is a discrepancy against the guidance in that there are no procedures or	

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	from DRPs. • Assisting or observing workers during removal of outer protective clothing to help avoid contamination of inner protective clothing and the workers. • Wiping down respirators to remove discrete particles prior to bagging and removal from the area. • Clearly identifying material removed from DRP areas, such as tools and radioactive waste. • Using specific colored bags for all materials removed from DRP areas, and prohibiting opening except in specially equipped areas. Protective clothing is removed at the boundary of the DRP area and a whole-body frisk is performed as close to the DRP area as possible. Contamination monitoring using a whole-body frisker is performed as soon as workers leave the DRP area. The monitoring can also be done before workers are allowed re-entry to the DRP area. Develop procedures for and train radiological protection personnel in identifying particles. These procedures should describe decontamination methods, which include the capture of the particle for later analysis and the correct survey methods to aid in subsequent dose determinations. Incorporate skin dose calculation methods (for example, VARSKIN or equivalent) specific to	training regarding identification of DRPs. AR 28399594-07 was raised to develop and provide training on techniques for identifying DRPs. The assignment was closed on February 9, 2014, to TCR 15629, and the TCR was completed on March 10, 2014. [BP-RPP-00007], Decontamination, describes decontamination methods for DRPs. The calculation of skin dose from DRPs is described in Dosimetry Methodology - Skin Dose from Contamination [SEC-DOS-00043]. c. Equipment and material control - Gap Waste management is outside the scope of this Safety Factor. 1) Surveys - Compliant [BP-RPP-00027], Contaminated Tools and Equipment, Section 4.4 describes the requirement to survey items for loose and fixed contamination. [BP-RPP-00033], Unconditional Releases and Conditional Transfer of Material, Section 4.1.7 allows release of items only if: "- Results from a direct contamination survey (using a 15 cm^2 pancake detector) are less than 100 cpm β/γ above a background of less than 100 cpm β/γ. - There is no detectable loose contamination on the item surveyed indirectly with a smear or Masslinn cloth. - There is a very low probability of internal contamination of	

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	small particles of radioactivity into plant procedures. c. Equipment and material control Minimise long-term on-site storage of low-level waste (LLW) 1) Surveys Survey equipment and material being transferred from RCAs, contaminated areas and highly contaminated task locations for loose and fixed contamination. Ensure that limits are met and that no detectable radioactive material is unconditionally released from the protected area. Potentially contaminated bulk materials such as soil shall be analysed and determined to be free of detectable contamination prior to release. For bulk materials that are not suitable for normal loose and fixed contamination level assessment techniques, count representative samples to environmental levels using established procedures and methods. This is done to ensure that no detectable radioactive material is unconditionally released with the bulk material. For unconditional release surveys of equipment and material, exercise caution to ensure the item is surveyed by qualified radiological protection personnel. Dismantle the equipment or use special survey techniques to gain access to	the item." There are no documented requirements for the analysis and unconditional release of potentially contaminated bulk materials. [SA-RPR-2013-03] notes that there is "No objective evidence that procedural requirements have been developed for analysis of soil, aggregate and other bulk materials... Bulk volumetric analysis processes have not been developed to count samples to environmental levels." Recommendation RAM-10 was to "Evaluate a volumetric sampling program for bulk materials that counts down to environmental levels to ensure that no detectable radioactive material is unconditionally released off site." This recommendation was documented in AR 28399594-10, which was closed in July 2015 and DCR 28506094 was created to make the necessary change to [BP-RPP-00033]. The DCR is at Approved status and has a due date of July 1, 2016. Since a corrective action is still in progress to address this issue, it is not considered to be a gap. [BP-RPP-00033], Section 4.1.12: "A Qualified person shall perform the surveys specified by the CTP (Conditional Transfer Permit). A different Qualified individual shall perform a second independent survey of the package." [BP-RPP-00033] Sections 4.1.19 and 4.1.21 require approval of the RP FLM and/or a Health Physicist for items that have a probability of internal contamination. [SA-RPR-2013-03] notes that "a gap exists in that the procedure does not require dismantlement of equipment to gain access to inaccessible surfaces... In addition, the radioactive release program at BP should be improved by treating inaccessible surfaces as contaminated unless an evaluation determines that no potential exists for contamination." There is a	

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	inaccessible surfaces for monitoring. Treat inaccessible surfaces as contaminated unless an evaluation determines that no potential exists for contamination. Consider an independent survey or supervisory approval if materials are released by survey with a handheld instrument. Some utilities have established logs to document unconditional release surveys, to ensure a sense of personal accountability and to help identify the source of any radioactive material found outside the RCA. Develop a release plan for those items going into the RCA that cannot be surveyed in a gamma-sensitive tool monitor and that are expected to be released from the RCA. The use of automated gamma-sensitive tool monitors eliminates human error normally associated with manual frisking and improves the ability to detect contamination composed primarily of gamma emitters. Station workers may be trained to use the automated tool monitors for personal items that have not been taken into contaminated areas. In general, the following are the recommended methods for monitoring personal items for removal from the RCA: • Lanyards, hard hats, badges and primary and secondary dosimetry may remain on the individual and be worn through the whole-body contamination monitors. • Sensitive items worn by security	discrepancy between BP-RPP-00033 and the guidance regarding dismantlement of equipment to gain access to inaccessible surfaces to perform contamination surveys. AR 28399594-11 was raised to initiate a DCR to add a provision to BP-RPP-00033 to require RPM or AHP approval for unconditional release of material with inaccessible surfaces and complex geometries. The AR was closed on July 3, 2015 to DCR 28446123, with a due date of July 31, 2015. It was set to "Approved" status on October 21, 2015, with no further changes since. However, Bruce Power HPs establish detailed contamination survey requirements for complex equipment, including dismantling to gain access to internal surfaces. RP practices that are not documented in RP Program governance is discussed in Section 5.6. A log of Unconditional Release surveys is kept via use of [FORM-11050], Unconditional Release Permit (URP), as described in [BP-RPP-00033]. Sections 4.1.20 and 4.1.21 of [BP-RPP-00033] require that special arrangements be made for release of large quantities of items, or non-routine release. Section 3.1.8 specifies that a standing unconditional release permit, with special instructions, is required for items that will not fit in a small article monitor. Sections 4.1.7 and 4.1.14 document the requirement to use automated, gamma-sensitive, small article monitors. Section 4.1.14 documents the requirement that personnel are expected to use small article monitors to confirm that personal items are not contaminated. Section 3.1.4 defines No-permit release items. Lanyards, badges, dosimeters and sensitive items worn by security	

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	personnel, such as firearms and ammunition, may remain on the individual and be worn through the whole-body contamination monitors. • Personal items in an individual's pockets or worn on the belt, such as mobile phones, pagers and keys, may remain on the individual and be worn through the whole-body contamination monitor. These items should be monitored in the gamma- sensitive tool monitor if used in the RCA. • Certain items should always be released by monitoring in a gamma-sensitive tool monitor. These include the following: - data logging devices in the RCA (for example, operator rounds data loggers) - radios - flashlights - gloves - hand-carried items, such as notebooks, pens, and briefcases Trained qualified radiological protection technicians perform unconditional release surveys of equipment and tools. Personal tools that have been used in a contaminated area, which are typically worn on the belt - such as multi-tools, fuse pullers, and pocket knives - are included in such surveys. Prior to unconditional release, ensure that items are free of loose surface	personnel may be worn on the body and monitored using the whole body monitor. Keys, phones, and small stationary items may be monitored on-person using the whole body monitor provided they have not been handled or used in Zones 2 and/or 3. If they have been handled or used in Zones 2 and/or 3 then they must be monitored using a small article monitor. Hard hats, clip boards/notebooks, radios, briefcases and other items are listed as requiring monitoring in a small article monitor prior to release. While flashlights are not specifically mentioned in the list in Section 3.1.4, the intent of the guideline is met. Section 4.5 describes the process for releasing material into Zone 1 or the Public Domain from a higher numbered zone or the Unzoned Area and requires that qualified personnel perform it. Section 4.1.5 (1) of [BP-RPP-00027], Contaminated Tools and Equipment, requires that "All tools, equipment and related materials that are returned to stores… must be surveyed for beta-gamma contamination by a Yellow or Green qualified person before being returned." Section 4.1.7 (3) requires that "there is no detectable loose contamination on the item surveyed indirectly with a smear or Masslinn cloth." [BP-RPP-00022] Section 4.3.3 states that exiting a CCA must be performed by qualified personnel or by unqualified personnel under the direct protection of a qualified person. 2) Container controls - Compliant [BP-RPP-00027], Contaminated Tools and Equipment,	

