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INTERIM ASSESSMENT OF THE RECOVERY PLAN FOR RADIATION PROTECTION AT BRUCE POWER

Radiation Safety Institute of Canada

Institut de radioprotection du Canada

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Summary

The Radiation Safety Institute of Canada (RSIC) has conducted an interim assessment of the recovery plan and work completed to date of the Radiation Protection Recovery Team established by Bruce Power in response to the alpha contamination event that occurred during refurbishment of Bruce Power Unit 1 in November/December, 2009. The present report is a subset of the larger independent assessment of Bruce Power's response to the event being performed by the RSIC as requested by the Ontario Building and Construction Trades Council, Bruce Power, Comstock Canada, and AECL.

Overall, this interim assessment concludes that the Recovery Team Plan is comprehensive and addresses the right issues. While substantial progress has been made and significant improvements have been implemented in the field which have limited additional exposures to workers, it is noted that some elements of the recovery effort are behind schedule. Examples include training for Radiation Protection Assistants and startup of the alpha counting room. Much is left to be done to complete the original scope of work to develop protective measures against alpha exposure in particular and improvements to the Radiation Protection Program in general.

An important element of the project is assessment of alpha dose to workers. At this point, several hundred preliminary dose assessments have been done but no dose assignments have been made pending the finalization of the dose model. A critical input to the dose model is the source term characterization work which the Recovery Team has undertaken. This is still a "work in progress" and the RSIC supports all efforts to refine the source term as discussed in section 3.2.3 of this report. The RSIC is also, as part of its overall review, independently reviewing the dose assessment methodology used by Bruce Power including the analytical procedures of external bioassay laboratories and the dose model being developed. The status of that review is discussed in section 3.6.

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1 Background

During the period November 24, 2009 to December 21, 2009, as part of the refurbishment of Bruce Units 1 and 2, a number of Bruce Power contract employees were engaged in the cutting and grinding of feeder pipes as part of the feeder replacement protocol. This job resulted in the release into the general reactor vault atmosphere of significant quantities of airborne actinide (alpha) contamination. As a result, over 500 construction trades workers were potentially exposed to airborne alpha contamination. In response, Bruce Power under the direction of Mr. Michael Quinn organized a Radiation Protection Recovery Team of fifteen full time and six part time members involving a wide range of disciplines required to address the spectrum of tasks needed to recover from the incident. (The Recovery Team composition at the time of preparation of this report is presented in Appendix A). The Radiation Safety Institute of Canada (RSIC) was asked by the Ontario Building and Construction Trades Council, Bruce Power, Comstock Canada and AECL to independently assess the situation, address worker concerns, and review the work of the Recovery Team and offer recommendations for improvement as required.

The present report is not a final assessment. It is an **interim** assessment of the Recovery Team's plan and work completed to date. This interim assessment was requested by Mr. Quinn in mid August, 2010 to assist the Recovery Team to meet scheduled review requirements. The RSIC agreed to provide an interim assessment on condition that the RSIC report would be presented by RSIC staff to the RSIC Joint Steering Committee at its first meeting.

1.1 Review Objectives and Scope

The objectives of the **overall** review by the RSIC are:

- To independently evaluate the recovery plan to identify any significant areas that have not been addressed;
- To independently evaluate the efforts directed to major issues intended to ensure that the alpha radiation exposures of workers and their consequent doses were properly characterized;
- To independently evaluate the effort intended to ensure that personnel will not be exposed to alpha radiation exposures in the future;
- To independently evaluate the effort to ensure that alpha contaminated equipment and waste are properly monitored and characterized and are rehabilitated and/or disposed of in a manner consistent with Canadian regulations;
- To provide independent verification to the workers at Bruce Power and their bargaining agents that their concerns are being addressed;

The scope of the **interim** review consists of evaluating the progress to date of the recovery effort by Bruce Power in general and the Recovery Team in particular. The primary issues identified are listed in Section 3.

It should be noted that the work of the Recovery Team has not been completed and, in a number of key areas is in the relatively early phase of their efforts. Accordingly, this report must be considered as interim, that is to say it is a snap shot of the progress towards achieving the final goals of the recovery effort. _Accordingly, it should be noted that the review is continuing and further data are

becoming available; thus, any conclusions reached or implied below are tentative pending completion of the review.

