



Minutes of the Canadian Nuclear Safety
Commission (CNSC) Meeting Held on
November 9, 2017

Minutes of the Canadian Nuclear Safety Commission (CNSC) meeting held Thursday, November 9, 2017, beginning at 9:00 a.m., at the Public Hearing Room, 14th floor, 280 Slater Street, Ottawa, ON.

Present:

M. Binder, President
Dr. S. McEwan
Dr. S. Soliman
Dr. S. Demeter

K. McGee, Assistant Secretary
L. Thiele, Senior General Counsel
S. Baskey, P. McNelles, C. Moreau, Recording Secretaries

CNSC staff advisors were:

G. Frappier, H. Tadros, K. Glenn, R. Garg, J. Mecke, M. Rinker, N. Kwamena, J. Burtt, N. St.-Amant, E. Dagher, K. Sauvé, A. Du Sautoy, P. Thompson, R. Lane, S. Simic and N. Riendeau, J. Leblanc

Other contributors were:

Ontario Power Generation: S. Smith
New Brunswick Power: J. Nouwens
Bruce Power: M. Burton
Nuclear Waste Management Organization: L. Swami, P. Gierszewski, B. Helfadhel, D. Wilson, B. Watts and L. Frizzell
Natural Resources Canada: D. McCauley
Canadian Nuclear Laboratories: D. Klokov

Constitution

1. With the notice of meeting CMD 17-M54 having been properly given and a quorum of permanent Commission members being present, the meeting was declared to be properly constituted.
2. Since the meeting of the Commission held October 11-12, 2017, Commission member documents (CMD) 17-M41, 17-M46, 17-M48, 17-M50, 17-M55.B, 17-M57 were distributed to members. These documents are further detailed in Annex A of these minutes.

Adoption of the Agenda

3. The revised agenda, CMD 17-M55.B, was adopted as presented.

Chair and Secretary

4. The President chaired the meeting of the Commission, assisted by K. McGee, Assistant Secretary and S. Baskey, P. McNelles and C. Moreau, Recording Secretaries.

Minutes of the CNSC Meeting Held August 16-17, 2017

5. The draft minutes of the August 16-17, 2017 Commission meeting, CMD 17-M41 were approved. One correction to the draft minutes was directed. Paragraph 37, which read “CNSC staff added that they do not look specifically to a number but at the trend on a daily basis” will be corrected to say “CNSC staff added that they do not look specifically to a number but at the trend on a quarterly basis”.

Minutes of the CNSC Meeting Held October 11-12, 2017

6. The minutes of the October 11-12, 2017 Commission meeting will be approved at a later date.

STATUS REPORTS

Status Report on Power Reactors

7. With reference to CMD 17-M57, which provides the Status Report on Power Reactors, CNSC staff provided updates:
 - Bruce Nuclear Generating Station (NGS) Unit 2 had returned to full power.
 - New Brunswick Power Corporation (NB Power) submitted a report in accordance with REGDOC-3.1.1¹ in regard to the October 24, 2017 steam burn accident and CNSC staff was in the process of reviewing the report and the corrective actions undertaken.

NB Power Point Lepreau NGS Conventional Steam Burn

8. The Commission sought clarification about whether the review NB Power would be conducting regarding the potential hazards at the Point Lepreau NGS and the personal protective equipment (PPE) used would be a broad review or specific to that particular steam accident. The NB Power representative explained that NB Power was focusing on PPE and procedures specifically related to systems involving saturated liquids that could pose a steam hazard, particularly, those low to the ground. The NB Power representative also provided information about lessons learned that resulted in new operational procedures. The Commission was satisfied with the information provided in this regard.

¹ CNSC Regulatory Document REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*, Version 2, April 2016.

Bruce Power NGS Unit 2 Repair of Small Instrument Line Leak on the Heat Transport System (HTS)

9. The Commission requested additional details about the location and cause of the leak on the HTS. The Bruce Power representative explained that the leak occurred on a flow-sensing instrument line for the HTS in the feed cabinet that came from one of the pressure tubes. The Bruce Power representative also stated that the leak occurred because of a loose segment in the instrument line that began chafing against the feeder cabinet insulation and provided information regarding the repairs and corrective actions that Bruce Power would undertake. CNSC staff added that the leak had been below Bruce Power's Operating Principles and Procedures limits and confirmed that but Bruce Power had proactively shut down the unit and performed the repair as described.
10. The Commission requested additional information about the repair that Bruce Power had carried out and whether follow-ups would be conducted. The Bruce Power representative explained that the leaking section of the instrument line had been removed and replaced using Swagelok fittings, in accordance with approved procedures, and that further supports had been installed and inspected to ensure that the instrument line was not in contact with the insulation. CNSC staff informed the Commission a focused inspection would be carried out regarding this line leak during staff's regulatory oversight activities.