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	contamination, either by process controls and/or physical surveys. Process controls include maintaining radioactive contamination within established boundaries, routinely surveying uncontaminated areas within the RCA and being aware of the areas the item was used in prior to release from the RCA. All tools, equipment and items removed from contaminated areas must be surveyed by trained RP technicians. 2) Container controls Equipment and material with contamination limits above control levels are stored in contaminated areas or radioactive material storage areas after being placed in containers. Radioactive waste containers that will not be opened on site do not require documentation of internal contamination levels. Containers that are continuously attended by a radiation worker need not be labelled, such as at a drum packing station or while materials are being loaded into a second container. Whenever practical, use strong, tight containers. Seal bags with tape. Material with fixed contamination may not need to be placed in containers but may still need to be labelled and controlled. 3) Vacuum cleaners Control vacuum cleaners used within the RCA.	Section 4.1.5 4(c): "An item with loose contamination that is waiting to be decontaminated shall be contained and may be stored temporarily in a contamination control area." Types of containers and methods of sealing bags are governed by the Waste Management program and outside the scope of this assessment. 3) Vacuum cleaners - Gap Vacuum cleaners used in the RCA have HEPA filters on exhaust as per [BP-RPP-00045], Management and Use of HEPA Vacuums and Portable HEPA Filtration Systems for Radiological Use: "The purpose of this document is to describe the use of High Efficiency Particulate Air (HEPA) filtered vacuum cleaners and portable HEPA filtration systems for radiological work and is an implementing document to [BP-RPP-00022], Contamination Control." Section 4.4.1: "filter replacement and testing are important to the continued safe operation of the unit. In place testing is designed not only to validate the HEPA filter, but also to verify the integrity of associated seals, gaskets, ducting, and housings regarding leakage." Section 4.2.2.8: "Vacuum cleaners designated as 'Radioactive Use' and/or 'Alpha Level 2 or 3 Area Use' shall be controlled such that only qualified personnel can access or operate them (i.e., vacuums are locked in controlled cages or rooms or are secured with locking devices controlled by the RPD)." Section 4.3.2: "Qualified personnel who open radiological vacuums shall be trained on proper contamination controls,	

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	Effective controls include the following: • Vacuum cleaners used in RCAs have high- efficiency particulate air (HEPA) filters installed to filter the exhaust. • A filter integrity test is performed following installation of a HEPA filter to ensure that the filter is in good condition and is installed properly. The test is repeated annually or when activities such as opening of the vacuum could have invalidated the test results. • Vacuum cleaners designated for RCA use are controlled such that only authorised/trained personnel can access or operate them. For example, vacuums are locked in controlled cages or rooms, or electrical plugs and air inlet connections are secured with locking devices controlled by RP. • Personnel who open vacuums are trained on proper contamination controls, filter installation and inspection. • A locking device or seal is employed on joints between the vacuum cleaner head and body to prevent inadvertent opening of the unit. • Radiation surveys are performed periodically for vacuum cleaners in use. • For areas in which a vacuum could become highly radioactive in a short period, remote monitoring is used.	filter installation and inspection, and be on an applicable REP." Section 4.2.1.15 requires verification that the locking device is attached and intact. Section 4.4.1: "Radiation and contamination surveys should be performed periodically for PHFS (Portable HEPA Filtration Systems) and HEPA vacuums in use." Section 4.2.2.9: "For areas in which a vacuum could become highly radioactive in a short period, remote monitoring should be used." Appendix B, p. 27: "This machine is not a wet/dry vacuum. It is intended for dry collection only. Do not use this vacuum to pick up liquids, or any wet materials in general." Page 34 provides further detailed instruction on dry and wet use of the HEPA vacuum. Section 4.3.1 states that "disassembly may need to be accomplished in specially designed glove bag, inside a containment tent, or CCA." While the procedure does identify that physical controls may be needed, there is a discrepancy against the guidance in that physical controls are not required when contaminated vacuums are opened. Section 4.3.2 states that "airborne radioactivity samples should be taken during the work and additional provisions, such as a continuous air monitor, used to inform workers if elevated levels of airborne radioactivity are encountered." While the procedure recommends airborne activity samples, it does not require them, constituting a discrepancy against the guidance Section 4.2.1.6: "Normally a vacuum cleaner hose has the	

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	• Controls are in place to ensure that liquids are not vacuumed with units that are not designed for wet materials. • Physical controls such as a room, tent or containment bag are used to control the spread of contamination when contaminated vacuums are opened. • Breathing zone air is sampled each time a vacuum is opened. • All vacuum cleaner and hose openings are securely covered to prevent the spread of contamination. 4) Instrumentation Calibrate contamination survey equipment prior to initial use, at least annually, following repairs and whenever malfunction is known or suspected. At least each day an instrument (such as a whole-body contamination monitor, handheld frisker and gamma tool monitor) is in use to monitor personnel or equipment contamination, perform a response check using a radioactive source. For exceptions to daily response checks, see subsection C.2.a, Automatic contamination monitors. If more than one detector or alarm circuit may be used, then response check each detector or alarm circuit. The radioactive source used to check the alarm set points should have energy levels consistent with the station	nozzle bagged in plastic material when not in use. Extra care should be used when handling vacuum cleaner hoses as they can become highly contaminated internally. If the vacuum cleaner hose is installed in a glove bag for negative ventilation, it is not necessary to bag the hose end after each use if the glove bag remains closed." [SA-RPR-2013-03] notes that "contrary to WANO guidelines, all vacuum cleaner and hose openings are not always required by procedure to be securely covered to prevent the spread of contamination. The procedure states that normally a vacuum cleaner hose has the nozzle bagged in plastic material when not in use. The vacuum port is not specifically referenced in the procedure." There is a discrepancy against the guidance regarding securely covering all HEPA vacuum and hose openings to prevent the spread of contamination. BP-RPP-00045 Section 4.2.1.7 says that “The hose and vacuum cleaner are considered radioactively contaminated and should be controlled as radioactive material.” This implies that BP-RPP-00027, Contaminated Tools and Equipment applies. Section 4.1.5 item 4c of BP-RPP-00027 says that “An item with loose contamination that is waiting to be decontaminated shall be contained...” This implies indirect compliance with the recommendation. However, AR 28399594-18 was raised to initiate a DCR to revise [BP-RPP-00045] to require that all HEPA unit, vacuum cleaner, and hose openings be securely covered to prevent the spread of contamination when HEPA units or vacuums are not in use. The AR also requests revision of procedural wording from "should" to "shall" when addressing the requirement for breathing zone air sampling when opening vacuums and use of approved containment devices when	

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	radionuclide mix and the strength of the source should provide confidence that the monitors will alarm at a level of 5,000 dpm/100 cm2 (beta and gamma).	disassembling units. The assignment was closed to DCR 28417170 on February 10, 2014. The DCR is at "Approved" status with a due date of February 27, 2015. Consequently, a gap remains. **Gap 2** This also shows a procedural noncompliance, which is addressed under Safety Factor 10, Organization and Administration. 4) Instrumentation - Compliant [BP-PROC-00037], Calibration and Maintenance of Fixed Contamination Monitors, and [BP-PROC-00370], Calibration and Maintenance of Portable Radiation Protection Instrumentation, both state in Section 4.2.2: "Calibration shall be performed at a maximum interval of 12 months or annually." In Section 4.1 of both procedures, it is stated that "Instruments which have undergone repair must, at a minimum, have the affected detector(s) re-calibrated before returning to service." [BP-RPP-00012], Use of Portable Radiation Instrumentation, Section 4.1, 3(f) and (g): "Ensure PRI (Portable Radiation Instrumentation) is functioning properly by performing the pre operational checks prior to use... Pre operational checks of instruments are to be performed, at minimum, once per shift as long as the instrument is in the care and custody of the qualified worker for the entire shift." For the additional requirements listed in this clause of the guideline pertaining to automatic contamination monitors please see the assessments for Clause C2, a.	
VI.C4.	a. Preventing materials from becoming	Radioactive waste	IC