1.2 RSIC Technical Review Strategy

The strategy undertaken by the RSIC technical review team is to work closely with Bruce Power technical staff in general and the RP Recovery Team in particular to gain an in-depth understanding of the progress made in the key areas listed in Section 3. To accomplish this, members of the RSIC technical review team have been engaged in the following activities:

- Review and analysis of documentation prepared by Bruce Power regular and attached staff
- Attendance at meetings on site on major issues including meetings of the Recovery Team and the Extent of Condition Team
- Interviews of key Bruce Power personnel
- Attendance at worker information sessions to identify the issues that were of concern to workers
- Attendance at Bruce Power Training sessions

1.3 Independent Review Team Members

The RSIC technical team charged with conducting the independent review is presented below in Table 1.

Member	Areas of Responsibility	Affiliations	Areas of Expertise
Claire Cohalan, MSc	• Assistant Project Coordination	RSIC – Staff Scientist	General Radiation Protection Physics
Mike Haynes, MSc	• Project Coordination • Instrumentation • Training • RP Organization • RP Procedures • Field Monitoring	RSIC – Scientific Director Former OPG – Health Physics Department Manager and Station RPM	Operational Health Physics
Andreas Vikis, PhD	• Source Characterization & Bioassay Procedures	RSIC – Consulting Scientist Former - AECL, Health, Chemistry & Environment Division, Director	Radiochemistry
Ed Waller, PhD	• Internal Dosimetry	RSIC – Consulting Scientist University of Ontario Institute of Technology – Head, Nuclear Engineering Program	Dosimetry Nuclear Science
Murray Walsh, MSc	• Project Coordination • Extent of Condition • RP Organization	RSIC – Consulting Scientist W&W Radiological and Environmental Consultant Services, Inc. – Principal Former Ontario Hydro – Technical Safety Standards, Manager	Operational Health Physics Dosimetry

1.4 The Radiation Safety Institute of Canada

This independent review is being conducted by the Radiation Safety Institute of Canada (RSIC). Founded in 1980, the RSIC is an independent national organization dedicated to promoting and advancing radiation safety in the workplace, in the environment and in the community. The Institute is committed to the principle of providing "good science in plain language" ®. The RSIC provides a broad range of educational, technical and scientific services to businesses, government organizations, health care providers, communities and individuals across Canada and around the world. More complete information on the RSIC is available on the Institute's website: www.radiationsafety.ca/.

2 Bruce Power Recovery Team Plan

2.1 Review of the Recovery Team Plan

The Bruce Power Restart Radiation Protection Program Recovery Plan(R-0) was created in response to the November- December, 2009 alpha event in Bruce Unit 1 and subsequent root cause investigation. The plan was developed in recognition of the need to upgrade Restart and Bruce Power radiation protection programs, processes and functions to include identification, assessment and control of alpha hazards. In addition, the plan states that , "as a result of this event, it was felt that the Bruce Power radiation protection (RP) program and function needs to be upgraded from its present state to a very high performing RP organization".

The Recovery Plan includes three phases as follows:

I. Response to the Incident
II. Integration of Alpha into the Bruce Power RP Program
III. Identification of the Remaining Gaps and Weaknesses

2.2 Scope of the Performance Objectives

The scope of the recovery program includes Unit 1 and 2 restart projects with the intent that new programs and procedures will be incorporated into the overall Bruce Power RP program. It is intended that new programs will be consistent with best industry standards including those established by the World Association of Nuclear Power Operators (WANO), the Institute of Nuclear Power Operators (INPO), the International Atomic Energy Agency (IAEA) , the International Commission on Radiological Protection (ICRP) and the Electric Power Research Institute (EPRI). In particular, the EPRI Alpha Monitoring Guidelines for Operating Nuclear Power Stations will be adopted as part of the recovery effort.

Comment:
In general, the RSIC considers that the scope of the RP Recovery team objectives are sufficiently broad in scope and address the appropriate subject areas including review of existing Bruce Power RP programs and procedures, dosimetry, training, source term characterization and extent of condition. To this point, the extent of condition investigation has required a more substantial effort than originally envisaged and has added significant scope to the overall process. However this is a necessary process to ensure that all potential alpha exposures are evaluated across the Bruce site and accordingly, the increased effort is justified. This item will be discussed further in section 3.3.

2.3 Management of the Scope of Work

A large team of industry professionals with experience in alpha monitoring, dosimetry and workplace controls has been assembled to execute the recovery plan. They have been assigned specific areas of responsibility under the plan. Regular (weekly) and ad hoc team meetings are conducted to report progress and address problem areas.

Comment:

Members of the RSIC team have attended several of these meetings over the past few months and find them generally well managed.

2.4 Integration of the RP Elements into the Operating Units

Many new workplace procedures have been developed for workplace monitoring and control of alpha hazards in support of the Restart project. The overall program is defined by SEC-RPR-00016, Alpha Monitoring Procedure. The RP Recovery Plan includes a process for transfer and integration of newly developed procedures for alpha monitoring from the Restart project into BP documentation. This is accomplished through interface with the RP Programs Department and includes RP Procedures that apply to all Bruce Power staff (RPPs) and those that are only performed by Bruce Power RP staff (referred to as SEC- RPRs).

