
Prepared by
Office of Audit and Evaluation
Health Canada and the Public Health Agency of Canada

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List of Acronyms

ALARA  As Low As Reasonably Achievable
BioDoseNet  Global Biodosimetry Laboratories Network for Radiation Emergencies
CCRPB  Consumer and Clinical Radiation Protection Bureau
CNSC  Canadian Nuclear Safety Commission
CRMN  Canadian Radiological Monitoring Network
CTBT  Comprehensive Nuclear-Test-Ban Treaty
CTBTO  Comprehensive Nuclear-Test-Ban Treaty Organisation
DPR  Departmental Performance Report
ERHSD  Environmental and Radiation Health Sciences Directorate
HECSB  Healthy Environments and Consumer Safety Branch
IAEA  International Atomic Energy Agency
InFORM  Integrated Fukushima Ocean Radionuclide Monitoring
IPPRS  Integrated Planning and Performance Reporting System
IT  Information technology
NBDRP  National Biological Dosimetry Response Plan
NEPRD  Nuclear Emergency Preparedness and Response Division
NDS  National Dosimetry Services
NDR  National Dose Registry
NORM  Naturally Occurring Radioactive Materials
FERP  Federal Emergency Response Plan
FNEP  Federal Nuclear Emergency Plan
FPT  Federal/Provincial/Territorial
MOU  Memorandum of Understanding
mSv  millisieverts
PSAT  Public Security and Anti-Terrorism Initiative
RHAD  Radiation Health Assessment Division
RPB  Radiation Protection Bureau
RSD  Radiation Surveillance Division
SSC  Shared Services Canada
TAG  Technical Assessment Group
UNSCEAR  United Nations Scientific Committee on the Effects of Atomic Radiation
WHO  World Health Organization
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Executive Summary

This evaluation of Health Canada’s radiation protection activities covered the period from April 2010 to March 2015. The evaluation was undertaken in fulfillment of the requirements of the Treasury Board of Canada’s Policy on Evaluation (2009).

Evaluation Purpose and Scope

The purpose of the evaluation was to assess the relevance and performance of Health Canada’s radiation protection activities. Health Canada’s radiation protection activities are led by the Radiation Protection Bureau (RPB) and the Consumer and Clinical Radiation Protection Bureau (CCRPB) within the Environmental and Radiation Health Sciences Directorate (ERHSD) of the Healthy Environments and Consumer Safety Branch (HECSB). The evaluation covered activities undertaken by: RPB’s Nuclear Emergency Preparedness and Response Division; Radiation Surveillance Division; National Dosimetry Services Division; sections of the Radiation Health Assessment Division (including the National Dose Registry); as well as CCRPB’s Radiobiology Division. The National Radon Program was excluded from this evaluation as it had previously been evaluated as part of the Clean Air Regulatory Agenda, and activities related to radiation emitting devices were excluded as they had previously been evaluated as part of the Evaluation of Consumer Products Activities.

Program Description

The objective of Health Canada’s radiation protection activities is to inform and advise other government departments, collaborate with international partners, and inform Canadians about the health risks associated with radiation and strategies to manage associated risks. To achieve these objectives, Health Canada carries out the following key activities:

• managing the Federal Nuclear Emergency Plan (FNEP) and providing technical support for a radiological/nuclear emergency that requires a coordinated federal response;
• monitoring environmental radiation;
• conducting radiation surveillance to support Canada’s role within the Comprehensive Nuclear-Test-Ban Treaty Organization;
• providing occupational dosimetry services;
• providing a centralized radiation dose record system;
• performing radiation health risk assessments and management; and,
• conducting research on the biological effects of radiation and exposure trends.
CONCLUSIONS - RELEVANCE

Continued Need

The evaluation found that there is an ongoing need for radiation protection activities to manage health risks associated with exposure to radiation, and to support nuclear non-proliferation. Exposure to ionizing radiation can occur from a variety of natural and human-made sources. Although radiation can be used for beneficial applications, it can also have negative impacts on human health including a range of somatic effects that are limited to the exposed individual and genetic effects that may affect subsequent unexposed generations.

International issues, including the nuclear power accident in Fukushima and the recent claim by North Korea regarding nuclear warfare, have highlighted the importance of being ready for an emergency exposure situation that, although rare, can occur.

Alignment with Government Priorities

Although not explicitly mentioned in recent federal announcements about health, radiation protection activities are consistent with the Government of Canada’s priorities related to the health and safety of Canadians, and are aligned with Health Canada’s objective, “to inform and advise other government Departments, international partners, and Canadians in general about the health risks associated with radiation, and inform Canadians of strategies to manage associated risks”, as articulated in the 2014-2015 Health Canada Report on Plans and Priorities.

Alignment with Federal Roles and Responsibilities

Most radiation protection activities are consistent with Health Canada’s roles and responsibilities under legislation (such as the Emergency Management Act, the Radiation Protection Regulations under the Nuclear Safety and Control Act, and the Canadian Environmental Assessment Act, 2012), and national and international agreements. However, there is no clear federal mandate for providing commercial dosimetry services and, although Health Canada was previously the only commercial dosimetry provider in the Canadian market, there are now other licenced private-sector companies that can provide comparable services. There is some duplication and lack of clarity regarding the roles of Health Canada versus the Canadian Nuclear Safety Commission for nuclear emergencies.

CONCLUSIONS – PERFORMANCE

Achievement of Expected Outcomes (Effectiveness)

Radiation protection activities have provided information to Canadians and other key stakeholders and partners, and contributed to protecting Canadians from health risks associated with radiation, by determining individuals’ exposure levels (through both personal dosimetry and biological dosimetry), by monitoring the concentration of ionizing radiation in the environment (through three complementary monitoring networks), and by producing research and guidelines
to assess and manage the health impacts of radiation. The evaluation identified challenges related to communications to the public both in terms of crisis communications in an emergency and day-to-day information provision (for example, providing environmental monitoring data to the public in near real-time and providing annual reports on occupational exposure).

Evidence suggests that Health Canada is currently well positioned to respond to nuclear emergencies and threats. Health Canada is responsible for the FNEP, which is the primary federal plan governing nuclear emergencies. The FNEP contains formalized roles and responsibilities both within and outside the federal government, and plans have been tested and improved upon to address issues identified through simulated and real emergency scenarios. The state of emergency preparedness appears to have improved following Health Canada’s response to, and lessons learned from, the Fukushima nuclear accident. According to both internal and external key informants, as well as ‘After Action Reports’ prepared following the full-scale national exercise Unified Response, Health Canada’s emergency response capabilities have improved significantly as a result of the Fukushima experience, although concerns around the timeliness and coordination of public communications in an emergency remain.

Overall, the Program appears to be effective in terms of supporting partners and stakeholders nationally through the provision of data, research, technical advice, and services related to radiation protection. External key informants were generally positive about Health Canada’s contributions and support to partners. However, annual reports on Occupational Radiation Exposure in Canada and Health Canada research publications based on NDR data have not been produced since 2008 and 2001 respectively, due to issues with IT, staff complements and gaps in data. Issues around limited accessibility of data were raised by data users (e.g., provinces, OGDs).

In terms of contributions outside of Canada, the Program is an active participant in a variety of international agreements and committees, and has supported a range of radiation protection and nuclear security efforts on the international stage, including nuclear non-proliferation efforts. External key informants were positive about Health Canada’s contributions internationally. Following the nuclear accident in Fukushima, Health Canada provided support to international partners, for example through environmental monitoring, research, and emergency dosimetry. Health Canada’s contributions to Japan related to Fukushima were formally recognized by the Government of Japan.

**Demonstration of Economy and Efficiency**

Overall spending averages approximately $15M annually, and has remained fairly stable over the five-year evaluation period. Spending generally aligns to plans, with the majority of spending directed to dosimetry, emergency preparedness and surveillance activities. The operating and salary costs of providing dosimetry services are largely cost recovered; however, the Program does not recover all its costs when previous long term Program investments are taken into account. Looking to the future, Program representatives are concerned that the sun-setting of some funding sources may affect emergency preparedness.
The Program has introduced efficiencies through leveraging the use of monitoring equipment and data, and through operational measures, although some opportunities to improve efficiency have been hampered by IT and staffing issues.