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	contaminated It is assumed that materials within the RCA may become contaminated or radioactive. Therefore, the most effective method of preventing materials from becoming contaminated is to control the entry of materials into the RCA. Controls for materials include the following: • Set up a tool room in the RCA for tool storage and issue. • Use a system for clearly identifying, storing and issuing RCA tools and equipment. • Except for speciality tools, tools brought into the RCA should remain in the RCA. • Avoid storing non contaminated parts within contaminated areas. If such parts must be stored within contaminated areas, bag them to prevent the parts from becoming contaminated. • Remove packing boxes and other wrapping materials prior to transferring tools, equipment or parts into the RCA. • Segregate non contaminated trash from contaminated trash at the point of generation. • A system of marked containers within the RCA can also be used to collect non-contaminated and contaminated trash separately. b. Decontamination and reuse of tools and	The prevention of contamination and decontamination of tools and equipment are within the scope of this Safety Factor. The remaining clauses in Chapter VI.C4 are related to waste management and outside of that scope. Programmatic: Indirect Compliance a. Preventing materials from becoming contaminated – Indirect Compliance The procedure Contamination Control [BP-RPP-00022] provides detailed guidance on this topic. While the details are not the same as the guidance, the objective is met. b. Decontamination and reuse of tools and equipment - Compliant The procedure Contaminated Tools and Equipment [BP-RPP-00027] “specifies requirements for identification, use and storage of contaminated tools, equipment and related materials…” (Section 1.0). Tools and equipment with fixed contamination may be stored in Zone 2 Stores or any Zone 2 radioactive material storage area. They must be labeled according to the level of contamination, as specified in Section 4.1.1 of the procedure. The procedure Decontamination [BP-RPP-00007] provides details on how to decontaminate tools and equipment. This includes both loose contamination and fixed contamination above the limits permitted by [BP-RPP-00022].	

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	equipment Tools and equipment designated for use in the RCA during both operational and outage periods are monitored for radioactivity after use and are stored properly. Decontaminate items with removable contamination prior to storage or reuse, whenever practical. Maintain a well-supplied tool room designated for use in the RCA, to prevent clean tools from being brought in and out of the RCA. Periodically, perform random radiological surveys of tools stored in the RCA to ensure that station contamination limits are not being exceeded. Fixed contamination limits should be set low enough to prevent contamination from becoming removable during heavy use; for example, ≤ 5,000 cpm per probe area of a handheld frisker. Conduct periodic surveys of tools used in the RCA that are released and stored outside the RCA. Use the best available technology, such as gamma-sensitive tool monitors, to verify that tool survey and unconditional release practices are effective. c. Sorting materials Prior to packaging materials for disposal as radioactive waste, check for non-contaminated and reusable materials and also for contaminated materials that require further processing.	Tools and equipment may be transferred out of the radiological zones only if they meet the usual requirements for an unconditional release or a conditional transfer, described in [BP-RPP-00033]. This includes surveying for loose and fixed contamination.	

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	Automated surface or volume radioactivity detection devices have proven effective in confirming that material is nonradioactive. Calibrate and check this equipment to ensure that detectable contamination is not released off site. Do not place flammable and corrosive materials into containers for disposal without neutralisation. Dry or solidify wet materials. Vent or puncture spray cans that cannot be decontaminated or reused, to ensure that they will not explode when compacted. For non-contaminated yellow plastic materials, protective clothing, and materials marked with radiation symbols or other markings that indicate their use for control of radioactivity at the nuclear station, shred or deface prior to disposal as nonradioactive. The appearance of these materials, even though nonradioactive, in public or at other nonradioactive disposal sites could cause unnecessary public concern. d. Mixed radioactive waste Mixed waste is low-level radioactive waste also containing constituents that are either a listed hazardous waste or that exhibit hazardous characteristics. Mixed waste generated at nuclear power plants must be managed in accordance with regulations. One of the first steps in establishing a mixed		

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	waste management programme is to identify and characterise actual and potential mixed waste streams. Mixed waste may include dry cleaning filters and evaporator bottoms, acetone-based cleaning solutions, oil/solvent mixtures, and, possibly, decontamination solutions. Once waste streams are identified, evaluate reduction methods, such as substituting alternate materials not listed as hazardous and not exhibiting hazardous characteristics. e. Volume reduction techniques Benchmark volume reduction techniques developed at other nuclear stations or commercial industries for possible use. Radioactive waste processing and treatment vendors are also potential sources of information on new volume reduction technologies. f. Unconditional release of clean trash from the radiologically controlled area Trash is monitored to ensure radioactive material will not be released off site. This monitoring may be accomplished in a number of ways. For example, use a gamma-sensitive tool or box monitor capable of detecting contamination within the bag of trash at a level of 5,000 dpm. Each piece of trash may be surveyed with a handheld beta-sensitive frisker and then re-bagged and an		

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	aggregate survey performed. The aggregate survey should be performed with a gamma-sensitive instrument that is capable of measuring in the micro-R range (for example, 370-740 Bq (10 to 20 nanocuries)). g. Shipping of radioactive materials Package, label, and ship radioactive materials in accordance with applicable federal and state regulations. Use up-to-date copies of these regulations to prepare radioactive materials for shipment. Each shipment of radioactive materials is verified for compliance with regulations and procedures. Personnel independent of the radioactive materials shipping organisation routinely review radioactive material shipments. This review should verify that shipping procedures are in place and are being followed. Use independent verification of radioactive material shipment surveys, step-by-step checklists, and survey instruments similar to those that will be used to perform the receipt surveys, to reduce common errors that have resulted in shipping noncompliance. Radiation protection manager approval should be required to ship material if survey results are near 80 per cent of the regulatory limit. Store radioactive materials packaged for shipment in a manner that minimises personnel radiation exposure, prevents deterioration of the containers,		

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	and prevents the spread of radioactive contamination. Minimise outdoor storage of radioactive materials packaged for shipment. Provide personnel, including supplemental workers, involved in shipping radioactive materials with the instructions necessary to handle a spill, leak or accident while en route. Ensure that the transporter has a 24-hour emergency telephone contact and that this contact has been given enough guidance to respond correctly. Many stations designate the control room supervisors as this point of contact. h. Liquid radioactive waste processing Minimise the generation of processing resins, filters, and evaporator bottoms. Characterise waste stream inputs (for example, sources, locations, volumes and chemistry) to identify the means for reducing the volumes of liquid waste processed and for improving decontamination factors. i. Temporary on-site storage If disposal site access is unavailable, then design on-site storage with consideration for minimising personnel dose, for inventory and accountability, for the types and volumes of materials stored and for maintaining package integrity. Radiological considerations for dry fuel storage facilities are		

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	typically addressed in the licenses and do not fall within the guidance discussed in this section. Implement a programme for monitoring stored radioactive material and waste that includes the following: • Evaluation of dose received from radwaste processing, storage, retrieval, and shipping. • Inspection and evaluation of the material condition of storage facilities, container integrity and radiological posting/labeling. • Verification that waste storage is within the design basis for the interim waste storage facility and the safety analysis. • Evaluation of methane and hydrogen production. • Contingency plans for punctured containers, container settling, spills and fire.		
VII.C1.	a. Line supervision First-line supervising personnel (for example, from Operations, Maintenance, and Engineering) perform the following for personnel in their respective areas: • Ensure that the jobs performed in the RCA are well planned and that each person understands how to perform assigned tasks efficiently. • Brief personnel on the radiological protection hazards and controls to be used for each	Programmatic: Indirect compliance a. Line supervision - Compliant [BP-RPP-00040], Oversight of Radiological Work, in Section 4.2 shows two tables describing radiological protection expectations for work planning and preparation: Table 1 - Section Manager of work group is responsible for preparation of ALARA plans, First Line Manager is responsible for review of ALARA Plan prior to conducting	IC