The general strategy at this time is that only qualified persons within the RP Departments will perform alpha surveys and others will only perform beta-gamma surveys. Accordingly, the changes to the RPPs are minor and only indicate that alpha monitoring requirements are contained within specific SEC-RPRs and will be performed by RP staff. Changes to SEC-RPRs are far more substantial, reflecting those changes already introduced into the Restart project.

Comment:
Currently, all affected RPPs have been modified by the RP Recovery team and turned over to Bruce Power for further internal review. This includes review by site wide joint committees, specifically the Joint Health and Safety Committee, the Joint Committee on Radiation Protection and the Training Program Review Committee. Further work is required for the Section RPRs.

SEC-RPR-00016 described above has been issued but is likely to undergo further revision. Work is ongoing on several other SEC-RPRs. The planned completion date for revisions to all RPPs and SEC-RPRs is September 30, 2010. **However, the revisions are behind schedule and this target may not be met.**

Some workplace alpha monitoring procedures (issued as temporary documents) have been integrated into the operating units to support planned outages, specifically the Unit 3 outage at Bruce A and the Unit 6 outage at Bruce B. For the Unit 3 outage, many additional alpha controls were put in place including radioactive work planning, protective equipment, workplace monitoring for airborne and surface contamination and dosimetry . Additional training was required for RP Technicians. Much of this work was accomplished with the help of the RP Recovery Team in the form of new equipment, procedures and training. While alpha surface contamination was detected in several areas within the Unit 3 reactor vault during the Unit 3 outage, only 15 Personal Contamination Events (PCEs) occurred at the exit from the reactor vault and only 4 instances of loose contamination were found outside of rubber areas. These results indicate that the alpha controls were effective.

2.5 Task Structure and Analysis

Comment:
Most elements of the Recovery Plan have sufficient task breakdown in the plan itself and the project schedule to support execution and monitor progress. However, some elements of the plan are clearly lacking task detail. For example, Phase two, element 9.0, Training, Full Spectrum SAT would

benefit from a more detailed task breakdown to ensure that the elements of a Systematic Approach to Training (SAT) are fully implemented in accordance with the Bruce Power SAT standard (BP-PROG-02.02). Other examples where further task breakdown is required are Phase two, elements 10.0, Plant Effluent Monitoring and 11.0, Waste Management.

While the overall Recovery Plan is considered comprehensive and a good planning tool, it should be reviewed and revised as appropriate to ensure that all elements are broken down into sufficient task detail to support execution and to monitor and report progress.

2.6 Performance Monitoring of the Plan Elements

Progress versus plan is reviewed regularly at the weekly RP Recovery Team Meetings chaired by the project manager. All team members participate, briefly report progress and problem areas are raised for discussion and resolution. The project schedule is maintained by one of the team members and is updated on a regular basis.

Comment:
Overall, the project is behind the original schedule and it appears that completion of all elements will extend into at least the first quarter of 2011. This is likely due to expansion of the scope as new issues have arisen (e.g. the extent of condition element is larger than originally thought) and the challenges of making changes in a complex work environment which may not have been fully appreciated at the outset. Another item that was not explicitly planned for that has been very time consuming has been the bioassay debrief sessions with workers to explain their individual bioassay results and related dose assessments. Nevertheless, these sessions are critical to ensure that workers better understand the significance of their exposures.

2.7 RP Recovery Team Resources and Capability

The team includes fifteen full time professional and administrative support staff plus six part time members from related departments across the site. A listing of the personnel and their qualifications is provided in Appendix A. The full time professional staff members are typically contract staff and all have relevant experience in alpha detection, monitoring and workplace control in the nuclear power industry.

Comment:
All RP Recovery Team staff appear be knowledgeable and capable in the subject area. It is noted that most of the professional staff have come from U.S. utilities or other U.S. nuclear industry organizations. While this can result in some inefficiencies due to differences in CANDU design and workplace practices, it also brings an outside perspective based on broader industry experience which is helpful. The administrative staff is judged to be very effective in supporting the team. Overall, team resources and capability are judged to be adequate for the job.