In terms of governance, the grouping of radiation protection activities considered under this evaluation does not have an overarching governance structure, although there are a number of committees that integrate radiation protection activities within Health Canada and with other agencies. Some internal interviewees noted that greater integration between the Program’s divisions and within the health portfolio overall would be beneficial. With respect to performance measurement, there is no logic model or performance measurement strategy for radiation protection activities as a whole, although draft logic models do exist at the divisional level. Internal interviewees were generally positive about the utility of existing performance information. However, performance information mainly relates to outputs, rather than outcomes.

RECOMMENDATIONS

Recommendation 1

Explore opportunities to enhance public communications and data access related to environmental and occupational monitoring information, and for emergency situations.

Issues related to communications to the public and access to data were identified in many activity areas, for example, radiation surveillance, emergency preparedness and the NDR. There is evidence that some Canadians have had a difficult time trying to find or interpret Health Canada’s most current surveillance data, in addition to distinguishing the differences amongst its three surveillance networks. For NDR data, the ‘Annual Report on Occupational Radiation Exposure in Canada’ has not been produced since 2008, and direct access to data for partners is no longer available. In terms of emergency preparedness, an After Action report following a FNEP exercise identified the need to ensure public communications are rapid and coordinated. Both external and internal key informants indicated that Health Canada’s communication efforts are not adequate or timely. Further, there is evidence that other groups, such as CNSC, took action to address gaps in information to the public during and following the accident at Fukushima.

Recommendation 2

Clarify, implement and communicate the appropriate roles and responsibilities related to nuclear emergency preparedness and response with CNSC.

The evaluation identified concerns with duplication and a lack of clarity around the roles of Health Canada and the CNSC in some areas. The most common concern cited was in relation to communications to Canadians in emergencies. An external advisory committee report on the Fukushima response that was prepared for the CNSC concluded that there was no official federal government ‘voice’ to provide updates to the public. In addition, internal and external key informants had varying views on the roles associated with the Technical Advisory Group for emergencies and who should be the lead for the FNEP.
Recommendation 3

Examine options to address issues related to IT program support.

IT support issues were identified for a number of activity areas, including dosimetry services, surveillance, emergency preparedness and the NDR. In addition, potential efficiency improvements through the automation of several processes (NDR data requests and incoming files, NDS retrieval of customer service and client information, and RSD surveillance activities) have not been realized as a result of continued and longstanding IT challenges.

Recommendation 4

In the longer term, consider options to reduce involvement in the provision of commercial dosimetry services.

The evaluation found that there is no federal mandate for the government to provide commercial dosimetry services. There are currently two private-sector companies that offer similar services in Canada. Some internal key informants raised issues related to the ability/willingness of private services to accommodate both official languages, meet privacy requirements, and take on smaller enterprises. This evaluation confirmed that external commercial dosimetry providers are able to address these concerns.

When O&M and capital expenditures are taken into account, the NDS has not covered its costs over the past 8 years. Further, the NDS acts as a commercial provider within a government environment and, as such, is constrained in its: competitiveness; responsiveness; and, ability to communicate with the public.
Management Response and Action Plan
Evaluation of Radiation Protection Activities
September 27, 2016

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Response</th>
<th>Action Plan</th>
<th>Deliverables</th>
<th>Expected Completion Date</th>
<th>Accountability</th>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommendation 1</td>
<td>Agree.</td>
<td>CPAB will explore opportunities to enhance public communications and access to available data by leveraging online tools through the Regulatory Transparency and Openness Framework and GC Web Renewal Initiative.</td>
<td>1) In collaboration with ERHSD, evaluate current web content and online tools and identify required improvements to enhance public communications and data access related to environmental and occupational monitoring information, and for emergency situations.</td>
<td>Evaluation to be completed by March 2017.</td>
<td>DG, PAD</td>
<td>No additional resources required.</td>
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<td></td>
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<td></td>
<td>2) Use social media, periodic risk communications and leverage external partners (e.g. Public Safety and CNSC) to expand reach and to enable Canadians to make informed decisions to protect against and mitigate risk.</td>
<td>Starting Q1 2016-17</td>
<td>DG, HSCD</td>
<td>No additional resources required.</td>
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<td></td>
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<td>3) HC will begin tweeting to inform Canadians of data updates posted online. We will also look at including topics related to radiation in our annual risk communications calendar for 2016-17.</td>
<td>Starting Q2 2016-17</td>
<td>DG, HSCD</td>
<td>No additional resources required.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>4) Publication of renewed National Dose Registry Annual Report.</td>
<td>Draft report to be completed by March 2017. Publication to be completed by September 2017.</td>
<td>ADM, HECSB</td>
<td>No additional resources required.</td>
</tr>
</tbody>
</table>
## Recommendation 2

**Clarify, implement and communicate the appropriate roles and responsibilities related to nuclear emergency preparedness and response with CNSC.**

<table>
<thead>
<tr>
<th>Response</th>
<th>Action Plan</th>
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<th>Accountability</th>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agree.</td>
<td>Update the Memorandum of Understanding (MOU) between Health Canada and the Canadian Nuclear Safety Commission to better clarify roles and responsibilities for nuclear emergency preparedness and response. Seek senior management approval of the MOU, and implement the MOU through collaboration between HC and the CNSC at the Director General, Director and working-levels.</td>
<td>1) Update HC-CNSC MOU&lt;br&gt; 2) Seek approval from HC Deputy Minister and from CNSC President of updated HC-CNSC MOU</td>
<td>January 2017&lt;br&gt; May 2017</td>
<td>DG, ERHSD&lt;br&gt; ADM, HECSB</td>
<td>No additional resources required.</td>
</tr>
</tbody>
</table>

## Recommendation 3

**Examine options to address issues related to IT program support.**

<p>| Management agrees with the recommendation | 1) Environmental and Radiation Health Sciences Directorate (ERHSD) of the Healthy Environments and Consumer Safety Branch (HECSB) will work with Information Management Services Directorate of Corporate Services Branch to reconfirm short and long term (2 year) business requirements regarding IT Support.&lt;br&gt; 2) ERHSD and IMSD will collaborate to develop an action plan for delivering IT support to meet the business requirements identified in 3.1.&lt;br&gt; 3) ERHSD and IMSD will collaboratively track the progress of the action plan bi-annually. If the biannual progress report does not indicate significant progress to meet ERHSD business requirements, ERHSD and IMSD will work together to revisit the action plan. | Short and long term business requirements document identifying the Environmental and Radiation Health Sciences Directorate’s (ERHSD) IT support needs.&lt;br&gt; Action plan document identifying ERHSD IT support requirements, actions, leads, and timeframes for completion.&lt;br&gt; Biannual progress report to ADM, HECSB and ADM, CSB. | October 2016&lt;br&gt; December 2016&lt;br&gt; Every April and October (beginning in 2017) until all items on the action plan have been completed. | DG, ERHSD&lt;br&gt; CIO, HC and DG, ERHSD | Existing resources&lt;br&gt; Existing resources&lt;br&gt; Existing resources |</p>
<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Response</th>
<th>Action Plan</th>
<th>Deliverables</th>
<th>Expected Completion Date</th>
<th>Accountability</th>
<th>Resources</th>
</tr>
</thead>
</table>
| **Recommendation 4** | Agree. | Re-consider options to reduce involvement in the provision of commercial dosimetry services. | 1) Annual reports to HC Executive Committee on the transformation and financial efficiency of the NDS program.  
2) Review the NDS commercial dosimetry program in the future further to the ongoing organizational transformation. Work to begin in March 2020.  
3) Communicate the outcome of this review and recommended way forward to the HC DM. | Annual reports to be delivered by Q1 of subsequent fiscal year until Q1 2021. | DG, ERHSD | No immediate resource implications. Longer-term resource implications would be dependent on future review of the program. |

As noted in the Evaluation Report, “A current internal review of the NDS recognises the responsibility to provide emergency dosimetry services as per the FNEP and recommends maintaining the status quo to minimise costs and avoid negative impacts on NDS clients and staff while maintaining an emergency dosimetry capacity (Health Canada, 2015).” This internal review has now been completed. The outcome of this review is to maintain commercial dosimetry services, while implementing an organizational transformation to increase efficiency and performance as well as reduce costs.
1.0 Evaluation Purpose

The purpose of this evaluation was to assess the relevance and performance (effectiveness, efficiency and economy) of Health Canada’s radiation protection activities for the period of April 2010 to March 2015. The evaluation was performed in accordance with the Treasury Board of Canada’s Policy on Evaluation (2009) to conduct a departmental evaluation of all direct program spending every five years. The evaluation is part of the Five-Year Evaluation Plan of Health Canada and the Public Health Agency of Canada.