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	surveillance, repair, test or other job that involves radiological protection. • Use the minimum number of properly trained and qualified personnel to perform assigned tasks. • Routinely monitor the performance of personnel during work to reinforce high standards of radiological work performance and to correct improper work practices or violations of radiological protection requirements on the spot. • Investigate instances in which personnel are involved in radiological events or deficiencies. Monitor corrective actions to ensure effectiveness. • Ensure assigned workers have available dose margin remaining and radiological training to perform the task (respirator qualified, radiation worker training and mock- up training, as required). b. Radiological protection personnel Radiological protection personnel monitor the performance of radiation workers periodically and coach workers to improve their radiological work performance. Improper work practices of a serious nature are documented and corrected through the station corrective action programme. Radiological protection supervision ensures that technicians assigned radiological protection	work. Table 2 - Pre-job brief is conducted by qualified supervisor, or supervisor with assistance of green qualified person. Section 4.3.3 of the procedure Executing Radiological Work [BP-RPP-00041] discusses management of worker dose, including considerations for attempting to reduce worker dose. Among these considerations is to ensure that the number of workers assigned to the job is relevant to the scope and that only workers essential to completing the task should execute the work. Section 4.3 of [BP-RPP-00040]: "The Line Manager shall perform observation and coaching of their workers to ensure that all of the expectations of the activities… are met and must correct any deficiencies identified immediately. This oversight involves reviews of work to be conducted, observation in the field of compliance with the requirements of the work, and review of the work once completed." [BP-PROC-00271], Observation and Coaching, describes the process for conducting observation and coaching at BP, which "drives performance improvement by influencing the behaviours of employees at all levels of the organization. This tool is used to mitigate risks to employees and to the business, primarily through the setting and reinforcing of high standards" (Section 1.0). Two Independent Oversight Quarterly Reports, [B-AQR-01-2015] and [B-AQR-03-2015], both noted deficiencies in ALARA accountability among station managers, supervisors and workers. Corrective actions are in progress; details are provided in Section 7.2.1 of this report.	

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	coverage responsibility have reviewed applicable ALARA work plans, RWPs, work packages, procedures and other relevant documents so they understand how jobs are to be performed, systems that will be opened or manipulated, and planned actions to reduce dose and control contamination. Station managers periodically monitor the radiological performance of first-line supervisors, radiological protection technicians and workers, as well as the effectiveness of corrective actions to improve radiological work performance. 1) Continuous radiological protection coverage A radiological protection technician may need to provide continuous coverage of a complex job to ensure effective radiological work control. Continuous coverage does not necessarily mean continuous presence of the radiological protection technician at the work site; rather, it means one or more technicians are given sole responsibility to cover a job. Continuous coverage can be provided by remote camera surveillance, effective audio communication with the work area and teledosimetry. Consider assigning specific technicians or groups of technicians dedicated to large-scope work, such as steam generator maintenance activities, refuelling operations and reactor head repairs. Technicians should be	[BP-RPP-00044], ALARA Program, Section 4.5: "Responsible Managers shall ensure the implementation of the radioactive work planning process by: Assessing planned work, and the production and approval of REPs; (and) providing radiological oversight during the conduct of work as required by procedure…" [BP-PROC-00060] documents the Station Condition Record Process, which as stated in Section 4.0 "is used by all Bruce Power staff, including contractors, to document adverse conditions, investigation results and corrective actions related to people, plant, environment and process." Section 4.6.1 documents the alternative processes for performing SCR investigations. Section 4.9 states that "The Performance Improvement Department will MONITOR the SCR Process and report on program compliance and effectiveness…" [BP-RPP-00041], Section 4.1.3: "Worker(s) shall be selected to perform the radiological work defined in the REP by the WG Supervisor by adding the worker(s) to the REP Worker List, prior to work the start of work. "Prior to being added, the WG Supervisor shall ensure workers are adequately trained to the standards of BP-RPP-00006 and in accordance with the Training and Qualification Descriptions for the work group." RPP-00006 is an obsolete document, superseded by the RP Program document, which in turn refers to BP-RPP-00006. This is a document control issue, which is addressed under Safety Factor 10, Organization and Administration. [BP-RPP-00041], Section 4.1.3 goes on to say: "Prior to	

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	assigned early enough to become familiar with the work plan and to provide planning input. When radiological conditions require continuous technician presence at the job site, consider remote monitoring to reduce technician dose. Wireless remote dosimetry, along with video and audio monitoring, implemented with a thorough understanding of system limitations and failure modes can allow appropriate job oversight without additional personnel being present in the work area, thus minimising dose for tasks that require continuous coverage. Remote monitoring includes administrative controls such that the names of workers issued telemetry dosimeters are communicated to the radiological protection personnel monitoring the telemetry readout, to ensure that their doses are being captured. In procedures and RWPs, clearly identify job situations and conditions that require continuous coverage. Example conditions are as follows: • work in an area with dose rates greater than 10 mSv/hour at 30 cm or extremity dose rates greater than 50 mSv/hour; • work in an area with known DRPs ≥100 mrad/hour on contact (open window), loose surface contamination levels above 1,000,000 dpm/100 cm2, or airborne radioactivity levels above 10 DACs;	being added to the REP Worker List, the WG Supervisor shall ensure workers are not on removal from radiological work, as described in BP-RPP-00020, Dose Limits and Exposure Control. In addition, prior to adding a worker to the REP Worker List, the WG Supervisor shall confirm the worker is able to complete the assigned task without exceeding any Exposure Control Levels (ECLs). "If the REP specifies additional RP requirements/oversight for a specific WO/WOT, then the WG Supervisor shall add these workers to the REP Worker List as well." Section 4.1.4: "Prior to starting the work, the WG Supervisor is responsible for ensuring that… Workers review the REP or are provided REP instructions and conditions to ensure radiological work instructions are understood, and to ensure that radiation personal protection equipment (RPPE) and instruments are properly selected." Appendix C provides the RP requirements for pre-job briefs. Users are directed to consider several questions when reviewing planned radioactive work. Set 11. g of questions addresses exposure planning, including: - Have all of the ALARA planning requirements been met? - Are any workers on removal or approaching exposure control limits? - Are mock-ups, rehearsals or special training required? All of the recommendations included in the guidance regarding line supervision are addressed in BP procedures.	

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	• entry into an area where the radiation, contamination, or airborne radioactivity levels are unknown or may change significantly or rapidly; During outages or major repairs that involve radiological protection, consider locating radiological protection personnel at one or more local access or control points. Personnel at the control point are responsible for the following: • ensuring workers understand the work scope and radiological conditions, hold points, stop work restrictions and operating experience—Conduct radiological briefings, as necessary; • monitoring worker radiation dose to ensure administrative control levels are not exceeded; • ensuring that personnel entering the work areas have authorisation to enter; wear proper protective clothing; understand the requirements for the assigned work activity, respiratory equipment and correct dosimetry; and fully understand the RWP requirements; • periodically monitoring radiological work performance and coaching workers to improve performance; • responding to radiological problems in the work area, such as changes in radiological work conditions, electronic dosimeter alarms, area radiation monitor alarms or other abnormal	b. Radiological protection personnel - Compliant [SEC-RPR-00025], Radiation Protection Field Inspection Oversight, Section 4.1, Table 1 provides the oversight activities and frequencies required by the RP organization. These include: - attend and participate in pre-job briefs - observe pre and post radiological work activities - assess radiation survey entries - observe high hazard work rehearsals, all to be performed weekly. Section 4.2: "Field walk downs shall occur at a weekly frequency by assigned RP Technicians… at designated locations to ensure that radioactive work is conducted in accordance with BP-PROG-12.05, Radiation Protection Program, and associated Radiation Protection Procedures. Deficiencies observed during the field inspection are noted… When a non compliance event is observed, the RP Technician shall record and immediately correct the non compliance, and initiate a SCR." [BP-RPP-00040], Oversight of Radiological Work, Section 4.3 requires RP staff to conduct observation and coaching on RP requirements to ensure that they are understood and conducted. They have the authority to stop work when it is not being done safely. Section 4.3 goes on to require that non-compliance with the RP Program be noted in an SCR by the Line Manager of the individual not complying. [BP-RPP-00019], Greenmanning, Protection Assistants, Section 4.1.1: "Individuals assigned the radiological	