3 Issues and Status

3.1 RP Organization, Communications and Capability

Based on the RSIC's review of the root cause report related to the "alpha event" and subsequent interviews with senior RP staff within the Restart organization and across the site**, it is clear that poor communication between RP departments was a major contributing factor to this event.**

The site RP organization including Restart consists of no fewer than six different departments, all reporting to different managers. It is likely that many RP staff had at least some knowledge that could have been applied to prevent or mitigate this event. This includes long standing OPEX reports and source term information specifically assembled for the Restart project related to alpha contamination. The RSIC is of the view that not all of this information was freely exchanged prior to the event in a constructive and cooperative manner. There is ample evidence that the level of communication between the various groups was at some times completely absent, at some times acrimonious and often dysfunctional. This was particularly true between the AECL and Bruce Power RP departments within the Restart organization. This issue needs to be fixed.

Interviews conducted with senior members of several RP departments on site also indicated that they were not fully aware of the status of the recovery project. In addition, some interviewees expressed concern at the rate of progress. As major stakeholders of the outcome of the recovery project, it is important that RPMs in particular across the Bruce site be fully aware of project status and engaged in the development of proposed changes to the broader RP program.

Additionally, based on interviews with several senior RP staff across the site and the professional judgement of the RSIC team, professional Health Physicist (HP) resources across the site appear to be stretched very thin and not consistent in number with best industry standards. The situation is also characterized by poor demographics with several senior RP staff being close to retirement and several young and inexperienced (but technically capable) staff filling key positions. This situation was exacerbated by the reported loss of 12-13 professional RP staff from Bruce Power during 2006/2007. In particular, there is an acute shortage of CNSC authorized (certified) HPs. All Canadian NPP Operating Licences require a CNSC authorized HP for each plant.

3.1.1 Recommendation

It is critical that Bruce Power rationalize the RP organization across the site and within the Restart project going forward (e.g. for Unit 3/4 refurbishment) to ensure that all accountabilities and interfaces are defined. In general, it would be preferable to have fewer groups and only one within Restart.

3.1.2 Recommendation

The manager of the RP Recovery project should provide regular (monthly) updates of project progress and any challenges to schedule to all RP departments across the site to ensure common understanding and to solicit support if required. This could be done verbally (face to face) or in writing, although the former would be more effective.

3.2 Source Characterization & Bioassay

3.2.1 Background

The relevant literature provided by Bruce Power, including the Bruce Power presentations to the CNSC, was reviewed in order to obtain a better understanding of the Unit 1 alpha contamination incident. In addition, a number of COG reports were reviewed on: a) The potential of alpha contamination in CANDU refurbishment operations; b) fuel failures and release of actinides and fission products; and c) corrosion and activity transport in CANDU reactors.

Following three visits to the site to meet with Bruce A Restart staff and to obtain relevant data on the incident, examination and analysis of the relevant data began. Key elements of the review are discussed below.

3.2.2 Bioassay Suppliers and Procedures

Non-disclosure agreements have been signed with Kinectrics and Atomic Energy of Canada Limited (AECL) Chalk River Laboratories (CRL) to enable a review of the procedures used in relevant radio-analytical work for Unit 1. Test America Labs and GEL Labs have authorized Bruce Power to release their radio-analytical procedures for review.

AECL CRL has been reviewed in a recent visit to assess the capability for analysis of plutonium in urine by Thermal Ionization Mass Spectrometry (TIMS) and in-vivo detection of plutonium and americium by Whole Body Counting/ Lung Counting. **It was concluded that state-of-the-art facilities and proven procedures were employed by well-qualified and dedicated staff to perform these measurements for the evaluation of the impact of the Unit 1 incident.**

A preliminary review of related information provided by Kinectrics, Test America Labs, and GEL Labs has been completed and plans are in place to visit these laboratories in order to ascertain their capabilities.

3.2.3 Source-Term Review

Source term data obtained in response to the Source Term Sampling Plan PMC.5.8.2.039 Rev 1 (dated June 11 2008) were reviewed. The data show that much more emphasis was placed on collecting data for Unit 2 compared to Unit 1. Within experimental variability, actinide activities at two sampling points common to both units show about the same amounts of activity in both units. This was also the case for the $(\beta+\gamma)/\alpha$ activity ratios. This tends to show that there was nothing in the data collected in response to Source Term Sampling Plan PMC.5.8.2.039 Rev 1 to alert station RP of higher amounts of actinides in Unit 1 relative to Unit 2. However, data received from Kinectrics and quoted in a 2010 August 19 report by Frank Greening reveal that actinide activity levels in smear samples, collected from areas adjacent to the west face feeder pipes, had about ten times more actinides in Unit 1 than Unit 2.