Darlington NGS Unit 1 Outage to Address Turbine Control Issue

11. The Commission requested additional information about the nature of the control issue that led to Darlington NGS Unit 1 outage on October 27, 2017. CNSC staff stated that a routine test on Turbine 1 revealed possible control issues that warranted further investigations. The OPG representative further clarified that during a planned shutdown of Unit 1 the matter, specifically a pressure switch, was further investigated.
12. The Commission also enquired as to whether CNSC staff had any concerns about putting the reactor through a complete thermal cycle in a single day. CNSC staff explained that there were no concerns about the procedure used because OPG had properly executed the shutdown and restart in accordance with its operational procedures approved by CNSC.

13. The Commission suggested that ambiguities in the language used, such as control issues, would benefit from additional explanation in future reports.

INFORMATION ITEMS

Long-term Management of Canada's Used Nuclear Fuel

14. With reference to CMD 17-M50.1 and CMD 17-M50.1A, representatives from the Nuclear Waste Management Organization (NWMO) presented on the Adaptive Phased Management (APM) plan. APM was the approach selected by the Government of Canada for the long-term management of used nuclear fuel in Canada that would be implemented by the NWMO.² The technical end-point of the APM program is the centralized containment of used nuclear fuel within a deep geological repository (DGR) in an area with an informed and willing host community. In addition, under the APM program, a transportation system would be developed in order to transport the used nuclear fuel to the repository site. As this repository would first require to be licensed by the CNSC pursuant to the *Nuclear Safety and Control Act*³ (NSCA) before its construction and operation could begin, the information presented by the NWMO sought to provide the Commission with information regarding:

- the history of APM
- an overview of the technical program and DGR site selection process
- the current project status and timelines

The NWMO had previously committed to inform the Commission and CNSC staff in respect of the NWMO's activities and progress in respect of the APM program throughout the pre-licensing period.

15. With reference to CMD 17-M50, CNSC staff presented an update on its early role in the APM initiative. The presentation provided by CNSC staff discussed its activities with respect to this initiative, which fell into three specific areas:

- pre-licensing activities
- CNSC international and research activities
- outreach activities, including Indigenous engagement

² GoC. 2007a. Government Approval of APM, Order-in-Council, Part 11, Vol. 141, No. 13 of the Canada Gazette, SI/TR/2007-63. Government of Canada.

³ *Nuclear Safety and Control Act* (S.C. 1997, c. 9)

CNSC staff stated that it would continue with these activities throughout the implementation of the APM program and would provide the next update to the Commission on this initiative in 2020.

ACTION
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16. The Commission requested additional information regarding the benefits of the high-resolution aerial geographic surveys that were performed by the NWMO. The NWMO representative provided the Commission with detailed information on the history and purpose of the magnetic and gravitational surveys, stating that the increased survey resolution provided the NWMO with information on previously unidentified geological features and rock types in areas that had not undergone detailed geological surveys. The NWMO representative also stated that the information gained from those surveys would be used to further refine the areas that the NWMO considered to be geologically stable and potentially suitable for the proposed repository site.
17. The Commission expressed its dissatisfaction with the concept of 'closure' of the proposed used fuel DGR, noting that this terminology implied abandonment of the facility. In this regard, the NWMO representative clarified to the Commission that the closure of the proposed repository referred to the time when it reached capacity and the access to the repository would be physically closed off from the surface with an engineered barrier. The NWMO representative confirmed to the Commission that the closure of that repository did not imply that it would be abandoned.
18. Referring to the international cooperation agreements to which Canada was a signatory in respect of the development of a used fuel DGR, the Commission enquired about the US role in these agreements, noting that the US had participated in the CNSC-established international DGR Regulatory Forum (DGRRF). CNSC staff provided the Commission with information regarding its collaborative activities with the US, such as the DGRRF, and also noted that the CNSC had a regulatory cooperation memorandum of understanding with the United States Nuclear Regulatory Commission (USNRC).
19. The Commission noted the quality and comprehensiveness of the presentations and information provided by the NWMO and CNSC staff.