2.0 Program Description

2.1 Program Context

Radiation protection is a general term applied to a range of activities that aim to protect people and the environment from the harmful effects of ionizing radiation. In general, programming addresses the harmful impacts of radiation from natural or human-made sources in three areas: occupational; medical; and, public (International Atomic Energy Agency, 2014).

Occupational focussed programing involves the protection of workers in situations where their exposure to radiation is directly related to, or required by, their work. Health Canada contributes in this area by offering a commercial dosimetry service as well as a service for nuclear emergency response through the National Dosimetry Service (established in 1951) that is licensed by the Canadian Nuclear Safety Commission, and a National Dose Registry (established in 1951) to record all dosimetry measurements from licensed dosimetry service providers across Canada.

Medical focussed programing involves the protection of patients exposed to radiation as part of their diagnosis or treatment. Health Canada contributes in this area by enforcing the Radiation Emitting Device Act and producing safety codes, such as Safety Code 33 for radiation protection in mammography and Safety Code 35 for x-ray equipment in large medical facilities.¹

Public focussed programing involves protecting the general population from both natural and human-made sources of radiation in normal and emergency situations. Health Canada contributes in this area with environmental radiation surveillance, research on the biological effects of radiation and exposure trends, radiation health assessment, radon education and awareness², and nuclear emergency preparedness and response.

¹ Not part of this evaluation, as related activities were covered in the Consumer Products Activities Evaluation.
² Not part of this evaluation, as related activities were covered in the Clean Air Regulatory Agenda Evaluation.


2.2 Program Profile

Objective
The objective of Health Canada’s radiation protection activities is to inform and advise other government departments, collaborate with international partners, and inform Canadians about the health risks associated with radiation and strategies to manage associated risks.

Authorities
The Department of Health Act provides the legislative authority for the radiation protection activities to monitor, advise and report on exposure to radiation that occurs both naturally and from man-made sources. Furthermore, the Program supports Canada’s role within the Comprehensive Nuclear-Test-Ban Treaty Organization. The Emergency Management Act requires Ministers to ensure emergency management plans are in place with respect to risks within a Minister’s area of responsibility. The program is responsible for coordinating the Federal Nuclear Emergency Plan. In the case of a nuclear emergency that requires a coordinated federal response, Health Canada coordinates the federal technical/scientific support to provinces/territories. In addition, the Program is licensed under the Canadian Nuclear Safety Commission's Nuclear Safety and Control Act to deliver the National Dosimetry Service, which provides occupational radiation monitoring services.

Organizational Structure
Health Canada’s radiation protection activities are led by the Radiation Protection Bureau (RPB) and the Consumer and Clinical Radiation Protection Bureau (CCRPB) within the Environmental and Radiation Health Sciences Directorate (ERHSD) of the Healthy Environments and Consumer Safety Branch (HECSB). RPB and CCRPB work with other Health Canada branches to implement some radiation protection activities, including: Communications and Public Affairs Branch; Corporate Services Branch; and, Regions and Programs Bureau.

A listing of the ERHSD divisions whose activities are included in the evaluation, and an overview of their roles, is provided in Table 1.
Table 1: Roles and responsibilities of relevant divisions

<table>
<thead>
<tr>
<th>Division</th>
<th>Roles and responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear Emergency Preparedness and Response Division (NEPRD)</td>
<td>Administration of the FNEP, maintaining readiness and strengthening federal and national inter-jurisdictional preparedness and response capabilities for radiological and nuclear emergencies, coordination of departmental nuclear emergency response capabilities, and fulfilment of international obligations under conventions on emergency notification and assistance.</td>
</tr>
<tr>
<td>Radiation Surveillance Division (RSD)</td>
<td>Operation and maintenance of Canada-wide networks of radiation monitoring stations (over 100 stations across the country) and CTBT monitoring stations, operation of radioanalytical laboratories, fulfilment of Canada’s commitments relating to the Comprehensive Nuclear-Test-Ban Treaty, and provision of Health Canada’s core environmental radiation surveillance expertise</td>
</tr>
<tr>
<td>Radiation Health Assessment Division (RHAD)</td>
<td>Research, guidance, assessments, and services to help reduce the risks to Canadians from exposure to ionizing radiation. There are two main activity areas covered by the evaluation: 1) Radiation Health Assessment and Research – Research to support the assessment and management of radiation health risks, development of radiological guidance documents and assessment of situations where radiation may have an impact on the public and the environment, such as assessment of projects under the Canadian Environmental Assessment Act, 2012 and dose assessments in the event of a nuclear emergency. 2) Occupational Radiation Health Assessment Services – Delivery of two programs under a Memorandum of Understanding (MOU) with the CNSC to support licensing requirements for dosimetry service providers: the National Calibration Reference Centre for Bioassay and In Vivo Monitoring, and the National Dose Registry, which is Canada’s central repository for occupational radiation dose records.</td>
</tr>
<tr>
<td>National Dosimetry Services (NDS)</td>
<td>Provision of a licensed dosimetry service to over 100,000 clients on a cost-recovery basis and emergency dosimetry capability in support of nuclear emergency response.</td>
</tr>
<tr>
<td>Radiobiology Division</td>
<td>Provision of biological dosimetry assessments for Canadians (nuclear energy workers, other radiation workers, general public and astronauts); development of innovative new markers for exposure to ionizing radiation; development of high throughput biodosimetry services under the National Biomedical Dosimetry Response Plan.</td>
</tr>
</tbody>
</table>


**Key Activities and Partners**

The key radiation protection activities in Health Canada that were assessed in this evaluation include:

- managing the Federal Nuclear Emergency Plan (FNEP) and providing technical support for a radiological/nuclear emergency that requires a coordinated federal response;
- monitoring environmental radiation;
- conducting radiation surveillance to support Canada’s role within the Comprehensive Nuclear-Test-Ban Treaty Organization;
- providing occupational dosimetry services;
- providing a centralized radiation dose record system;
- performing radiation health risk assessments and management; and,
- conducting research on the biological effects of radiation and exposure trends.

Key domestic partners in radiation protection include: the Canadian Nuclear Safety Commission (CNSC); Environment and Climate Change Canada; Natural Resources Canada; Canadian Nuclear Laboratories; Canadian Food Inspection Agency; Public Safety Canada; Public Health Agency of Canada; Health Products Food Branch of Health Canada; and, the provinces and territories. Key international partners include: the International Atomic Energy Agency (IAEA); the Comprehensive Nuclear-Test-Ban Treaty Organisation (CTBTO); and, the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR).
2.3 Expected Outcomes

The evaluation measured progress towards the following expected outcomes that were developed as part of the evaluation:

- Canadians are informed of and protected from health risks associated with radiation;
- The Program supports the Government of Canada in its preparedness and ability to respond to nuclear emergencies and threats;
- The Program supports other national partners and stakeholders; and,
- The Program supports international radiation protection efforts.

A formal logic model has not been developed for Health Canada’s radiation protection activities as a whole.

2.4 Program Alignment and Resources

The Radiation Protection Program is classified under Section 2.6 of Health Canada’s Program Alignment Architecture, and includes sub-programs 2.6.1 Environmental Radiation Monitoring and Protection, 2.6.2 Radiation Emitting Devices, and 2.6.3 Dosimetry Services. Relevant activities under the following sub-programs are included in the evaluation:

2.6.1 Environmental Radiation Monitoring and Protection

- Radiation Surveillance Division of RPB
- Nuclear Emergency Preparedness and Response Division of RPB
- Radiation Health Assessment Division of RPB

2.6.2 Radiation Emitting Devices

- Radiobiology Division of CCRPB

2.6.3 Dosimetry Services

- National Dosimetry Service of RPB
- National Dose Registry of RPB

The Program’s activities align with Health Canada’s Strategic Outcome #2: “health risks and benefits associated with food, products, substances, and environmental factors are appropriately managed and communicated to Canadians”.
Overall, the Program activities covered in the evaluation have expenditures of approximately $15 million annually and approximately 150 Full Time Equivalent. Actual spending for the years 2010-2011 through 2014-2015 is presented in Table 2; and, Table 3 presents expenditures by Division.