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	conditions; • monitoring personnel to ensure they remove protective clothing and perform required contamination monitoring correctly. 2) Stop-work authority Radiological protection personnel must have the responsibility and authority to stop or prevent initiation of any activity that, if continued, would result in the violation of radiological protection standards or procedures, result in unplanned radiation dose or otherwise endanger personnel. Station management is responsible for ensuring that workers, job supervision, and radiological protection technicians are aware of this responsibility. Stop-work authority is only effective if fully supported by all levels of station management. Radiological protection personnel should stop the work, allow workers to put the area in a safe condition, and immediately inform a member of station management of their actions. Radiological protection personnel receive guidance and training in the proper use of stop-work authority. Such training includes the use of job situation scenarios to illustrate the types of situations that warrant work stoppage and discussion of why and when to use stop-work authority.	protection coverage responsibility, either as Greenman or Protection Assistant, shall review applicable ALARA plans, REPs, work packages, procedures and other relevant documents, as well as, attend the pre job brief when required as per BP-RPP-00011 to ensure understanding of how jobs are to be performed, systems that will be opened or manipulated, and planned actions to reduce dose and control contamination." [BP-RPP-00040], Section 7.1: "Managers are responsible for the oversight of the implementation of the RP Program during the planning, preparation, execution and completion of radiological work. This oversight is conducted through management observation and coaching of staff. Managers will correct non compliances immediately and will take appropriate actions to protect individuals and others as necessary." [BP-PROC-00060], SCR Process, Section 7.11 assigns to the Department Manager, Performance Improvement, the responsibility to review root cause investigations and apparent cause evaluations to verify that the corrective actions have been completed and that they have addressed the causes and eliminated the adverse condition. [BP-PROC-00506], Effectiveness Reviews, describes the process for conducting a review of the effectiveness of corrective actions. It assigns responsibility to Department Managers and Vice Presidents for the quality of the effectiveness review and for any necessary follow up. 1) Continuous radiological protection coverage - Indirect	

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		Compliance [BP-RPP-00019], Greenmanning, Protection Assistants includes the following definitions: "3.1.8 Direct Protection refers to the provision of radiation protection support and continuous presence by a Green Qualified Person to Unqualified personnel who are performing radiological work… " This means that direct protection goes beyond the requirement for continuous protection in the Guideline, since it does require the continuous presence of a Green Qualified Person. "3.1.12 Indirect Protection refers to the provision of radiation protection support by a Green Qualified person to Orange Qualified personnel performing radiological work, where the Green Qualified Person is not continuously present. "3.1.11 Greenmanning performed by a Green Qualified person, is the act of providing radiological protection to Unqualified personnel by a Green Qualified Person… "3.1.13 Protection Assistant (PA) is a Green Qualified Person who provides continuous presence and assists Yellow or Green Qualified staff with radiation protection tasks when they are working on a high hazard or radiologically complex job. The PA can also be the Green Qualified person for any Unqualified Personnel on the same job. However, the PA cannot actively participate in the tasks being performed during the high hazard work." Section 4.1.2:	

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		"A green qualified person shall not exercise indirect protection: 1. For the protection of red qualified personnel. 2. For High Hazard Work (HHW) or medium hazard work. 3. When radiological hazards in the work area are anticipated to significantly increase due to system changes, planned work or other work being done in the area by other work groups. 4. For work in containment." [SEC-RPR-00037], Audio-Visual Teledosimetry System (AVTS) Operating Procedure, provides instruction on the use of the AVTS for direct protection. All AVTS staff must be Green Qualified and members of the RP Department. The AVTS Panel operator also requires specialized training on the use of the AVTS. Section 4.1 requires that the Work Group Supervisor provide to the AVTS Issuer a worker short list. This is then reviewed by the AVTS Issuer to ensure its currency and correctness, before teledosimetry is issued to the work group. [BP-RPP-00011], Requirements for Planning Radiological Work, in Table 2 describes the hazards associated with the categories low, medium and high hazard work, and indicates that direct protection is required for medium and high hazard work. The conditions requiring direct protection are generally consistent with those requiring continuous coverage in the Guideline, with two exceptions: 1. extremity doses ≥10 rem/h require direct protection, rather than >5 rem/h as recommended in the Guideline.	

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		2. airborne tritium concentrations ≥200 MPCa require direct protection, whereas the Guideline proposes airborne concentrations (presumably particulate) >10 DACs. These differences were noted in [SA-RPR-2013-03], and led to Recommendation RWC-2, which was captured as AR 28399596-02. That AR was closed to DCR 28515709 in September 2015, and the DCR is at Approved status with a due date of September 1, 2016. There is no specific procedural requirement to locate RP personnel at local access or control points during outages or major repairs. However, the duties proposed for such personnel are carried out by work group supervisors, Yellow or Green Qualified workers, protection assistants and/or AVTS staff, depending on the hazard level and the REP requirements. Consequently, compliance is considered to be indirect. 2) Stop-work authority - Compliant [BP-RPP-00040], Section 4.3: "RP staff… have the authority to stop work when it is not being conducted safely." [BP-RPP-00041], Section 4.3 goes farther in granting stop-work authority to all workers: "All workers performing radiological work are responsible for the safe conduct of radiological work in accordance with the instructions they have been provided and have the authority to stop work or prevent the initiation of work that could result in a violation of the radiation protection procedures, unplanned radiation dose or that which could otherwise	

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		endanger personnel." That procedure also says in Section 4.4.1: "RP Department staff have the authority to stop work, if necessary, to perform an ALARA WIP [work-in-progress] Review on jobs that meet the above criteria. Information shall be documented in a SCR to ensure that corrective actions are taken where needed." Appendix D of [BP-RPP-00041] provides specific direction on Execution of Stop Work Authority, including that work may be stopped for "any act of RP non-compliance or engaging in a work activity that involves an unsafe radiological act…" [SA-RPR-2013-03] notes that "a gap exists in that BP has not developed training on the proper use of stop-work authority… radiation protection training does not include job situation scenarios in training to illustrate and to guide RP personnel on the types of situations that warrant work stoppage including discussion of why and when to use stop-work authority." There was a gap against the guidance in that RP personnel were not being trained in the proper use of stop-work authority. The resulting recommendation RWC-3, to initiate a TCR to add the required training, led to AR 28399596-03, which was closed to [TCR 15630] in February 2014. The TCR was completed on March 10, 2014.	
VII.C2.	a. Work procedures 1) Planning Sufficient preparation time is important when radiological work is being planned. Proper	Programmatic: Gap a. Work procedures - Acceptable Deviation	Gap

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	planning ensures a job will have controls in place to conduct work safely. Planning of the radiological aspects of work is integrated into the station work planning process and is the responsibility of job-planning personnel in conjunction with work group supervision and radiological protection personnel. Methods available for radiological control-such as engineered controls, shielding, efficiency improvement, decontamination, containment devices, work rescheduling, hot-spot flushing and mock-ups-are made a part of the job. When additional measures are not feasible for urgent jobs, sufficient management review should ensure that appropriate radiological controls are in place. Additionally, the work is evaluated to identify and document needed improvements for future jobs. During outages, the radiological protection organisation is actively involved with the implementation of outage plans and any decisions to deviate from those plans that may have a radiological impact. Radiological protection personnel monitor the outage schedule and emergent work to anticipate the need for and to plan radiological protection activities, minimising their impact on outage tasks while reducing collective dose. For emergent work activities, radiological protection, station management, and, as appropriate, the station ALARA Committee should ensure that appropriate additional controls	1) Planning - Compliant [BP-RPP-00011], Requirements for Planning Radiological Work, Section 4.1 provides an overview of the radiological planning process as well as the responsibilities of the work group and RP in the process. Throughout the procedure there are references to the BP work management system, and radiological planning is done in conjunction with that system. Section 4.2 describes the process for emergent work, for which the ALARA planning process can be expedited. "Verbal contact with a RP Supervisor or designate must be made to expedite the processing of Health Physics Permit requests for H (high) priority work... For work of an emergent nature that arises outside normal business hours, the On Call HP shall be consulted by the Shift Manager to determine the ALARA planning requirements." All REP approvals are still required, as documented in Section 4.1.1.2. Sections 7.2.5, 7.3.2, 7.7.1 and 7.10.1.1 document the approval process required for emergency work. ALARA or radiological HHW plans may be informally documented until enough time exists for completion of the applicable documentation and approvals. Section 4.4.1: "The timeline for completion of the required ALARA documentation for outage work is dictated by the outage milestones as defined in BP-PROC-00342. The HP or delegate should participate in outage planning meetings, such as Scope Review Panel for the purposes of identifying work requiring ALARA Plans... ALARA planning for outages, complex work and large evolutions should occur as early in the planning process as possible to ensure all required ALARA measures, as defined in the ALARA Plan, can be	