Indigenous and Community Engagement, and Public Information

20. The Commission noted the NWMO's use of cultural assessments during the preliminary assessment phase and enquired as to how those assessments were applied to the site selection process. The NWMO representative responded that the cultural assessment was

- used to determine how the APM program would improve the future well-being of a potential host community from social, cultural and economic perspectives, and provided a detailed explanation of how those assessments were performed. The NWMO representative further stated that along with safety, the partnership with communities was an essential site selection criterion, and described the main principles of that partnership. The NWMO representative provided additional details on how the NWMO carried out cultural assessments with a specific focus on First Nation and Métis communities, noting that these included traditional land use studies.
21. The Commission enquired as to how the NWMO would determine if a community was willing to host the repository and how the NWMO would retain this willingness throughout the entire APM program lifecycle. The NWMO representative described the NWMO's criteria for a willing host community and explained that the NWMO would continuously engage and build relationships with communities throughout the pre-licencing, licence application, and potential operational phase of the APM program.
 22. The Commission noted the potential for significant impacts in the selected host community due to the APM project and enquired about how the NWMO would manage those impacts. The NWMO representative stated that they recognized that there would be impacts on the host community, and that the NWMO would work with the selected host community to support capacity within the community and to ensure that it could accommodate additional personnel and infrastructure.
 23. The Commission noted the site selection process for the used fuel repository in Sweden, where two sites were selected in order to mitigate the event where the host community reconsidered and then decided not to host the proposed repository, and enquired about whether the NWMO had considered such a process. The NWMO representative reported that the NWMO's site selection process was accepted by the Minister of Natural Resources and it required significant resources. The NWMO representative further noted that they were of the view that due to relationships that had been and would continue to be built between the NWMO and the selected host community, there was very little risk of the selected host community withdrawing from the APM project. The NWMO representative added that its current review was focused on seven communities that had voiced their support with respect to being the host community for the APM project.⁴

⁴ After the closure of the Commission meeting, the Commission noted that the NWMO was longer considering Blind River and Elliot Lake as potential host communities for the proposed repository. Nuclear Waste Management Organization – *Blind River, Elliot Lake and Area No Longer Part of Site Selection*,

24. In response to the Commission's enquiry regarding the NWMO's reporting, the NWMO representative confirmed to the Commission that its annual and triennial reports, as well as the agreements that the NWMO had made with potential host communities, were publicly available. The NWMO representative also informed the Commission regarding the nature of those community agreements, such as funding agreements which would ensure that the potential host community would not bear the financial burden from its participation in the APM project.
25. The Commission also noted the quality of the references in the NWMO's publicly available documentation and asked how that information would be maintained as the APM project moved forward. The NWMO representative provided an overview of all of the NWMO's publicly-available information. CNSC staff further informed the Commission regarding the related information that was available on the CNSC website as well as the CNSC's plan to retain and build upon that information as the project progressed.

Used Fuel Management

26. The Commission enquired whether the NWMO could manage used fuel from non-CANDU reactors. The NWMO representative responded that the types of fuel that would be accepted into the repository, included certain non-CANDU fuel sources. The NWMO representative stated that it was the responsibility of the waste owner to ensure that the used fuel was put into a form that could be managed by the NWMO in the DGR.
27. The Commission enquired whether owners of non-fuel high-level waste would be obligated to dispose of their waste in the proposed used fuel repository. CNSC staff reported that CNSC would not dictate where the waste would be disposed of as long as the health and safety of people and the environment remained protected. CNSC staff confirmed to the Commission that nuclear waste producers were responsible for managing their nuclear waste.
28. The Commission recognized the narrow definition of "nuclear fuel waste" as defined in the Nuclear Fuel Waste Act (NFWA) and enquired as to whether this definition was sufficient to address all high-level nuclear waste in Canada. The Natural Resources Canada (NRCan) representative confirmed to the Commission the definition of "nuclear fuel waste" under the NFWA and provided a detailed description of the forms of waste that could be accommodated in the planned repository. The NRCan representative provided further information regarding the