**Table 2: Program Resources (Actual Spending in $M)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Salary</th>
<th>O&amp;M</th>
<th>Capital</th>
<th>Total*</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010-2011</td>
<td>$10.72</td>
<td>$4.33</td>
<td>$0.00</td>
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</tr>
<tr>
<td>2011-2012</td>
<td>$10.78</td>
<td>$3.11</td>
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<tr>
<td>2012-2013</td>
<td>$11.32</td>
<td>$3.34</td>
<td>$0.30</td>
<td>$14.96</td>
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<tr>
<td>2013-2014</td>
<td>$11.89</td>
<td>$3.26</td>
<td>$0.07</td>
<td>$15.21</td>
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<tr>
<td>2014-2015</td>
<td>$11.95</td>
<td>$3.54</td>
<td>$0.04</td>
<td>$15.52</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$56.66</td>
<td>$17.58</td>
<td>$0.90</td>
<td>$75.13</td>
</tr>
</tbody>
</table>

Source: The Branch Senior Financial Officer of the HECSB.
* Salary data includes Employee Benefit Plans (EBP); Financial data does not include resources for radiation protection activities that were covered under the Evaluation of Canada’s Clean Air Regulatory Agenda and the Evaluation of Consumer Product Activities.
** Numbers may not add to total due to rounding.

**Table 3: Program Resources by Activity Division (Actual Spending in $M)**

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>National Dosimetry Services Division</td>
<td>$5.62</td>
<td>$4.67</td>
<td>$4.92</td>
<td>$4.83</td>
<td>$5.47</td>
<td>$25.51</td>
</tr>
<tr>
<td>Nuclear Emergency Preparedness And Response Division</td>
<td>$3.60</td>
<td>$4.02</td>
<td>$4.05</td>
<td>$3.97</td>
<td>$3.61</td>
<td>$19.24</td>
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<tr>
<td>Radiation Surveillance Division</td>
<td>$2.96</td>
<td>$2.77</td>
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<td>$15.26</td>
</tr>
<tr>
<td>Radiation Health Assessment Division</td>
<td>$2.29</td>
<td>$2.18</td>
<td>$2.33</td>
<td>$2.35</td>
<td>$2.35</td>
<td>$11.50</td>
</tr>
<tr>
<td>(including NDR)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radiobiology Division</td>
<td>$0.60</td>
<td>$0.74</td>
<td>$0.67</td>
<td>$0.78</td>
<td>$0.83</td>
<td>$3.62</td>
</tr>
<tr>
<td>Overall Total*</td>
<td><strong>$15.06</strong></td>
<td><strong>$14.38</strong></td>
<td><strong>$14.96</strong></td>
<td><strong>$15.21</strong></td>
<td><strong>$15.52</strong></td>
<td><strong>$75.13</strong></td>
</tr>
</tbody>
</table>

Source: The Branch Senior Financial Officer of the HECSB
* Numbers may not add to total due to rounding.

### 3.0 Evaluation Description

#### 3.1 Evaluation Scope, Approach and Design

The scope of this evaluation covered the period from April 1, 2010 to March 31, 2015 and included all activities in sub-program 2.6.3, and select activities in sub-program 2.6.1 and 2.6.2 that were not previously covered by other evaluations. The evaluation covered activities undertaken by: RPB’s Nuclear Emergency Preparedness and Response Division; Radiation Surveillance Division; National Dosimetry Services Division; sections of the Radiation Health Assessment Division (including the National Dose Registry); as well as CCRPB’s Radiobiology Division.
Division. The National Radon Program was excluded from this evaluation as it had previously been evaluated as part of the Clean Air Regulatory Agenda, and activities related to radiation emitting devices were excluded as they had previously been evaluated as part of the Evaluation of Consumer Products Activities.

The evaluation was conducted by Health Canada’s Office of Audit and Evaluation between April 2015 and November 2015. The evaluation approach aligned with the Treasury Board of Canada’s Policy on Evaluation (2009) and considered its five core issues under the two themes of relevance and performance. Corresponding to each of the core issues, specific questions were developed based on Program considerations and these guided the evaluation process.

The Treasury Board’s Policy on Evaluation (2009) also guided the identification of the evaluation design and data collection methods so that the evaluation would meet the objectives and requirements of the policy. The evaluation framework detailed the evaluation strategy for this Program and provided consistency in the collection of data to support the evaluation.

The evaluation was calibrated as a “small/medium” scale evaluation in the Five-Year Evaluation plan of Health Canada and the Public Health Agency of Canada. As a result of relative materiality, the evaluation had greater focus on the areas of the National Dosimetry Services Division, the Nuclear Emergency Preparedness and Response Division, and the Radiation Surveillance Division.

Data for the evaluation was collected using various methods, including a document review, a literature review, key informant interviews and a case study. More specific details are in Appendix 2. Data were analyzed by triangulating information gathered from the different methods listed above. The use of multiple lines of evidence and triangulation were intended to increase the reliability and credibility of the evaluation findings and conclusions.

### 3.2 Limitations and Mitigation Strategies

Most evaluations face constraints that may have implications for the validity and reliability of evaluation findings and conclusions. The following table outlines the limitations encountered during the implementation of the selected methods for this evaluation. Also noted are the mitigation strategies put in place to ensure that the evaluation findings can be used with confidence.
Table 4: Limitations and Mitigation Strategies

<table>
<thead>
<tr>
<th>Limitation</th>
<th>Impact</th>
<th>Mitigation Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key Informant Interviews - interviews retrospective in nature.</td>
<td>Interviewees may provide recent perspectives on past events. This can impact validity of assessing activities or results.</td>
<td>Interviewees were asked to provide and describe specific examples during the time period under review. Also, interview findings were used in conjunction with other lines of evidence.</td>
</tr>
<tr>
<td>Key Informant Interviews - selection of interviewees. External key informants were identified based on purposive sampling, and then snowball sampling. Budget and timing considerations placed constraints on the number of external key informant interviews that could be completed.</td>
<td>Program partners and stakeholders with particular views may be missed. External key informant interview findings cannot be interpreted as representing the views of all stakeholders or categories of stakeholders.</td>
<td>Candidates for interviews were selected from across the categories of partners and stakeholders. Within each category, there was a purposeful identification of candidates. Interview findings are used in conjunction with other lines of evidence.</td>
</tr>
<tr>
<td>Activities in this area span across separate divisions, making it difficult to integrate into one evaluation with common outcomes. There is no overall logic model that encompasses all radiation protection activities.</td>
<td>The evaluation did not have clear outcomes against which to assess Program performance. Assessing Program activity areas separately would be akin to conducting multiple evaluations.</td>
<td>The evaluation team worked closely with the Program to define relevant outcomes that relate to work done under multiple activity areas.</td>
</tr>
<tr>
<td>Limited quantitative information was available to support the analysis of efficiency and economy. Although some output-based costing information was available (e.g., for dosimetry services), activity- and output-based costing information for all Program activities and over time was not available.</td>
<td>Quantitative analysis of economy is limited primarily to comparing planned and actual spending.</td>
<td>Analysis is supplemented by qualitative information on efficiency from interviews and the literature review.</td>
</tr>
</tbody>
</table>

4.0 Findings

4.1 Relevance: Issue #1 – Continued Need for the Program

Exposure to ionizing radiation can occur from a variety of natural and human-made sources. Although radiation can be used for beneficial applications, it can also pose risks to human health. There is an ongoing need for radiation protection activities to manage health risks associated with exposure to radiation, and to support nuclear non-proliferation.

Ionizing radiation is a natural phenomenon that exists throughout the universe, and can also be artificially generated to support many beneficial applications in medicine, industry, agriculture, research, nuclear power generation and propulsion (Canadian Nuclear Safety Commission, 2015). However, international safety standards recommend a need for radiation protection activities to be comprehensive, as people can be routinely exposed to ionizing radiation in a
variety of ways under different situational contexts and to various degrees, potentially resulting in harmful impacts. For example, people can be exposed to ionizing radiation via their work, through medical procedures or as part of everyday life; and their exposure can derive from existing situations, planned situations, or emergency situations (International Atomic Energy Agency, 2014).