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	and reviews are performed, to include effective planning and implementation of the work. Radiological protection personnel receive training on how to read and interpret the outage schedule and status reports. Changes in scheduled jobs are communicated to radiological protection technicians in the field. 2) Procedure use Plant operating and maintenance procedures or work documents for activities in elevated dose rate areas that involve significant collective dose, high contamination or the potential for the release of radioactive material include the important radiological protection actions identified during the planning process. This should include the requirement to notify Radiological Protection before these activities are initiated. Integrate radiological protection requirements into plant operation and maintenance procedures, whenever applicable, including action steps, hold points, notes, cautions and precautions. Radiological protection management reviews and concurs with procedures for activities with high radiation dose rates, accumulation of significant collective dose, high contamination or the potential for the release of radioactive material. Management establishes the expectation that personnel using these procedures will comply with all required actions. Radiological protection supervision reviews procedure changes if the changes affect	incorporated into the overall work management plan for the work... Commencing at outage Milestone 8 'Scope Freeze' and ending no later than 2 months prior to Milestone 16 'Outage Support documents/Revisions Prepared', the HP shall identify work that requires an ALARA Plan..." Section 4.5, 3 lists the requirements that need to be addressed in an ALARA plan. This includes consideration of shielding, contamination control measures, efficiency improvements (training, tooling improvement), scheduled task logic, and worker training. [SEC-RPR-00015], Radiation Exposure Permits, Section 4.7.4 requires that specific instruction on ALARA measures be provided in the REP: "Provide clear and concise directions on the topics of personnel movement and contamination control, hazards, dosimetry, RPPE and anything else that needs to be communicated to the worker in order to keep doses ALARA and to maintain contamination control." Appendices D and E provide considerations and PM&CC measures to be taken for work involving alpha radiation. [BP-RPP-00041], Executing Radiological Work, Section 4.6 requires verification of work following completion. "A post-job brief is conducted to communicate close-out expectations to workers. Lessons learned shall also be communicated as per BP-PROC-00617. During this meeting, workers shall be given the opportunity to feed back observations or suggest improvements to the process." Section 4.7 discusses the Post-job ALARA review. "Lessons learned from the Post-Work ALARA Reviews shall be documented as outlined in FORM-11102 to ensure corrective actions are taken that can be implemented in future	

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	radiological protection requirements or radiological conditions for the work area. b. Radiation work permits Radiation work permits (RWPs) represent one of the primary administrative controls by which radiological work is planned and radiological control is implemented. In addition, they provide a means to trend radiation dose by specific jobs and to plan similar jobs in the future. The RWP is a formal, documented mechanism for radiological protection supervision to communicate radiological conditions and job controls to radiation workers. Involvement and accountability of all workers is part of the RWP implementation process. 1) General radiation work permits Use general RWPs, or an equivalent administrative control, to govern routine work such as plant inspections, operator rounds and radiological protection technician surveys within the RCA. Radiological conditions for areas covered by general RWPs should be static, or the RWPs should address situations that could cause conditions to change. Clearly outline the type of work allowed under general RWPs for all radiation workers. Review routine surveys in areas covered by general RWPs for evidence of changing	radiological work planning for similar work." Section 4.1.2, 1 indicates that the work group supervisor is responsible for reviewing schedule changes and notifying the RP FLM if there will be an impact on the REP or resources required. [SA-RPR-2013-03] notes that "PEL ID 66686, is available to provide RP personnel training on how to read and interpret the outage schedule and status reports." 2) Procedure use - Acceptable Deviation At Bruce Power, radiation protection measures are described in procedures that come under the Radiation Protection Program, [BP-PROG-12.05]. The requirements of these procedures apply to all operating and maintenance activities. This is reflected in the Bruce B Operating Policies and Principles [BP-OPP-00001], which states in Section 03.3 that "Radiation protection of the public and station staff shall be in accordance with the Radiation Protection Program, [BP PROG 12.05]." Radioactive work is planned according to the requirements of the ALARA Program, [BP-RPP-00044], and the procedure Requirements for Planning of Radiological Work, [BP-RPP-00011]. It is conducted according to the procedure Executing Radiological Work, [BP-RPP-00041] and the suite of associated RP procedures. Together, these procedures address the topics mentioned in this clause. That they are not operating or maintenance procedures is an acceptable deviation from the Guideline.	

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	radiological conditions and revise the general RWP when appropriate. Use general RWPs to control specific maintenance jobs only when approved by radiological protection supervision and when such jobs do not involve work with complex radiological conditions. General RWPs are not normally used for personnel entry into areas with dose rates of 1 mSv/hour at 30 cm or greater. 2) Specific radiation work permits Use specific RWPs to control work in the RCA that is not covered by general RWPs. Such permits remain in effect only for the time needed to complete the job. Specific RWPs for jobs that are scheduled on a periodic basis, such as quarterly containment entries at power, are updated with current information before use and are only available for use by workers during the time scheduled for job performance. Perform surveys when radiological conditions are subject to change during the work, and revise the RWP as appropriate. The following are examples for which specific RWPs are used to control work: • Expected dose per worker exceeds 1 mSv. • Dose rates are greater than 1 mSv/hour	b. Radiation work permits - Gap [BP-RPP-00011], Requirements for Planning Radioactive Work, Section 4.1: "An approved FORM-11106, Radiological Exposure Permit (REP) is required to be issued for all radiological work." The REP is the Bruce Power equivalent to a radiation work permit. Section 4.3 and 4.5: "The REP serves to document ALARA instructions and all applicable radiological and ALARA controls are to be incorporated into the REP instructions. The REP may be supplemented with additional ALARA documentation, which may be electronically attached to the REP." [BP-RPP-00041], Executing Radiological Work, Section 4.0: "Radiological work requirements, planned and defined in accordance with BP-RPP-00011, are documented in the Radiation Exposure Permit (REP) associated with the Work Order (WO) or Work Order Task (WOT) for the work to be performed. All radiological work shall be executed in accordance with the REP and as described in this procedure." Section 4.1.2: "REPs identify radiological hazards involved with the assigned WO/WOT and define the radiological controls to be followed during the execution of radiological work." This section also documents the responsibilities of the Work Group supervisor in reviewing the REP and associated ALARA documents. Section 4.3: "Radiological work shall be performed conscientiously by workers such that all reasonable	

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	at 30 cm. • Contamination levels of ≥100,000 dpm/100 cm2 are involved or anticipated. • Work is in an alpha level 3 area. • A radiological hold point is necessary during the job (for example, a system breach). • Work is done in airborne contamination areas. • Radiological conditions are unknown. • Radiography operations are being conducted. • Protective clothing, special dosimetry or other requirements are needed that differ from standard requirements contained in general RWPs Specific job or task dose, dose accrual rate and work duration are desired for use by ALARA and job supervisors to support the capture of lessons learned and future performance improvement. 3) Radiation work permit preparation, approval and issuance Normally, the radiological protection organisation prepares, approves, issues and enforces RWPs and ALARA plans in accordance with written procedures. Steps include the following: • The job supervisor identifies all job	measures are taken to control their dose and the dose to others in the area in accordance with the limits and conditions specified on the REP. Workers shall confirm that they have the correct REP, WO/WOT for the work as applicable." External doses measured with EPDs during performance of a task are recorded under the REP for that task [BP-RPP-00020], Section 4.1 (9). If required by the REP, internal doses are also measured and recorded for the task [BP-RPP-00020], Sections 4.5.1 (6), 4.6.1 (2). This provides a means to trend dose by task. 1) General radiation work permits - Gap [BP-RPP-00011], Section 4.1.1.1, 2a refers to "routine and non-routine online work", indicating that in practice there is some differentiation between the two. [SEC-RPR-00015], Section 4.7.1, 2 refers to "general REPs", and "Work Group routine REPs", again indicating that in practice there is some differentiation between routine and/or general work and unique, specific work. There is a gap against the guidance in that while there seems to be two types of REPs (routine/general and unique/specific) the difference between them is not well explained or defined in the procedures. [SA-RPR-2013-03] notes that in [BP-RPP-00011], Table 2, REPs "are required for all radiological work according to listed Low, Medium and High Hazard Categories. A gap exists in that REPs are not delineated as general or specific permit types as recommended by WANO. The Low hazard category allows radiological work with whole body working distance dose rates up to 200 mrem/hr [2 mSv/h],	