- classification of nuclear waste in Canada and confirmed that the management of nuclear waste was the responsibility of the waste owner. The NRCan representative stated that NRCan was of the view that the existing legislation was adequate to accommodate all currently identified used fuel types. The NWMO representative confirmed the information that was provided by NRCan and stated that the NWMO was satisfied that the NFWA had addressed the management of used fuel in Canada. The NWMO representative added that the NWMO was committed to working with potential future entrants into the nuclear energy sector in order to address their specific used fuel management needs.
29. Further on this topic, CNSC staff provided the Commission with a detailed overview of the state of waste storage and disposal in Canada, and the CNSC's regulation of those activities. CNSC staff stated that the nuclear industry in Canada was working towards disposal solutions for all nuclear waste and that CNSC staff would monitor that progress. The Commission then asked about what information CNSC staff would present pursuant to the *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management* (Joint Convention).⁵ CNSC staff stated that its position would be that Canada had a robust regulatory framework that provided clear expectations with respect to used fuel management. CNSC staff added that its own progress in this regard would be subject to international peer review, in accordance with the national reporting and peer review meeting process under the Joint Convention.
30. The Commission enquired if additional regulations would be required in order to licence and regulate the proposed used fuel repository. CNSC staff responded that it was of the view that the CNSC's existing regulatory framework was, and would remain adequate to regulate and licence a high-level nuclear waste repository, as well as the transport of the waste to that repository. CNSC staff also explained that a recent discussion paper⁶ considered these regulatory issues in respect of the proposed repository and that it was found that any facility-specific requirements could be addressed through licence conditions and revised guidance documents, such as REGDOCs.
31. The Commission enquired about "stable shallow underground storage" that had been at one time considered as a viable option for the disposal of used nuclear fuel, and was mentioned in the

⁵ International Atomic Energy Agency – INFCIRC/546, *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*, December 1997, <<https://www.iaea.org/publications/documents/infcircs/joint-convention-safety-spent-fuel-management-and-safety-radioactive-waste-management> >.

⁶ Canadian Nuclear Safety Commission Discussion Paper – DIS-16-03, *Radioactive Waste Management and Decommissioning*, May 2016.

NWMO's documentation and presentation. The NWMO representative provided to the Commission an explanation of that previously-considered disposal method and informed the Commission about why that method was no longer under consideration as an option for the APM.

Design and Operational Safety

32. The Commission asked for additional information regarding climate change mitigation measures for the proposed repository. The NWMO representative stated that the long-term impacts of climate change were considered during the repository's post-closure safety assessments and its siting criteria. The NWMO representative further stated that the short-term effects of climate change would be considered during the design of the repository; however, it was too early in the project lifecycle to determine the exact facility design considerations that would be required.
33. The Commission asked for information regarding the operational safety aspects of the proposed facility. The NWMO representative provided to the Commission a detailed overview of the operational safety aspects with respect to the conceptual designs of the proposed repository. The NWMO representative provided examples of factors that would be considered for the design of the proposed repository, including the ALARA⁷ principle and assessments of postulated accidents.
34. Regarding how CNSC staff and NWMO answered the public's questions about the safety of the proposed repository, CNSC staff reported that it would explain to the public its role as the regulator, as well as the practices and methods it would use to ensure that the NWMO would safely construct and operate the proposed repository. The NWMO representative stated that during its communication with the public, the NWMO had provided a detailed overview of the measures that would be used to ensure the safety of the facility, including several examples of those measures. The NWMO representative also stated that the NWMO informed the public that Canada had a good record of safely storing and transporting used nuclear fuel, and that the NWMO's consultation activities have shown that the public has indicated that it would feel more confident in the safe storage of the used fuel after it was stored underground.
35. The Commission expressed surprise that emergency management considerations had not been presented by the NWMO or CNSC

⁷ As low as reasonably achievable (ALARA) principle: A principle of radiation protection that holds that exposures to radiation are kept as low as reasonably achievable, social and economic factors taken into account. Section 4 of the *Radiation Protection Regulations* stipulates licensee requirements with respect to ALARA.

staff in their presentations regarding the APM project. The Commission is of the view that that emergency management provisions should be considered early in the proposed project, especially during construction of the repository and the phase during which the used fuel would be placed in the repository.