A review of file "Alpha Source Term.xls", containing data from Kinectrics (eight measurements) obtained January 2010 shows that the data were averaged incorrectly to obtain the mean contribution of each actinide relative to Pu-239/240:

1) Pu-238 (.3598), Pu-239/240 (1.000), Am-241 (1.938), Cm-244 (.9561)
Statistical analysis of the Cm-244 data for samples 4,9,10 requires that they be rejected to obtain a new mean contribution of:

2) Pu-238 (.36), Pu-239/240 (1.00), Am-241 (1.94), Cm-244 (.40)
The latter is also in line with the mean contribution calculated from the Test America results for fecal analysis (Files J0C240533_Fecal Results Received 3-24-10_FINAL and J0D140480_Fecal Results Received 4-14-10):

3) Pu-238 (.39), Pu-239/240 (1.00), Am-241 (1.78), Cm-244 (.42)
Because the relative actinide contribution is an important parameter in calculating dose, and the one in (1) above was used in dose calculations, the issue was brought to the attention of the dosimetrists to review the impact on dose calculations.

Additional data by GEL on Unit 1&2 were reviewed, in an attempt to see whether any differences existed between Unit 1 and 2. According to distribution (2) above the Cm/Pu and Am/Pu ratios should be**:** Cm/Pu (0.29) and Am/Pu (1.43). Most data, irrespective of the Unit they come from, are reasonably consistent, as far as Am/Pu is concerned; but there are substantial variations in the Cm/Pu ratio. Other (unexplained) observations include:

- Spreadsheet BA Jun 9 data show an unusually high Cm-244 contribution.
- Spreadsheet BA Sept 9 data (samples 30,31, 32), which seem sufficiently robust, show a distribution Pu-238 (.46), Pu-239/240 (1.00), Am-241 (1.26), Cm-244 (.20) somewhat reduced in Am, Cm.
- Spreadsheet BB April 9 data show a high Cm-244 contribution

3.2.4 Observations and Recommendations

In general, current source term data show many unexplained trends. Additional source-term data, especially from the areas near the J-prep work, are needed.

In addition, a recommendation by Frank Greening "to recover a large high activity HEPA filter that was used in the B1 vault to collect airborne activity from J-prep work areas" is endorsed by the RSIC team. . In particular, Greening has recommended that this filter be used as a representative source term sample for tests of solubility in lung fluid. These tests could be conducted at CRL as a valuable input to the dosimetry model. **RSIC strongly supports this recommendation.**

3.3 Extent of Condition Project

3.3.1 Project Objectives and Scope

The objectives of the project are:

- To identify and characterize exposures to airborne alpha contamination of personnel engaged in restart activities in Unit 1 and Unit 2 outside of the dates of the "incident".

- To identify and characterize exposures to airborne alpha contamination of personnel engaged in operational and maintenance tasks conducted in the operating units.
- To provide data to formulate policies and procedures to minimize future exposures to airborne alpha contamination.

3.3.2 Project Methodology

The process consisted of two pathways to select personnel for alpha uptakes and dosimetry evaluations. It may be summarized as follows:

- The first pathway is based on the particular jobs which have potential exposures to alpha contamination and matching personnel to the jobs based on radiation exposure permits
- The second pathway is based on a list of potential exposed employees submitted by union stewards
- The two lists are compared and prioritized based on criteria of likelihood of exposures
- Bioassay (fecal) samples are requested from personnel with elevated probabilities of having been exposed.

It should be noted that Bruce Power has committed that any employee who requests personal monitoring will be monitored. However, owing to the relatively slow throughput of the bioassay analysis, it is possible that lower priority individuals may have to wait up to a year before monitoring

For a more complete discussion of the methodology, the reader is referred to the presentation by Jag Mohindra (project leader) entitled "Extent of Condition Alpha Airborne Hazard" dated August 11, 2010.

3.3.3 Project Status and Evaluation

Comment:
The project is well organized and the selection process is logical. The project is advancing well under the Project Leader Jag Mohindra. The name selection and bioassay sampling is on-going. Of the total target population of approximately 2600 workers, 426 bioassay analyses are in progress, and 37 analytical results have been obtained for personnel engaged in the restart and 10 analytical results received for personnel engaged in Fuel Handling in Bruce A and Bruce B.

3.3.4 Recommendations

3.3.4.1 Documentation of the current project should be improved and left as procedural templates for continuing alpha monitoring after the current campaign has been completed.

3.3.4.2 Following the completion of the current campaign and the accumulation of bioassay data, consideration should be given to a comprehensive statistical analysis to attempt to provide better confidence in the sampling strategy to identify personnel who may be exposed to alpha airborne contamination in the future.