The 2011 accident at the Daiichi nuclear power facility in Fukushima, Japan highlighted the importance of being ready for an emergency exposure situation that, although rare, can occur (Canadian Nuclear Safety Commission, 2014). North Korea’s official statement on October 3, 2006 that it “will, in the future, be conducting a nuclear test” and its follow-up contraventions in doing so in 2006, 2010 and 2013 highlighted the importance of being ready to detect releases of ionizing radiation in the atmosphere, and a need to support efforts of the Comprehensive Nuclear-Test-Ban Treaty (Congressional Research Service, 2010). More recently, in December 2015, North Korea claimed that it developed a hydrogen bomb. As well, Program representatives noted that discussions as part of the IAEA and the Treaty on the Non-Proliferation of Nuclear Weapons indicated that there is an increasing risk of nuclear weapons proliferation.

**Health Impacts of Radiation**

Ionizing radiation cannot be seen, heard, smelled, tasted, or felt by human senses, so the capacity to detect and assess its impact on people and the environment requires a need for radiation sciences and surveillance technology that takes into account artificial and natural sources of radiation (World Health Organization, 2015) (United States Nuclear Regulatory Commission, 2014) (Health Canada, 2010). All creatures respond to radiation differently, and human health risks from ionizing radiation can depend on several factors, including:

- the nature of the ionizing radiation;
- the strength of the source;
- the biological sensitivity of the area exposed; and,
- a variety of exposure factors such as time, distance, and shielding from the source (Health Canada, 2008).

Overall, it is generally assumed that all exposures to ionizing radiation carry a risk of biological damage, although this risk decreases as the exposure decreases (Health Canada, 2008). The health risks associated with exposure to ionizing radiation can include a range of somatic effects that are limited to the exposed individual (e.g., skin redness, hair loss, radiation burns, acute radiation syndrome, cancer) and genetic effects that may affect subsequent unexposed generations (e.g., genetic damage, birth defects) (Public Health Agency of Canada, 2010) (Taylor, 1962). The prevailing risk model in radiation protection activities, therefore, assumes that health risks from radiation exposure are proportional to dose. This risk model has led to the fundamental principles of justification, optimization and dose limitation, and the general approach to managing and controlling radiation exposure to as low as is reasonably achievable (ALARA) while taking into account social, environmental, and economic factors (Canadian Nuclear Safety Commission, 2004).
Public Exposure Rates to Ionizing Radiation in Canada

In Canada, exposure to ionizing radiation varies slightly across the country, but the average radiation dose from all naturally occurring sources is about 1.8 millisieverts (mSv) per year – with a sievert being the international system of units for measuring ionizing radiation dose (Canadian Nuclear Safety Commission, 2015). To compare, the total worldwide average dose from natural radiation sources is approximately 2.4 mSv a year.

According to the CNSC, “normally, there is little that we can do to change or reduce ionizing radiation that comes from natural sources like the sun, soil or rocks. This kind of exposure, while never entirely free of risk, is generally quite low. However, in some cases, natural sources of radioactivity may be unacceptably high and need to be reduced, such as radon gas in the home.” (2015).

Overall, international safety standards note that the risks to people and the environment that may arise from natural or artificial sources of ionizing radiation have to be assessed and, if necessary, controlled (International Atomic Energy Agency, 2014). All artificial sources of radiation in Canada are under regulatory control. In Canada, the effective dose limit for the public from licensed sources of ionizing radiation (excluding medical exposures) is 1 mSv in one calendar year and regular monitoring has demonstrated that the average annual effective doses to the public from activities licensed by the CNSC range from 0.001 to 0.1 mSv per year (Canadian Nuclear Safety Commission, 2015). Examples of typical radiation doses include approximately 0.001 mSv from living one year within a few kilometres of an operating nuclear power plant in Canada, approximately 0.02 mSv from a cross-Canada flight and approximately 0.1 mSv from a chest x-ray. The annual occupational dose limit for a nuclear energy worker is 50 mSv, with a maximum of 100 mSv over five years.

4.2 Relevance: Issue #2 – Alignment with Government Priorities

Although not explicitly mentioned in recent federal announcements about health, radiation protection activities are consistent with Government of Canada and Health Canada priorities related to the health and safety of Canadians.

Recent Budgets and Speeches from the Throne have not explicitly mentioned radiation protection activities in the context of health, but have discussed ‘protecting the health and safety of Canadians and their families’ and the importance of ‘safe and healthy communities’, and a ‘clean and healthy environment’.

Outside of the health context, the 2010 Speech from the Throne made the following commitments related to radiation: “Recognizing the danger posed by the proliferation of nuclear materials and technology to global peace and security, our Government will support the initiatives of President Obama and participate fully in the landmark Nuclear Security Summit in Washington in April”.

Radiation protection activities are aligned with Health Canada’s Strategic Outcome 2, “health risks and benefits associated with food, products, substances, and environmental factors are appropriately managed and communicated to Canadians”.

Health Canada’s radiation protection activities are consistent with the department’s objective for radiation protection, “to inform and advise other government Departments, international partners, and Canadians in general about the health risks associated with radiation, and inform Canadians of strategies to manage associated risks”, as articulated in the 2014-2015 Health Canada Report on Plans and Priorities.

4.3 Relevance: Issue #3 – Alignment with Federal Roles and Responsibilities

Most radiation protection activities are consistent with Health Canada’s roles and responsibilities under legislation and national and international agreements. However, there is no clear federal mandate for providing commercial dosimetry services, and although Health Canada was previously the only commercial dosimetry provider in the Canadian market, there are now other licenced private-sector companies that can provide comparable services. Some duplication and lack of clarity was noted in regard to the roles of Health Canada versus the Canadian Nuclear Safety Commission for nuclear emergencies.

Radiation protection is a shared responsibility of federal, provincial, territorial, municipal and international governments. Most of Health Canada’s radiation protection activities are consistent with federal roles and responsibilities, as set out in legislation, and in national and international agreements.

Legislation

Key legislative authority for Health Canada’s radiation protection activities includes:

- Authority for the Federal Nuclear Emergency Plan (FNEP) is derived from the federal Emergency Management Act (2007). In addition, a letter from the (then) Prime Minister in 1984 gave responsibility for the FNEP to the (then) Minister of Health and Welfare.

- The Radiation Protection Regulations under the Nuclear Safety and Control Act require all dosimetry services licensed by the CNSC to submit dose records to the National Dose Registry. Some provincial legislation (Alberta, Saskatchewan) also require this for provincially regulated workers who may be exposed to radiation.

- Health Canada also has the responsibility under the Canadian Environmental Assessment Act, 2012 to make available, upon request, specialist information and knowledge within its possession, which includes the health effects of environmental radioactivity.
• Although it has not entered into force because some states have yet to ratify the Comprehensive Nuclear-Test-Ban Treaty, the Comprehensive Nuclear-Test-Ban Treaty (CTBT) Implementation Act provides Health Canada with domestic responsibility for the CTBT monitoring stations and laboratory in preparation for the coming into force of the Treaty.

National Agreements
The FNEP describes Health Canada’s responsibilities for, inter alia, providing emergency dosimetry and radiobiology services, radiation surveillance and radiation health assessment.

Memoranda of Understanding (MOUs) with other government departments include commitments for Health Canada related to radiation health assessment (CNSC) and radiobiology services (CNSC, Canadian Space Agency); radiation surveillance (Environment and Climate Change Canada, Natural Resources Canada, Department of National Defence, CNSC); and nuclear emergency management (CNSC, Environment and Climate Change Canada).

International Agreements
Obligations for radiation surveillance are noted under the CTBT, while nuclear emergency commitments are noted under two international conventions from the International Atomic Energy Agency:

• Convention on Early Notification of a Nuclear Accident, 1986; and,
• Convention on Assistance in Case of a Nuclear Accident or Radiological Emergency, 1986.

Health Canada also has a Statement of Intent with the United States Department of Energy for nuclear emergency preparedness and response including mutual assistance.