Used Fuel Transport Container Testing

36. The Commission enquired about the non-destructive testing (NDT) that would be performed on the containers that would transport and store the used nuclear fuel in the proposed repository. The NWMO representative provided an overview of the NWMO's planned NDT requirements for the used fuel containers, the design and prototyping of the NDT equipment that would be used, and the types of flaws and defects that those tests were expected to detect.
37. The Commission asked for additional information regarding the testing requirements for the used fuel transport containers. The NWMO representative reported to the Commission that the NWMO had performed tests on those containers in accordance with international standards. CNSC staff informed the Commission that those tests were performed for a range of extreme events and accidents scenarios, in accordance with IAEA SSR-6, *Regulations for the Safe Transport of Radioactive Material*,⁸ and that those tests ensure that the structural integrity of the container would not be compromised in case of an accident. CNSC staff further described the multiple safety barriers incorporated into the containers and the additional testing requirements the containers would be subjected to. CNSC staff also informed the Commission that, although internationally there had been accidents involving the transport of high-level radioactive material containers, the containers had, in all cases performed as expected.

Update on the implementation of recommendations from the Tritium Studies Project Synthesis Report

38. With reference to CMD 17-M48, CNSC staff presented the Commission with an update on the implementation of the recommendations from the Tritium Studies Project Synthesis Report. The Tritium Studies Project, initiated in June 2007, was a Commission-directed initiative to conduct research studies on tritium to enhance the information available to guide the regulatory oversight of tritium processing facilities and tritium releases in Canada. The Commission had previously received presentations from Staff in 2010 and 2013 at which follow-up activities had been suggested. CNSC staff's presentation demonstrated that the project objectives had been met and that adequate provisions have been

⁸ International Atomic Energy Agency Specific Safety Requirements – SSR-6, *Regulations for the Safe Transport of Radioactive Material*, Vienna, 2012.

- made through existing regulatory mechanisms for the protection of Canadians and the environment from exposure to tritium releases.
39. The Commission requested additional information about the effective dose and half-life considerations due to the different biokinetic patterns of organically bound tritium (OBT) and tritiated water (HTO) that were identified by Canadian Nuclear Laboratories (CNL), noting that these contradicted current international literature. The CNL representative summarized the primary differences between CNL's study and the information in existing literature and opined that the differences in observed biological effects may have originated from the selection of a different subset of organic macromolecules for the studies. Asked whether CNL had carried out multiple studies in this regard, the CNL representative explained that, to date, only this study had been done. CNSC staff informed the Commission that, while CNL's tritium study provided novel information about the biological behaviour of different forms of tritium, further studies would be required for the CNSC to alter its current approach to the calculation of the dose consequence from tritium exposure.
 40. The Commission sought additional details about the passive and active tritium air sampling techniques and how an air sampling technique was selected for use. CNSC staff provided the Commission with information about the advantages and disadvantages of the two tritium air sampling techniques. CNSC staff explained that active samplers did not run continuously, which could affect the reliability of sampling in proximity to sources that did not continuously release tritium, whereas passive samplers had the advantage of collecting a long-term average value of tritium release. CNSC staff added that the use of different methodologies for the same parameter provided useful information about potential measurement biases, noting that the CNSC's independent environmental monitoring program (IEMP) had shifted to using active air monitoring systems and compared these results with those of licensees which generally employed passive air monitoring systems.
 41. The Commission enquired about the reported variability in HTO:OBT ratios with respect to exposure pathways and any potential regulatory impacts of these findings. CNSC staff emphasized that current ratios were estimated through laboratory experiments performed under ideal equilibrium conditions that were not influenced by random environmental influences such as changes in wind direction. CNSC staff also informed the Commission that CNSC staff performed additional calculations with ratios 10 to 15 times higher than those derived to ensure that the current model was conservative and there was no risk of adverse health effects to members of the public.