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	activities and evolutions that could affect worker radiological protection. Maintenance requests and work procedures that govern the job, or other records such as an RWP request, are submitted to the radiological protection organisation to ensure complete understanding of the job. The radiological protection organisation receives this information with sufficient time to complete necessary radiological protection tasks prior to the planned work. These tasks may include determining radiological conditions, determining dose and contamination reduction actions, writing and approving RWPs, setting up the work area and scheduling radiological protection technician coverage. Specific RWPs include a clear, detailed description of the job location and the work to be performed. • Review previous job history as well as station and industry operating experience to evaluate and incorporate lessons learned. • Survey the work area for radiation, loose surface contamination, discrete radioactive particles and airborne radioactivity levels, as applicable for each type of radiation that presents a hazard to the worker (alpha, beta, gamma and neutron). This survey should identify the work area, contact and general area dose rates in and near the job location, including hot spots. The identification of low dose rate areas will assist workers in reducing their own dose. Document this information on the RWP.	skin/extremity up to 10 rem/hr [0.1 Sv/h], airborne tritium up to 500 MPCa [revised to 200 MPCa in current revision] and loose alpha up to 100 dpm/100cm^2..." This gap gave rise to Recommendation RWC-5, to "Evaluate a tiered REP approach that utilizes general level REPs for all entries to Zone 2 (RMSAs) and Zone 3, and to govern routine work such as plant inspections, operator rounds and RP technician surveys. Develop criteria for the use of specific REPs to govern work in accordance with the guidance contained in the WANO document. Generate DCRs to revise SEC-RPR-00015 and/or BP-RPP-00011 as required." The recommendation was captured in AR 28399596-05, which is shown as complete on January 19, 2016, although the completion notes say "Radiography reps are aligned and OMS is working with the stations to align outage reps." Consequently, the action is not complete, and the gap remains. **Gap 1** [SA-RPR-2013-03] goes on to note that in [BP-RPP-00011], Table 2, "a gap exists in that the REPs for the Low Category allows work in radiological conditions with dose rates, airborne and contamination levels that are inherently challenged with radiological risk and are not static in nature. High dose gradients, such as with contact dose rates of < 10 rem/hr [0.1 Sv/h], that are allowed in the Low category can provide the avenue that could cause conditions to change triggered by simple situations not addressed ... general REPs are not utilized at BP for all entries with radiation workers and consequently the type of work allowed under general REPs is not outlined … the Low Category Radiological Work Hazard supports work in potentially complex radiological conditions…	

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	• Only rely on existing survey records in lieu of performing a new survey if they are current (that is, reflect present conditions) and appropriate (that is, include data on the types of radiation and the nature of contamination for the locations associated with the job). • Identify situations that require radiological hold points (for example, the work area cannot be completely surveyed because a system is not yet open). • Estimate person-rem for the job and determine appropriate dose reduction methods (if not already done). • Determine appropriate dose, contamination and solid radioactive waste controls. This should include the protective clothing, engineered controls, respirators, face shields, dosimeters and radiological hold points and the extent of radiological protection coverage needed for the job. When high radiation, discrete radioactive particle or airborne radioactivity conditions may be encountered, specify stop-work control levels (for example, dose rate or airborne radioactivity level) in the RWP at which all workers, including radiological protection personnel, are to leave the work area. • Compare the postings and boundary layout at the job site against that desired for the job and make necessary changes prior to the work. Expand contamination boundaries to	a gap exist in that the Low hazard category allows radiological work with whole body working distance dose rates up to 200 mrem/hr [2 mSv/h]." These observations document discrepancies against the guidance in that conditions for areas covered by general REPs should not be radiologically complex and should be static, and that general REPs should not normally be used for entry into areas with dose rates of 100 mrem/h (1 mSv/h) or greater. They resulted in Recommendation RWC-6, which translated into AR 28399596-06 to "initiate a DCR to revise applicable radiation protection procedures and forms… to integrate trigger levels for all radiological hazards into the processes for radiological controls. Trigger levels for contamination, alpha area, tritium and exposure rates, that trigger Hazard Levels, REPs, specific REP requirements, ALARA planning, and document approval levels need to be aligned." The AR was closed on September 4, 2015, to DCR 28515710. The DCR is at Approved status with a due date of September 1, 2016. Since this issue is being addressed through the action tracking system it is not considered a gap for the purposes of this assessment. 2) Specific radiation work permits - Compliant [SEC-RPR-00015], Radiation Exposure Permits, provides direction on the development of job/task specific REPs. Section 4.7.1(6) discusses the estimated job start and end dates for REPs and provides direction for setting them, to the extent possible, to correspond with actual job performance. Section 4.10 provides requirements for routine review of active REPs: "The RP FLM shall ensure that for online	

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	provide enough space for workers to accomplish the job without inadvertently crossing the boundary. • Determine the appropriate level of radiological protection surveillance (job coverage). Include the use of remote cameras, audio communications and teledosimetry, when appropriate. • Determine the frequency and type of radiological surveys required during the job. • Determine the maximum allowed stay time in the area when there is a potential for high radiation exposure (for example, exposure rates greater than 15 mSv/hour at 30 cm or exposure greater than 5 mSv per entry) and how it will be monitored and enforced. Radiation work permits are approved by the appropriate level of designated radiological protection personnel. For example, the radiological protection manager approves entry into areas of 0.1 Sv/hour at 30 cm or above. Changes to RWPs require the same level of review and approval as the original. Prior to using an RWP, workers document that they have read the RWP, fully understand all requirements and radiological conditions, and agree to comply with these requirements. If conditions are not fully known when the RWP is issued, protective requirements are based on the best information available, with consideration of	REPs, a review is completed at minimum once per 12 month period..." One item to be reviewed is that "Hazard levels in the REP are as per current field conditions, by performing a review of RHIS or job history files to determine current hazard levels." Section 4.7.4 (2) discusses radiation hazards and the requirement to "specify the survey types and frequencies to be performed for all types of hazards anticipated, including the use of continuous monitoring devices, especially for changing conditions." [SA-RPR-2013-03] notes that in [BP-RPP-00011], Table 2 "identifies the High Category Radiological Work Hazard when individual WB dose >500 mrem [5 mSv]. A gap exists in that specific REPs are not always used to control work when expected dose per worker exceeds 100 mrem [1 mSv]... Low Radiological Work Hazard Category allows work in areas with working distance dose rates up to 200 mrem/hr [2 mSv/h]. A gap exists in that there is no General or Specific work permit required at 100 mrem/hr [1 mSv/h] dose rate as recommended by WANO... Medium Radiological Work Hazard Category allows work in areas with loose beta/gamma surface contamination > 25,000 cpm (approximately > 250,000 dpm) and loose alpha surface contamination up to 2,000 dpm/100 cm^2. A gap exists in that there is no requirement for a Specific type REP as recommended by WANO when contamination levels of ≥100,000 dpm/100 cm^2 (approximately 10,000 cpm/100 cm^2) are involved or anticipated." AR 28399596-06, discussed above, addresses these gaps. Since this issue is being addressed through the action tracking system it is not considered a gap for the purposes of	

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	the most complex radiological conditions deemed probable. Therefore, avoid the use of a qualifier such as “as per Radiation Protection” for protective clothing or respirator requirements, because such qualifiers prevent workers from resolving questions and acknowledging that the instructions are understood. If conditions are not fully known when the RWP is issued, they should be determined as soon as possible or verified at the start of the work. Additionally, the probability of deficient protective requirements being prescribed at the job site increases because of insufficient forethought, work condition knowledge and planning and supervisory review.	this assessment. Regarding work in an alpha level 3 area, [SA-RPR-2013-03] notes that "Inconsistencies exist in how alpha is categorized by various procedures. In addition, Low, Medium and High hazard categories are used to characterize REPs rather than alpha levels. BP-RPP-00011... Table 2, identifies Medium Category with loose alpha up to 2,000 dpm/100cm^2. Alpha Level 3 is not defined in the hazard types identified by BP-RPP-00011. SEC-RPR-00015, Appendix E, Guidelines for Alpha Controls for Planning Radiological Work, identifies Low Hazard Level/work activity with loose surface alpha up to 100 dpm/100 cm^2. Alpha Level 3 where beta-gamma to alpha ratio is less than 50:1 [300:1 in current revision] is used in SEC-RPR-00016 … This procedure identifies a Level 3 alpha area where the abundance of alpha is elevated, but does not use 2,000 dpm/100 cm^2 as an alpha criterion. In addition, Form-11106, Radiological Exposure Permit (REP) does not prompt the user when manually generating a REP by identifying Alpha as a hazard for evaluation to anticipate and assess." These gaps are also addressed by AR 28399596-06, discussed above. [SEC-RPR-00015], Section 4.7.4 (2) directs REP writers to specify required hold points, where appropriate. Section 4.9.3 requires that the AHP review the REP to ensure that hold points and back-outs are clearly specified in the REP. Section 4.7.2 (3) directs REP writers on the specification of airborne hazards. Appendix D directs the REP writer on assessment of work involving alpha contamination for the potential to create airborne hazards. Section 4.7.2 directs REP writers on specification of	