Federal Mandate for Commercial Dosimetry Services
While the National Dosimetry Service is licensed by the CNSC and Health Canada is responsible for emergency dosimetry services as defined in the FNEP, there is no legislative mandate for Health Canada to operate commercial dosimetry services.

The National Dosimetry Service (NDS) in Health Canada began operations in 1951 to protect Canadian workers at a time when there was no regulatory framework and no other commercial dosimetry service in Canada. In 1994, the Radiation Protection Regulations and the Regulatory Standard for Quality Assurance Requirements for Dosimetry Services were approved, which allowed private sector companies to become licensed dosimetry service providers. Now, there are two multinational companies (Landauer Inc. and Mirion Technologies) licensed to provide commercial dosimetry services in Canada that serve the same client types as the NDS. These companies have been providing services in Canada since 2001 and 2004, respectively. Ten other organizations are licensed to provide in-house dosimetry services to their own employees. According to the program, however, Health Canada’s commercial service provides the capability

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3 Both these firms are based in the United States.
and expertise for its emergency dosimetry services for responders in the event of a nuclear emergency. An environmental scan of the provision of dosimetry services in the United States, United Kingdom, France and Australia indicated that multiple models for delivery exist internationally (e.g., via private and public entities, via health or nuclear safety departments). Apart from Canada, two of the national governments offered dosimetry services on a commercial basis (United Kingdom; Australia) while two did not (United States, France). Only the United Kingdom has their equivalent to the Department of Health operate such services.

Several recent external reviews have questioned or recommended against the continuation of Health Canada’s commercial dosimetry services (KellySears, ERHSD Mandate Review: Radiation Protection Bureau: Final Report, 2015) (Institute on Governance, 2013). These recommendations were based on the lack of federal mandate in this area, the fact that other commercial service providers are now available, and constraints that the NDS faces. Since the NDS acts as a commercial provider within a government environment, it is constrained in its: competitiveness (e.g., not able to solicit business, ability to change fee structure); responsiveness (e.g., may not be able to keep up with technological advances and information technology (IT) advances); and, ability to communicate with the public (e.g., as it may be seen to be seeking new customers).

Some internal key informants indicated that the external reviews were flawed, and raised issues related to the ability/willingness of private services to accommodate both official languages, meet privacy requirements, and take on smaller enterprises (e.g., dental clinics). This evaluation found that external commercial dosimetry providers are able to address these concerns (e.g., are already targeting smaller clients, are meeting privacy requirements of other countries, and, are providing services in multiple countries and multiple languages, including French).

Internal key informants cited the loss of NDS commercial service support for the emergency response capacity as a concern. A current internal review of the NDS recognises the responsibility to provide emergency dosimetry services as per the FNEP and recommends maintaining the status quo to minimise costs and avoid negative impacts on NDS clients and staff while maintaining an emergency dosimetry capacity (Health Canada, 2015).

**Roles Relative to the CNSC**

Both internal and external key informants expressed concerns about duplication and the lack of clarity around the roles of Health Canada and the CNSC in some areas. The most common concern cited was in relation to communication to Canadians in emergencies (discussed further in Outcome 1). A small number also commented on the roles associated with the FNEP Technical Assessment Group for emergencies (there was a perception that some duplication of activities and analyses occurred during the response to the Fukushima accident). In addition, a few internal and external interviewees suggested that other federal partners may be a more appropriate lead for the FNEP, for example, Public Safety Canada or CNSC, given their respective mandates. There was a perception by those interviewees that radiation protection is ‘buried’ within Health Canada’s wide mandate or one of a large number of issues that Health Canada is responsible for, in contrast to a group like CNSC that is solely focussed on nuclear safety and security. However, they indicated that such a shift would not be without concerns, for example a potential conflict of interest with having the regulator (CNSC) also responsible for
coordinating the federal response to address the health impacts of a nuclear emergency. An environmental scan of the United States, United Kingdom, Germany and France found that these countries do not have the federal responsibility for nuclear emergency response embedded within their respective nuclear regulatory authorities or departments of health; most appear to have nuclear emergency response within either an emergency management or civil defence department.

### 4.4 Performance: Issue #4 – Achievement of Expected Outcomes (Effectiveness)

#### 4.4.1 Outcome #1: Canadians are informed of and protected from health risks associated with radiation

Radiation protection activities have provided information to Canadians and other key stakeholders and partners. The activities have contributed to protecting Canadians from health risks associated with radiation by determining individuals’ exposure levels and the levels of ionizing radiation in the environment, and by producing assessments, research and guidelines to assess and manage the health impacts of radiation. The evaluation identified challenges related to communications to the public both in terms of crisis communications in an emergency and day-to-day information provision (for example, providing environmental monitoring data to the public in near real-time and providing annual reports on occupational exposure).

Health Canada’s radiation activities examined as part of this evaluation contribute to protecting Canadians from health risks associated with radiation through providing information on exposure to radiation in occupational settings, and environmental radiation, on associated health risk assessments, and by undertaking and contributing to research and developing guidelines related to assessing and managing the health impacts of radiation. Each is discussed below.

**Information to help protect Canadians from overexposure to radiation in occupational settings**

Health Canada has undertaken activities in a number of areas related to occupational exposure to radiation that have provided information to help protect Canadians. This includes provision of data on individual exposures using external and internal dosimetry, and maintaining a database of dose records of individuals with occupational exposures over their lifetimes regardless of employer.

Personal dosimetry is used to determine doses to individuals who are exposed to radiation related to their work activities. In Canada, for federally regulated activities, if effective doses of radiation could exceed 5 mSv per year, personal dosimetry must be performed by a licensed dosimetry service (Canadian Nuclear Safety Commission, 2012). Provinces regulate other activities, such as X-rays, and set dose limits, as appropriate.
Although the employer is responsible for the health and safety of their employee, the NDS, as a licensed dosimetry service, provides services and information that helps ensure the employee is protected. Annually, the NDS provides dosimetry services to over 100,000 workers across a range of occupational settings. According to internal records, the largest client groups are dental clinics (48%) and private clinics (31%), followed by hospitals (8%), industry/commerce (5%), research (3%), government (2%), other (2%) and mobile X-ray units (1%).

Activities undertaken by the NDS over the period of the evaluation include: maintaining accounts for approximately 13,000 unique organizations; shipping dosimeters; conducting blind tests; undertaking a variety of quality assurance activities to maintain its operating licence; providing over 1,000 brochures and fact sheets (e.g., veterinary and dental fact sheets) to NDS clients and at tradeshows where clients are in attendance; and implementing new dosimeter technologies.

The NDS is viewed favourably by clients who use the service. Relevant external key informants reported high levels of satisfaction with NDS, citing NDS’s collaborative approach and the move to more current dosimeter technology. Client satisfaction surveys showed high levels of satisfaction with customer service and with dosimeters, and these results were consistent across the available surveys. In terms of customer service, over the period of the evaluation, on average 85% of respondents were satisfied, 14% were neutral and only 1% were dissatisfied. For the actual dosimeter, 86% were satisfied, 10% were neutral and 4% were dissatisfied. Similar findings emerged through a previous study on the NDS which found that there was a high degree of satisfaction with the customer service provided. Minor opportunities for improvement were noted but these were primarily suggestions aimed at improving convenience for the customers. The single-window customer experience and the timeliness of responses were highlighted as particular strengths of the NDS (Institute on Governance, 2013).

NDS has also undertaken surveys specific to the newly introduced dosimeters, including ‘InLight’ and ‘Next Generation’ models. As part of the communication plan for the launch of the ‘InLight’ dosimeter, a survey was included in each client’s first shipment. Results showed high levels of satisfaction with dosimeters and the communications plans. However, results from the most recent survey indicated that some high-risk clients had identified issues with the dosimeter. According to Program representatives, the results of the client questionnaires are shared internally for consideration by relevant areas of NDS. For example, client suggestions on areas of improvement for the dosimeter itself are shared with the Research and Development team.

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4 Results from 4 surveys were provided to the evaluation: undated, Feb 2013, June 2013, April 2014. Based on available results, the survey was sent to a total of 3250 clients (undated – 250; Feb 2013 – 750; June 2013 – 1000; and, April 2014 – 1250). Response rates varied from 29% to 43%. Client categories include: Dental, Hospital, Private Practitioner, Research, DND, Industry and Commerce, and Other. Timing of the survey is cited as “per quarter” (undated, Feb 2013, June 2013) or “semi-annually” (April 2014), although actual results received do not appear to consistently reflect this.