42. In reference to a concern raised by an intervenor during a May 2015 hearing,⁹ regarding the effects of tritium on a fetus, the Commission requested a comment from CNSC staff about whether any of CNSC's staff conclusions from that hearing had changed as a result of the information gained from the additional research that had been carried out. CNSC staff stated that based on the most advanced and current international understanding of the biokinetics of tritium, there is no indication that tritium exposure around the facilities discussed during the May 2015 hearing was a risk to the health and safety of individuals, including pregnant women and infants. CNSC staff also stated that public outreach activities were essential in countering this misinformation regarding the risks of tritium exposure.
43. Considering the importance of the Great Lakes to Canada and the United States (US), the Commission enquired about whether CNSC staff collaborated with or made use of the expertise of the US National Council on Radiation Protection and Measurements (NCRP) and its resources. CNSC staff replied that through the International Atomic Energy Agency (IAEA) Modelling and Data for Radiological Impact Assessment (MODARIA) program they had been connected with the US tritium working group, but had not yet collaborated with them on any common initiatives. CNSC staff also remarked that work was being conducted to examine the impacts of radionuclides from the nuclear industry on the Great Lakes. CNSC staff emphasized that the tritium concentrations in the Great Lakes had peaked in the 1960s due to the above ground testing of atomic bombs and, in fact, the tritium concentrations had been decreasing ever since, despite the fact that a nuclear power industry had been constructed and operated during the same period up to present.
44. The Commission asked about CNSC staff's participation in the US Nuclear Regulatory Commission's (NRC) investigations into the tritium releases following the shutdown of the Vermont Yankee NGS. CNSC staff confirmed that their expertise had been requested by the NRC to provide the NRC's Commission with information about tritium and groundwater drinking standards.
45. Understanding that there are three forms of tritium, the Commission enquired about why the equation to derive an approximation for OBT did not account for non-oxidized tritium gas (HT). CNSC staff explained that the form of tritium released from facilities is often HT, but noted that HT was readily converted to oxidized tritium combined with water molecules (HTO) when

⁹ CNSC Record of Proceedings, Including Reasons for Decision – SRB Technologies (Canada) Inc., *Application to Renew the Class IB Nuclear Substance Processing Facility Operating Licence for the Gaseous Tritium Light Sources Facility in Pembroke, Ontario*, 2015.

- entering the atmosphere or plant matter. As such, the primary ratio considered in the dose models was the OBT over HTO ratio with the HT contribution considered negligible.
46. The Commission further enquired about whether HT could be absorbed directly by plant leaves, bypassing the soil-water uptake path. CNSC staff stated that, although HT contributions from the proposed mechanism could occur, these would remain small and therefore could be considered negligible. CNSC staff also indicated that, for these reasons, the greater scientific community focused on HTO pathway contributions for OBT formation.
47. The Commission asked CNSC staff why there appeared to be unavailable data concerning some criteria in the Pickering NGS summary data. CNSC staff explained that local foodstuff sampling near the Pickering NGS was difficult because there was little local produce and it was difficult to obtain local fish for the 2017 Pickering NGS IEMP sampling. CNSC staff added that CNSC staff was working with the local Indigenous groups and communities to ensure greater availability of these foodstuffs and, especially fish, for the next IEMP sampling plans near the Pickering NGS.
48. The Commission asked if CNSC staff was developing a regulatory document to provide guidance regarding tritium releases to the environment. CNSC staff responded that REGDOC-2.9.1 Part II,¹⁰ which was planned to be available for public consultation in the spring of 2018, would deal specifically with controlling tritium releases, and setting release limits and environmental action levels. CNSC staff added that N288.8,¹¹ which provides guidance for the development of environmental release action levels, would be incorporated into the CNSC's regulatory framework as well.
49. The Commission asked CNSC staff to address any progress that had been made respecting discrepancies between Health Canada's 7,000 Bq/L of tritium in drinking water limit and the lower 20 Bq/L concentration that had been suggested by the Ontario Drinking Water Advisory Council. CNSC responded that this topic was routinely discussed and that CNSC had submitted its recommendations in writing nearly 10 years ago; however, the province had not yet made a decision in this regard. The Commission was satisfied with the information provided on this matter.

¹⁰ CNSC Regulatory Document REGDOC-2.9.1: *Environmental Protection: Environmental Principles, Assessments and Protection Measures, Part II*, Not yet published.

¹¹ N288.4: *Establishing and implementing action levels for releases from the environment from nuclear facilities*, CSA Group, 2017.

50. The Commission complimented CNSC staff on the quality of the work that had been done which included original research, publications and reports. The Commission also credited CNSC staff with an excellent and informative presentation and suggested that many of their figures should be used in public outreach activities.