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		anticipated hazards. Back-out values are included as an upper bound. [BP-PROC-00036], Conduct of Radiography, Section 4.3.1(3) requires that a REP be assigned to all radiography tasks. [BP-RPP-00011], Section 4.5 and [SEC-RPR-00015] both require specification of RPPE, special dosimetry, and other requirements as necessary. 3) Radiation work permit preparation, approval and issuance - Gap [SEC-RPR-00015], Section 4.0: "Radiological Exposure Permits (REPs) are prepared by Radiation Protection (RP) and Health Physics (HP) personnel who hold Qualification ID 14359, Radiation Exposure Permit. "When writing new REPs or revising existing REPs, relevant information contained in the following As Low As Reasonably Achievable (ALARA) Planning documents shall be included, when these documents exist: - FORM-11101, ALARA Plan - FORM-11102, Post-Work ALARA Review Record - Job History File - Other applicable internal or external Operating Experience (OPEX)" Section 4.7.1 discusses the "Main" tab in a REP, which provides detailed job information. Item 13 in this section requires that an estimate of the dose for the job be made and	

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		included in the REP. Section 4.7.2 requires review of previous radiological hazard information when preparing REPs, and Section 4.0 suggests that the job history file should be attached to the REP, where one exists. Section 4.7.4 (5) requires that the REP "identify applicable internal and external OPEX related to the work (e.g., Station Condition Record [SCR]#, OPEX#, ALARA Plan OPEX) and identify any mitigating measures required." Section 4.7.2 discusses obtaining information on anticipated radiological hazards and verifying it before entering it into the REP. Section 4.7.4 (2) directs the REP preparer to "Specify the survey types and frequencies to be performed for all types of hazards anticipated, including the use of continuous monitoring devices, especially for changing conditions." Section 4.9 describes the requirements for REP review and approval by various RP personnel. [BP-RPP-00011], Section 4.1: "REPs are prepared by Radiation Protection Technicians who hold Qualification ID 14359 Radiation Exposure Permits (herein known as a RP Assessor), in accordance with SEC-RPR-00015, Radiation Exposure Permits." Note that [SEC-RPR-00015], Section 4.0 states that "Radiological Exposure Permits (REPs) are prepared by Radiation Protection (RP) and Health Physics (HP) personnel who hold Qualification ID 14359, Radiation Exposure Permit." The intent seems to be that it is the role of RP Assessors to prepare REPs, however any RP or HP staff with the required qualification can do so. The difference between these two	

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		descriptions could lead to confusion. [BP-RPP-00011] requires completion of an ALARA Plan [FORM-11101] for radiological work meeting the requirements outlined in Section 4.1.1.1. In Section 4.1, it is stated that "The ALARA Plan shall be used to document the ALARA requirements for the radiological work and is initiated by the Work Group Supervisor (WGS) or Project Manager (PM) for the work. ALARA Plans are approved as outlined in Section 4.1.1.1 and the WGS/PM is responsible for obtaining these approvals." Section 4.1.1: "The approvals required in the sections below shall be obtained prior to the work being performed and is the responsibility of the WGS or PM to obtain." Tables 1 and 2 outline the approval requirements for ALARA Plans and for REPs. Section 4.1.1.1 requires that dose estimates for specific jobs be made. The level of approval required for ALARA Plans is dependent on the collective dose anticipated, per Table 1. Section 4.1.1.2, Table 2 indicates the level of radiation protection requirements based on the hazards anticipated during the work. Section 4.7 indicates specific requirements for High Hazard work. Table 2 also indicates that AHP approval is required for work involving dose rates > 1 rem/h [0.01 Sv/h] at working distance (as opposed to the RP Manager as indicated in the guideline - this is an acceptable deviation). Section 4.1.1.2 indicates that "if at any time, the assumptions made or the conditions described in the REP change, the REP requires re-evaluation. Depending on the nature and	

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		impact of the re-evaluation, the REP and when required, the ALARA Plan, may require re-assessment and re-approval per the requirements of Table 1 and Table 2." Section 4.5 describes how Health Physics Permit requests are submitted and processed for RP involvement in work orders and processing of ALARA plans. This section includes complete assessment of the work in the development and approval of REPs and ALARA plans. ([SEC-RPR-00019], Dose Estimation for HP Permit Request Processing, Section 3.1.6 defines an HP Permit Request as "a hold placed in PASSPORT on a Work Order Task to request a REP and dose estimate for the task. These holds are placed by line assessors, and processed by Radiation Protection Technicians." Sections 4.4.1 and 4.4.2 of BP-RPP-00011 specify the timing requirements for submission of ALARA Plans and HP Permit requests. [SA-RPR-2013-03] notes an opportunity for improvement in [BP-RPP-00011], Table B.1: "beta radiation is indicated and anticipated only if and when the system is open (third column). Contrarily, beta radiation should be anticipated and expected any time identification of loose or fixed contamination is expected in the areas identified." There is an opportunity for improvement in specification of anticipated beta hazards in [BP-RPP-00011], documented as Recommendation RWC-7. This recommendation was captured as AR 28399596-07: "Initiate a DCR to revise BP-RPP-00011, Table B.1, Hazard Anticipation at Bruce Power Generating Stations, to expect and anticipate beta radiation any time loose or fixed contamination is present." The AR was closed on February 10, 2014 to DCR 28416993. The	

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		DCR is at "Approved" status with a due date of March 31, 2015. This shows a procedural noncompliance, which is addressed under Safety Factor 10, Organization and Administration. Appendix D of [BP-RPP-00041], Executing Radiological Work provides direction on the execution of stop-work authority in the event of abnormal, unexpected or degraded radiological conditions. This could include high radiation, DRP or airborne radioactivity conditions. Section 4.3 of this procedure notes that all workers have the authority to stop work that could result in unplanned radiation dose. However, the REP procedure, [SEC-RPR-00015], does not explicitly require stop-work (or back-out) levels be specified for DRPs or airborne particulates. The intention of the guideline is to provide, in the working-level document (REP) that all workers must review, a pre-determined, set level for airborne particulate and DRPs at which everyone is expected to back out. The RP governance as it exists requires reliance on the persons preparing, reviewing and approving the REP to identify the need for these back-out criteria. **Gap 2** [BP-RPP-00011], Section 4.7, (2)(d)(v) requires that stay times be included in the High Hazard Work Plan. [BP-RPP-00041], Executing Radiological Work, Section 4.3.2 requires that "Radiation surveys are performed before, during, and after work, as defined in the REP to verify that radiological conditions are as expected, whenever abnormal or suspected abnormal radiological conditions exist, or when it is known or suspected that conditions have changed." Section 4.3.4 discusses how contamination is controlled at the source during work.	

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		Appendix C, item 7: "The worker is responsible for reading and understanding the REP content and the PJB/ALARA Briefing. Questions regarding the content of the REP or the job scope shall be raised to the individual performing the PJB/ALARA Briefing. If changes to the REP are identified during the PJB/ALARA Briefing, the WG Supervisor ensures they are incorporated through working with the RP FLM prior to the starting the work." Appendix C, item 9: "Upon completion of an ALARA Briefing, all personnel shall sign the worker list to confirm attendance and understanding. All ALARA Briefing documentation, including the REP and REP Worker List shall be sent to the HP for review, retention and routing." The Worker List is considered part of the REP, and is signed by the workers to indicate that they have read and understood the requirements in the REP and any associated ALARA planning documentation. [BP-RPP-00018], Facility Access and Working Rights, Section 1.0: "This procedure … defines the Radiation Protection (RP) Qualification requirements for workers accessing and performing work at Bruce Power Facilities." Note that this procedure states that it is an implementing document of BP-RPP-00006, which is an obsolete document, superseded by the RP Program document, which in turn refers to BP-RPP-00006. This is a document control issue, which is addressed under Safety Factor 10, Organization and Administration. Note: waste considerations are outside the scope of this assessment.	