3.4 Workplace Alpha Monitoring

Many new alpha monitoring instruments have been procured in response to the incident. These include "state of the art" whole body monitors, hand held contamination meters, air samplers and continuous air monitors. This array of instruments gives the site much improved capability for early detection and protection against airborne or surface alpha contamination. All of these instruments need to be commissioned, user procedures developed and RP staff need to be trained in their use. This work is all proceeding, usually with temporary procedures for the Restart project initially. An alpha counting room to be manned by trained RPAs is also being put into service to support Restart. Training of RPAs on the count room is well advanced.

Comment:
The new alpha workplace monitoring procedures have been effective. The Bruce Power ALARA Section Manager reported that only one alpha PCE (a few counts per minute on an individual's hair) has been reported at the exit from the Unit 1 vault in the last 4-5 months. During that time, several thousand air samples have been taken with no activity detected. Anecdotally, it was reported that approximately 20,000 worker exits have occurred from the Unit 1 vault without detection of alpha contamination. This indicates effective control of contamination at the source.

3.5 Staff Training

The Recovery Plan includes provision for specialized training related to the alpha hazard for workers, RPAs and Health Physicists. An overall training plan to cover the development of training for these three groups was committed several months ago but is yet to be finalized. This is overdue.

Comments:
Workers on the Restart project are generally Orange qualified, ie elementary training in radiation protection which allows limited access to radioactive work areas and generally requires oversight by RPAs. The Orange Badge Qualification Manual (Radiation Safety Course # 6556) contained no information related to alpha radiation prior to the incident. Review of a revised version of the manual during this interim assessment indicated that only cursory changes had occurred in the course content with respect to mention of alpha hazards, and only with respect to submission of bioassay samples. While the RSIC has recently been advised that the necessary changes have now been made to the material, **a greater sense of urgency should have been applied to address this issue**. This should have been one of the first issues fixed in response to the event which occurred approximately nine months ago.

Training for RPAs who will operate instruments in the new alpha count room has been delivered to a designated set of RPAs. A lecture on radiation instruments was observed by RSIC and a hard copy of the lecture on counting statistics was also reviewed. While the quality of the training material is judged to be good, RSIC questions whether much of the material was fully comprehended by the students. Based on this small sample, the material appears to be pitched at too high a level, ie designed for RP professionals. The question arises as to whether this material was developed specifically for the needs of the RPAs or drawn from another "off the shelf" source.

In addition, an outline of a comprehensive training program for all Restart RPAs has recently been developed by the Recovery Team. This outline covers a broad range of radiation safety fundamentals and has the potential to greatly enhance RPA basic knowledge. As discussed above, it is important that the supporting training material be targeted at the right level.

3.5.1 Recommendations

3.5.1.1 The Recovery team needs to ensure that training material is consistent with the needs of the students (as per SAT principles) and that it is targeted at a level that the students can comprehend and retain.

3.6 Alpha Dosimetry

3.6.1 Background

An independent dose assessment has been conducted by the RSIC for three (3) workers involved in the "Alpha incident". The objectives of the independent dosimetry review were to:

- Obtain bioassay data (urine, fecal and lung count) for three contaminated workers with the following Dose Information System Numbers (DISN): 445551, 423909 and 404217
- Perform manual and IMBA calculations to independently verify the dose to contaminated individuals, and
- Assess validity of dosimetry assumptions

3.6.2 Review Methodology

The methodology employed to conduct the independent review was as follows:

1. Select a procedure to follow for the dose assessment. The procedure selected was that outlined by Marsh et al. (Marsh, J.W., Bailey, M.R. and Birchall, A. (2005) "A Step-by-Step Procedure to Aid the Assessment of Intake and Doses from Measurement Data", Rad. Prot. Dos., Vol. 114, No. 4, pp. 491-508.)
2. Make appropriate assumptions about the conditions relating to the intakes. This includes parameters such as time of exposure, particle size and source term.
3. Convert raw urine, fecal and lung count data to quantities usable in dosimetry calculations.
4. Perform dosimetric estimates following the procedure adopted in [1.] using the Integrated Modules for Bioassay Assessment (IMBA) internal dosimetry code, as well as performing hand calculations using IAEA37 intake retention fractions and ICRP 68 dose conversion factors.
5. Compare results with data provided by Bruce Power, which include
    a. Dose model provided to CNSC by Bruce Power
    b. IMBA CANDU output for DISN 445551 (as part of the dose model submitted to the CNSC)
    c. Tabulation of committed effective dose estimates for DISN 445551, 423909 and 404217.

3.6.3 Approach to ensuring validity of dosimetric models and dose assignments

To ensure validity of dosimetric models, comparisons were performed between hand calculations and IMBA calculations. This alone, however, will not ensure validity, as systemic errors can

promulgate to both calculations. Therefore, peer review of the independent dose assessment is currently being conducted to challenge the assumptions and models developed.