Biological Mechanisms Acting at Low Doses of Radiation

51. With reference to CMD 17-M46 and 17-M46.A, CNSC staff provided a briefing on four biological mechanisms that could occur at the cellular level following moderate, low and very low doses of radiation. CNSC staff highlighted that when radiation interacted with cells, it caused damage to critical molecules or targets, such as deoxyribonucleic acid (DNA), within the cell. CNSC staff concluded that the experimental evidence reviewed for this CMD did not suggest a direct causal relationship between individual biological mechanisms and human health effects for low doses of radiation. CNSC staff also reported that the Canadian radiation protection regulatory framework was based on the linear-non-threshold (LNT) dose-response model. CNSC staff stated that based on the current evidence, the current radiation protection framework is robust and protects all Canadians.
52. The Commission noted that CNSC staff provided information regarding nuclear DNA damage in the CMD and asked about the impact to a cell resulting from radiation-induced mitochondrial DNA damage. CNSC staff answered that the focus of the literature review that was carried out for this research paper focused on damage to nuclear DNA, noting that the most common topics identified during the literature review were how DNA damage would impact mitosis. The Commission recommended that, although CNSC staff found little to no information on this topic during the literature review, the paper should reflect this finding.
53. In relation to the implementation of the ALARA principle, the Commission enquired about the impact of the recent research on low-dose radiation response models could affect the consideration of economic factors by licensees. CNSC staff explained that industry was using the ALARA principle and lessons learned to optimize their processes without necessarily adding to their capital expenses to help minimize worker exposure.
54. The Commission asked if the amplitude and the frequency of the radiation were factors in its biological effect on a cell. CNSC staff indicated that, in the case of radiation, instead of looking at the amplitude and frequency in terms of a wave, the properties of radiation could be related to those of particles, in particular the number of photons and the energy of the photons.

55. The Commission further enquired about whether the exposure frequency of the receptor (the cell) had an impact on the effect of radiation on cellular structures. CNSC staff provided a detailed explanation regarding the mechanisms by which radiation could impact a cell. CNSC staff added that the bystander effect had shown that the energy from radiation could be deposited anywhere in the cell and adverse effects could occur in other cells not directly exposed to radiation.
56. The Commission asked about the effect of dose-rate on the biological mechanisms that CNSC staff had studied. CNSC staff responded that dose-rate seemed to have an impact on the outcome measured but that it was difficult to draw firm conclusions in this regard because the effects between high and low doses were not studied in a single study that was carried out under the same experimental conditions. Rather, CNSC staff had to compare different studies which suggested that dose-rate may have an impact on cell response.
57. The Commission inquired about individual susceptibility to radiation and what impact this could have from a radiation biology point of view. CNSC staff explained that individual variability was frequently seen with adaptive response to radiation. But CNSC staff added that, for other biological mechanisms, more research was required to more accurately model individual sensitivities.
58. The Commission inquired about the reason why the same radiation exposure might cause different responses in similar cells. CNSC staff explained that the main reason for this difference in response was the point at which the cells were in their biological cycle during the radiation exposure. CNSC staff added that high radiation doses would likely induce death in a large group of cells whereas consequences induced by low doses were more dependent on the biological stage of the cell.
59. The Commission sought more information about genomic instability. CNSC staff responded that genomic instability was described by the accumulation of new genetic alterations or changes observed in the progeny of irradiated cells, even multiple cellular generations after the radiation exposure. The Commission recommended that the CMD contain more detail about the different possible issues that could develop after cells were irradiated. The Commission also recommended clarifying the section of the CMD discussing chronic inflammation and epigenetics.

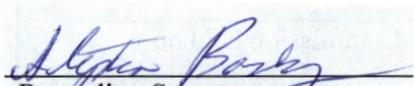
60. The Commission expressed satisfaction with CNSC staff's statement stating that "the LNT model should not be used for individual or population based cancer risk assessment." The Commission noted that the LNT model is often directly correlated with cancer risk assessment in literature, causing confusion and misinformation amongst the public.
61. The Commission asked whether it was possible to reduce radiological sensitivity with antioxidants or other biological interventions. CNSC staff answered that they were not aware of any intervention other than potassium iodide in the case of radioactive iodine exposure.
62. The Commission asked for further explanation about the dose level and the rate of repair as two statements in the CMD that seems to contradict one another. CNSC staff explained that in this particular case, the two papers discussed in the CMD had different experimental design and set-up; one experiment used a high dose, while the other experiment used a lower dose delivered at a higher rate.
63. At the request of the Commission, CNSC staff provided information on the progress of low-dose radiation research in the United States. CNSC staff also explained that the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR)'s role was to provide factual scientific documents for use by the IAEA and the International Commission on Radiological Protection (ICRP) and that ICRP was focusing on regulation.
64. The Commission invited CNSC staff to explain the difference between regulatory requirements, regulatory limits, and health limits in post-accident situation like Fukushima. CNSC staff responded that the ICRP framework were clear for accident and post-accident situations but that the framework was never designed to deal with contaminated sites and post-accident situations.
65. The Commission asked about the health impact of background radiation and whether a threshold at which an impact could be observed had been identified. CNSC staff indicated that the CNSC's radiation protection framework intends to regulate industries where radiation is controllable, whereas background radiation cannot be controlled. CNSC staff added that in the case of background radiation, higher doses are acceptable since they are naturally occurring and not controllable. CNSC staff also added that additional studies on the effects of background radiation need to be done to draw definite conclusions.