5 Results encompassing 4 surveys were provided to the evaluation: Dec 2011, April 2012, July 2012 and July 2013. It is unclear (unstated in the results reports) how many surveys were distributed. The number of returned surveys was: Dec 2011 – 92; April 2012 – 117; July 2012 – 165; July 2013 – 26). Client categories were not identified.
NDS also conducted surveys\(^6\) relating to the ‘Next Generation’ dosimeter. The survey results stated that the “vast majority” of responses regarding the Next Generation Dosimeter were positive.

Finally, when a client cancels dosimetry services, Health Canada sends an exit questionnaire to determine the client’s level of satisfaction with the dosimeters and services, the reason for cancelling the service and any suggestions for improvement. However, results from the exit questionnaires were not available to the evaluation.\(^7\)

On average, over the period of the evaluation, the service provided by the NDS appears to have been timely and often exceeded the CNSC’s standard. The Regulatory Standard set by CNSC for dosimeter processing and reporting to the NDR is within 45 calendar days of receipt, although NDS has set an internal service standard of 10 days. As shown in Table 5, on average, over the period of the evaluation, NDS met CNSC’s Regulatory Standard 99% of the time, and met its internal service standard 92% of the time.

<table>
<thead>
<tr>
<th>DOSIMETER PROCESSING AND REPORTING</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of dosimeters processed and reported</td>
<td>519,284</td>
<td>507,846</td>
<td>548,570</td>
<td>537,220</td>
<td>539,319</td>
</tr>
<tr>
<td>Number processed and reported within 45 calendar days</td>
<td>518,065</td>
<td>502,730</td>
<td>539,286</td>
<td>537,220</td>
<td>539,313</td>
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<td>Number processed and reported within 10 business days</td>
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<td>457,067</td>
<td>487,424</td>
<td>518,046</td>
<td>473,281</td>
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<tr>
<td>Number processed and reported in greater than 45 calendar days</td>
<td>1,219</td>
<td>5,116</td>
<td>9,284</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>% of dosimeters processed and reported within 10 days of receiving client dosimeters</td>
<td>96.9%</td>
<td>90.0%</td>
<td>88.9%</td>
<td>96.4%</td>
<td>87.8%</td>
</tr>
<tr>
<td>% of dosimeters processed and reported within 45 calendar days of receiving client dosimeters</td>
<td>99.8%</td>
<td>99.0%</td>
<td>98.3%</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Sources: Health Canada, National Dosimetry Services Annual Compliance Reports and Health Canada Program correspondence.

In 2011 and 2012, the number of dosimeters processed and reported in greater than 45 calendar days is higher than in other years. This relates to issues stemming from the October 2011 discovery of a calculation error that had led to under reporting of some doses since June 2008. A total of 1,769 workers in 334 organizations were affected by the calculation error; of those, three individuals had recalculated doses that exceeded the annual regulatory dose limit for extremities of 500 mSv. However, the overexposures were only marginally higher than the limit and well below levels at which health effects would occur. As a result, there were thought to be no health consequences associated with the error (Canadian Nuclear Safety Commission, 2011). Upon

\(^6\) Results from 2 surveys were provided to the evaluation: November 2014 and March 2015. It is unclear (unstated in the results reports) how many surveys were distributed. Number of returned surveys is: Nov 2014-79, March 2015-159. Client categories include Dental, Hospital, Private Practitioner, Research, Industry and Commerce, and Other.

\(^7\) According to Program representatives, there are no results for the exit questionnaire as the analysis has not yet been completed due to a lack of critical mass of responses; however, it appears that the most common reason for ceasing NDS service is that the service is no longer required (such as closure of a business).
discovery of the calculation error, Health Canada reported the issue to CNSC immediately. CNSC viewed the incident as a significant error, which resulted in regulatory non-compliance, and was not satisfied with NDS’s initial response – the root cause analysis performed by NDS was not considered adequate, and the initial proposed corrective actions were considered too superficial. The root cause analysis and corrective action plan were revised, and Health Canada worked with CNSC to address issues identified during the investigation using an iterative process, which included corrective actions to: improve quality assurance (e.g., implementing an independent internal audit function under the Director’s office, implementing Quality Management Review meetings, conducting quality awareness sessions with staff); redesign the Routine (Blind) Performance Test Process; redesign the Change Control Process; address weaknesses in the NDS organizational structure; and implement new quality management software systems. Issues related to external IT support have meant that improved quality management software has not been installed; it has been delayed for over 2 years, pending action from Shared Services Canada. Commitments related to the corrective actions were incorporated into NDS’s license renewal in 2012 (e.g., human resources/staffing action).

Through the NDR, Health Canada maintains the dose records of individuals who are monitored for occupational exposures to ionizing radiation. The NDR database tracks an individual’s exposure over his/her career, regardless of employer. This ensures that even if an individual changes jobs, his/her total cumulative exposure is still tracked. The literature review and external key informant interviews found that registries like the NDR are viewed to be a best practice and a potential model for other countries, for example, the United States, where a comprehensive dose registry is not in place (Shrader-Frechette, 2007).

The NDR started collecting data in 1951, although it contains records back to the 1940s. Functions of the NDR include: assisting in regulatory control by notifying regulatory authorities of overexposures within their jurisdiction; evaluating dose trends and statistics to answer requests from regulators and others; contributing to health research and to the scientific knowledge on risks from occupational exposure to ionizing radiation; and, providing dose histories to individual workers and organizations. Under the Radiation Protection Regulations of the Nuclear Safety and Control Act, all dosimetry service providers licensed by the CNSC must submit dose records of all monitored workers to the NDR. As well, some provinces require that the dose records of provincially regulated workers who may be exposed to radiation are submitted to the NDR (The Saskatchewan Gazette, 2005), (Province of Alberta).

Over the period of the evaluation, the NDR provided ~6,000 Personal Dose History Summaries per year to individuals who submitted requests; 100% were provided within the service standard of 10 days of receipt of request. The NDR also provided high exposure notifications when warranted. However, there were discrepancies with the number of notifications reported over the past five years (130 versus 117 depending on the source). According to Program representatives, the discrepancy in the data provided to the evaluation was due to different parameters being used to define a ‘countable’ overexposure from the NDR database; i.e., the NDR does not currently
have documented parameters for generating reporting statistics for overexposures.\(^8\) Program data showed that 100% of those overexposures that should have been reported on were reported within the required 24 hours of dose information being received into the NDR.

Health Canada provides information to individual Canadians that contributes to protecting them from radiation by providing biological dosimetry assessments\(^9\) for people who are suspected to have experienced an overexposure (including nuclear energy workers, other individuals who work with radiation, and the general public), and for astronauts. The demand for biological dosimetry assessments varies depending on the number of suspected occupational overexposures and the level of space activity by the Canadian and European Space Agencies\(^10\). Since 2010, a total of 6 assessments have been conducted: two for individuals with suspected occupational exposure (one of these assessments was completed in 8 days while the other required 52 days\(^11\)); and, 4 for astronauts (assessment times were 69 days, 42 days, 180 days and 140 days\(^12\)). According to Program representatives and external key informants, although only a few samples per year are received, each one requires a significant amount of work to analyse, and astronaut analysis is more involved and time consuming than individual analysis. A recent review commissioned by the Program indicated that as the length of missions to the International Space Station increases, the importance of testing will increase (KellySears Consulting Group, 2015, pp. 11-12).

The Program is currently working to increase awareness of the Radiobiology Program amongst regions, to help ensure that those who require testing in cases of occupational exposure can access the service.

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\(^8\) In the Program’s performance database (IPPRS), the indicator for high exposure notifications is identified as “percentage of overexposure readings reported to Regulatory Authorities within 24 hours of dose information received into the National Dose Registry” and the target is 100%. However, the database is set up to automatically generate a high exposure notification every time a dose limit is exceeded, so they may be generated in situations where there is no value to reporting them (e.g., corrections or additions of historic data). As well, a single overexposure can put an individual over the limit for up to 5 years and so high exposure notifications will continue to be generated long after the situation that created the overexposure has been addressed. These may only be reported the first two or three times, after which NDR staff will consult with the appropriate regulatory authority and may discontinue further reporting on the same event. According to Program representatives, there is work underway to better define this performance indicator, and the issue will be fixed when the system is transitioned to HC-standard platforms and HC-standard reporting tools.