Upon completion of the peer review of the independent dose assessments, a complete report will be released. As this review is in progress, no evaluation or recommendations are available at this time.

Appendix A - Recovery Team Overview

Team	Current Affiliation	Past Affiliations	Areas of Expertise	Education	Certifications	Responsibilities for RP Recovery
Bob Leddy	Millennium Services, Inc.	Millennium Services, Inc.	● Operational Health Physics Program Development & Implementation ● RP Program Management ● RP Program Assessments & Improvement Initiatives ● Radiological Surveys for Characterization and Free Release	● B.S. Health Physics ● M.S. Health Physics		● Support to Operating Plants ● RP Program model and organizational structure ● Root Cause Analysis (e.g., Unit 6 Tritium Event) ● Event response ● Procedure support
Dick Dubiel	Millennium Services, Inc.	Millennium Services, Inc.	● Operational Health Physics Program Development & Implementation ● RP Program Management ● RP Program Assessments & Improvement Initiatives ● Radiological Surveys for Characterization and Free Release ● Radiochemistry ● License Termination & Decommissioning	● B.S. Physics ● M.S. Nuclear Engineering	CHP	● RP Program Assessment ● RP Program model and organizational structure ● Support to Operating Plants ● Procedure support
Eric Darois	Executive Director, Radiation Safety & Control Services Inc. National Health Physics Society New England Chapter Health Physics Society Member ANSI N13.1	● Principal Investigator, EPRI Alpha Guidelines ● Principal Investigator, EPRI Groundwater Guidelines ● EPRI Groundwater Assessment Team (2005 to Present) ● NIOSH Dose Reconstruction Team Member (2005 to 2007) ● Yankee Atomic Deccommissioning LTP Project Technical Lead (2003 to 2007) ● Conneticut Yankee Decommissioning Project Health Physicist (1997 to 2006) ● Expert Panel Member for NRC's Advisory Committee on Nuclear Waste (2006 - 2007) ● Health Physics Supervisor Seabrook Station 1985 to 1996	● Radiation Detection ● Internal Dosimetry ● External Dosimetry ● Groundwater Contamination ● Environmental Measurements ● Neutron Characterization ● Decommissioning ● Decommissioning Cost Estimation ● RESRAD Modeling	● BS - Radiological Sciences U-Mass Lowell ● MS - Radiological Sciences U-Mass Lowell	ABHP Certified Health Physicist - 1985	● RP Program/Policy Development ● Characterization Support ● Air Sampling Program Upgrade ● Radon Testing ● Instrumentation Commissioning ● Training Program Development
Frank Greening	CTS	OPG Research	Radiochemistry	Ph.D.		Source Term Characterization
Frank Perry	Bartlett Nuclear Inc.	Northeast Utilities	Applied Radiation Protection	Assc.Gen.		Rad Protection Field Manager

Appendix A, continued

Hayley Hutcheon	RP Recovery Team - Administrative Assistant	AMEC - Return to Service Modifications Training Coordinator	● Data Management ● Communications	Business Insurance	Orange Badge Unit 1-8	● RPA Availability Assessment ● Develop and maintain action tracking systems for the RP Recovery effort and track completion dates to ensure closure
Howard Andes	Bartlett Nuclear Inc.					
Jagjit Mohindra	HP Consultant	OPGn Pickering NGS	HP and Engineering	M.Sc	CHP	Extent of Condition, Team Lead
Jay Tarzia				M.Sc	CHP, Sr Reactor Operator	
Jim Berger	Millennium	● DeNuke Services Inc. ● Safety & Ecology Corporation	● Radiation Detection Instrumentation ● Radiological Surveys for Characterization and Free Release ● License Termination & Decommissioning ● Dosimetry ●General Health Physics	● B.S. Physics ● M.S. Radiological Health	CHP	● Instrumentation Procedures ● Conditional and Free release protocols and criteria ● Support to Operating Plants ● Count Room
Jim Pyatt	Bruce Power		BP Operational RP and HP	BSc, CET		●EOC restart work alpha hazard conditions & identification exposure pathways ● Count Rm training ● RPA fundamental training development and delivery
Kaitlyn Petter	RP Recovery Team - Administrative Assistant	PMC Maintenance - Maintenance Clerk	● Data Management ● Communications	General BA Philosophy	Orange Badge Unit 1-8	● Data management for RP Recovery team and EOC Team ● Coordinate group bioasasy debrief meetings
Ken Gaynor	Bartlett Nuclear Services		Alpha Specialist	Grade12	3.1 SR HP	● Oversite ● Coaching ● Mentoring ● Recovery
Maung Zeya	HP Training Project Manager	Restart RP Field Manager	Field RP Oversight, decontamination	Ph.D.		Field Support
Michael Quinn	WorkPlace Cornerstone Group, LLC www.scwe.net	● Center for Conflict Resolution ● Connecticut Community Care, Inc. ● State of Vermont – Department of Public Service ● Entergy Nuclear – Vermont Yankee ● Dominion Power – Millstone Station ● Connecticut Yankee Atomic	● Project Management ● Nuclear Power Station Operations ● Organizational System Dynamics ● Safety Culture ● Root Cause ● Plant Radiochemistry and Environmental Dose Calculations ● Corrective Action Programs ● ***Change and Transition intervention***: change and transition management,	● Bachelor of Science Degree in Chemistry ● Masters in Business Administration with a focus in organizational behavior ● Doctorate of Science in Organizational Management System Dynamics	● FPI/ PII Prevention and Reduction of Organizational and Programmatic Failures ® ● Nuclear Safety Review Concepts Event Evaluation ® (certified root cause investigator)	Project Manager RP Recovery Team