- 66. The Commission complimented CNSC staff on the quality of the CMD and on the research that had been carried out. The Commission expects CNSC staff to publish this research study after the Commission recommendations, as noted in the paragraphs above, have been incorporated.

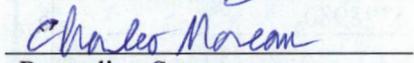
- 67. The Commission made various recommendations and requests to enhance and complete the information presented in the CMD, including:
 - to use the latest update of the Hanahan and Weinberg paper¹²
 - to add a discussion on cell death (apoptotic or necrotic after radiation damage)
 - to explain that the bystander effect¹³ was also seen in other biological phenomena
 - to include a description of the abscopal effect

Closure of the Public Meeting

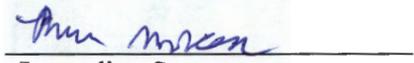
68. The meeting closed at 16:04.


 Recording Secretary

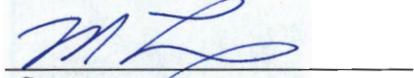
2017-12-14
 Date


 Recording Secretary

2017-12-14
 Date


 Recording Secretary

2017-12-14
 Date


 Secretary

15-12-2017
 Date

¹² The paper's version referred to in the CMD was: Hanahan, D. & Weinberg, R.A. 2000, "The hallmarks of cancer", *Cell*, vol. 100, no. 1, pp. 57-70.

¹³ As defined in CMD 17-M46. *The biological mechanisms acting a low doses of radiation*, November 2017.

APPENDIX A

CMD	Date	e-Docs No.
17-M54	2017-10-13	5347508
Notice of Commission Meeting		
17-M55	2017-10-25	5347713
Agenda of the Meeting of the Canadian Nuclear Safety Commission (CNSC) to be held on Thursday, November 9, 2017, in the Public Hearing Room, 14 th floor, 280 Slater Street, Ottawa, Ontario		
17-M55.A	2017-11-02	5374990
Updated Agenda of the Meeting of the Canadian Nuclear Safety Commission (CNSC) to be held on Thursday, November 9, 2017, in the Public Hearing Room, 14 th floor, 280 Slater Street, Ottawa, Ontario		
17-M55.B	2017-11-07	5386164
Updated Agenda of the Meeting of the Canadian Nuclear Safety Commission (CNSC) to be held on Thursday, November 9, 2017, in the Public Hearing Room, 14 th floor, 280 Slater Street, Ottawa, Ontario		
17-M41	2017-10-31	5348273
Draft Minutes of the Meeting of the Canadian Nuclear Safety Commission held on August 16 and 17, 2017		
17-M57	2017-11-01	5378980
Status Report on Power Reactors		
17-M50.1	2017-10-19	5372078
Information Item Long-term Management of Canada's Used Nuclear Fuel Submission from the Nuclear Waste Management Organization (NWMO)		
17-M50.1A	2017-11-01	5378995
Information Item Long-term Management of Canada's Used Nuclear Fuel Presentation by the Nuclear Waste Management Organization (NWMO)		
17-M50	2017-11-09	5358589
Information Item Long-term Management of Canada's Used Nuclear Fuel Presentation by CNSC Staff		

CMD	Date	e-Docs No.
17-M48	2017-10-23	5341317
Information Item Update on the Implementation of Recommendations from the Tritium Studies Project Synthesis Report Submission from CNSC Staff		
17-M48.A	2017-11-09	5375526
Information Item Update on the Implementation of Recommendations from the Tritium Studies Project Synthesis Report Presentation by CNSC Staff		
17-M46	2017-10-23	5333211
Information Item Biological Mechanisms Acting at Low Doses of Radiation Submission from CNSC Staff		
17-M46.A	2017-11-09	5377007
Information Item Biological Mechanisms Acting at Low Doses of Radiation Presentation by CNSC Staff		