Appendix A, continued

		Power Company ●U. S. Department of Homeland Security ● U.S. Federal Emergency Management Agency ● Day and Zimmermann NPS ● Florida Power and Light ● Millstone Nuclear Power Station ● Los Alamos National Lab (KSL Services) ● U.S. Department of Energy - Hanford WA ● Maine Yankee Atomic Power Company ● Met Life Insurance, New York ● General Electric-Hitachi ● Fabrico, Inc. ● Northeast Nuclear Energy Company ● Natural Technological Hazards (NTHMC) Inc. ● Nuclear Management Company (NMC) LLC ● Northeast Utilities ● Point Beach Nuclear Power Station ● Seabrook Nuclear Power Station ● South Texas Nuclear Project ● U.S. Department of Energy - Yucca Mtn ● U.S. Nuclear Regulatory Commission	coaching, conflict resolution, corrective action, targeted selection, root cause evaluations, strategic planning, and related human performance initiatives.		● DDI Assessment Center ® ● DDI Certified Behavioral Interviewing ® ● Hogan Assessment Systems ® (individual selection, executive and management coaching and development) ● Community Conflict Transformation ® ● Clark Wilson Group Certification ® (executive, management, group, and team assessments) ● US N.R.C. Senior Reactor Operator's License 10071	
Neil Knudsen	Bartlett Nuclear	● Dominion Power ● Northeast Utilities ● RAD Services ● General Dynamics	●ALARA ● Alpha Radiation Specialist ● Health Physics Technician ● Trainer	Assoc Sci. Mechanical Engineering	NRRPT	● Schedule Maintenance ● Work Observation ● Coaching
Paul Racicot	Bartlett Nuclear Inc.	Dominion Nuclear CT	Radiation Protection	B.Sc.		Alpha Field Specialist

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Rick Titolo	Millennium Services, Inc.	Millennium Services, Inc.	● Operational Health Physics Program Development & Implementation ● RP Program Management ● RP Program Assessments & Improvement Initiatives ● Radiological Surveys for Characterization and Free Release	● B.S. Health Physics ● M.S. Health Physics		● RP Program and Procedures ● Support to Restart ALARA Group ● RP Program model and organizational structure ● Support to Operating Plants
Robyn Bacon	EOC Team Technical Support	●Project Support Clerk, AMEC NSS ● ECC Clerk, AMEC NCL ● Document Administrator, AMEC NCL	● Technical Report Writing ● Data Management	Bachelor of Medical Sciences Honors Degree	● Orange Badge U1-8 (2010) ● Intro to CANDU (2009) ● Biosafety Training (2008)	● Gather data, maintain database, trend & summarize data for presentations & reports
Rory McDonald	Liaison to the workforce	Boilermakers	Labour relations	● RSO ● Journeyman	● RSO level 1 ● Humber college construction Boilermaker	Labour relations
Shane Bradley	Consultant	● Bruce Power - Consultant (2008 - present) ● Waste Auditors, Inc - Consultant (2001-2008) ● EMC Corp - Health Physicist/ Project Manager (1995-2001)	Training	28 yrs OJT	NRRPT	RP Training Gaps, Field Operations
Tom Dupes	Bartlett Nuclear	Bartlett Nuclear	Radiation Protection	MBA		Oversight, Support and Governance of RP Recovery
Tony Tetsuwari	Health Physics Society	Health Physics Society	Environmental Monitoring/HP	BS/MS	NavSeas 108	Training
Wayne Pestill	RP Recovery EOC	Conventional safety	Civil Construction 40 y.	HS	MCM	DWC Trades/ Interface