\(^9\) Biological dosimetry assessments use biological material to measure the amount of ionizing radiation received by an individual.

\(^10\) As part of the MOU with the Canadian Space Agency, Health Canada provides this service not only to Canadian astronauts but also European astronauts.

\(^11\) According to Program documents, due to exposure scenario, additional testing was required which increased analysis time.

\(^12\) According to Program documents, delays for the last two assessments were related to a lack of resources and other time pressures.
Information to protect Canadians from environmental radiation
Since 1959, Health Canada has acquired ~$11 million worth of monitoring equipment that is strategically located across Canada to support three distinct but complementary networks: the Canadian Radiological Monitoring Network (CRMN), the Fixed Point Surveillance Network (FPS) and Canada’s contribution to the International Monitoring System (IMS) of the CTBT network. These are discussed below.

The Canadian Radiological Monitoring Network (CRMN) – The CRMN includes 26 monitoring stations across Canada that measure radioactivity in various environmental media. The network was initiated in 1959 to monitor radioactivity in the environment from atmospheric nuclear weapons testing and accidents at nuclear power facilities. Current surveillance activities serve to establish background radiation levels across Canada and provide a frame of reference from which to identify and measure the intentional or accidental release of radioactivity into the environment. Since 1959, surveillance data has shown a steady decrease of artificial radioactivity levels in the environment and, regarding the 2011 nuclear power plant accident in Fukushima, data further showed that no radiation at harmful levels reached Canada (Health Canada, 2015). The CRMN samples a variety of media (e.g., air particulate; precipitation; external gamma dose; atmospheric water vapour; milk; and, drinking water) on a weekly or monthly basis; however, during a significant nuclear event the sampling frequency can be switched to daily, if necessary (Health Canada, 2015). In February 2014, Health Canada began publishing raw data from the CRMN on the Government of Canada’s Open Data Portal. Data is published on a quarterly basis and presented as monthly averages with no interpretations. According to available google analytics for the Open Data Portal (Table 6), a total of 1,235 download requests were recorded during the 2014 calendar year.

Table 6: Number of CRMN Reports Downloaded from the Government of Canada’s Open Data Portal During the 2014 Calendar Year

<table>
<thead>
<tr>
<th>CRMN Topic Area and Technical Dataset</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airborne Radioactivity</td>
<td>140</td>
<td>91</td>
<td>108</td>
<td>90</td>
<td>429</td>
</tr>
<tr>
<td>Tritium in Atmospheric Water Vapour</td>
<td>53</td>
<td>67</td>
<td>77</td>
<td>45</td>
<td>242</td>
</tr>
<tr>
<td>Thermoluminescent Dosimetry</td>
<td>36</td>
<td>63</td>
<td>67</td>
<td>24</td>
<td>190</td>
</tr>
<tr>
<td>Tritium in Drinking Water</td>
<td>49</td>
<td>22</td>
<td>55</td>
<td>20</td>
<td>146</td>
</tr>
<tr>
<td>Gross Alpha / Beta in Drinking Water</td>
<td>40</td>
<td>19</td>
<td>50</td>
<td>8</td>
<td>117</td>
</tr>
<tr>
<td>Strontium–90 in Milk</td>
<td>38</td>
<td>20</td>
<td>28</td>
<td>25</td>
<td>111</td>
</tr>
<tr>
<td>Total</td>
<td>356</td>
<td>282</td>
<td>385</td>
<td>212</td>
<td>1235</td>
</tr>
</tbody>
</table>

Source: Treasury Board of Canada Secretariat, Chief Information Officer Branch, 2015

The Fixed Point Surveillance Network (FPS) – The FPS includes 77 remotely operated monitoring stations across Canada for the measurement of radioactivity in airborne and ground deposited contaminants. The network was initiated in 2002 to expand Health Canada’s emergency response capabilities following the September 11, 2001 terrorist attacks, and to provide an early warning of any increases in radioactivity in the environment. The FPS network covers all nuclear power plants, nuclear vessel berths and major population centers in Canada; and, it is capable of providing real-time radiation measurements for day-to-day routine...
monitoring and emergency response situations (Health Canada, 2015). Since 2007, Health Canada has published raw data from the FPS on its website. Data is published on a quarterly basis and presented as monthly averages with no interpretations.

**Case Study**

In response to the nuclear accident in Fukushima, Health Canada temporarily changed its reporting schedule to a weekly basis with data presented as daily averages between May 2011 and September 2011.

According to available Google analytics for Health Canada’s FPS webpages (Table 7) that began tracking anonymous visitors from March 1, 2011 onwards, the demand for FPS data on radioactivity and public dose rates spiked in 2011 with ~57,000 views during the early stages of the nuclear emergency in Fukushima. There was also a minor spike in demand for FPS data in 2013, which Health Canada's Google Analytics team attributed to news stories about the United States Department of Health and Human Services ordering 14 million doses of potassium iodide, as well as hoax news stories on underground atomic explosions occurring in the Fukushima disaster zone on Dec 31, 2014.

**Table 7: Number of Recorded Visits to Health Canada’s FPS Network for Public Dose Data Since March 1, 2011**

| Number of visitors who searched for historic data from March 1, 2011 onwards | Number of visitors, as of March 1, 2011 |
|---|---|---|---|---|---|---|---|
| 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| 358 | 151 | 205 | 2,917 | 57,101 | 1,481 | 4,370 | 1,691 |

Source: Health Canada, Communication and Public Affairs Branch, 2015

Health Canada’s FPS network assets collect data continuously in real-time. As a result, the system has the capability to provide public dose data on a near real-time basis (hourly or daily). According to Program documents, the Canadian public has requested near real time reporting and most other G20 countries post near real-time data (Health Canada, 2015). Increasing the frequency of reporting this data to the public, therefore, remains a priority for the Program. The Program has put forth several business cases, the first in December 2013, regarding near real-time reporting, although progress is behind schedule and stalled. According to program representatives, this is related to delays associated with the SSC IT project prioritization.

Despite these challenges, the Program indicated that it is participating in a data reporting initiative through the International Atomic Energy Agency (IAEA). This initiative, known as the International Radiation Monitoring Information System (IRMIS), aims to make monitoring data from countries around the world available through a secure web interface in real-time to national authorities for routine and emergency response purposes. The system is expected to go live in early 2016.

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13 Near real-time refers to the time delay introduced, by automated data processing or network transmission, between the occurrence of an event and the use of the processed data.
The International Monitoring System (IMS) of the CTBTO – The CTBT, a multilateral treaty by which states agree to ban all nuclear explosions in all environments for military or civilian purposes, was adopted and opened for signature on September 10, 1996. Canada was one of the first countries to sign and ratify the Treaty. The success of the Treaty depends on the IMS to detect a nuclear explosion anywhere in the world, whether in the atmosphere, underground, or underwater. The IMS employs four types of monitoring to achieve this end – seismic, hydroacoustic, infrasound, and radiological. There are fifteen IMS monitoring stations across Canada, as well as a national data centre and radionuclide laboratory. Health Canada is responsible for the radionuclide laboratory and the four monitoring stations dedicated to radionuclide analysis, while the other eleven stations involving seismic, hydroacoustic and infrasound technology are managed by Natural Resources Canada. Health Canada’s IMS contribution is discussed further in Outcome 4.

Performance of Monitoring Networks
Available performance data (Table 8) shows that all three of Health Canada’s monitoring networks are prepared to collect data, and have been deemed operational the vast majority of the time during the last two years.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Q1 (%)</td>
<td>Q2 (%)</td>
</tr>
<tr>
<td>Canada’s contribution to the CTBT</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Fixed Point Surveillance Network</td>
<td>97</td>
<td>100</td>
</tr>
<tr>
<td>Canadian Radiation Monitoring Network</td>
<td>96</td>
<td>96</td>
</tr>
</tbody>
</table>

Source: Integrated Planning and Performance Reporting System

However, day-to-day operational challenges include the need to maintain the 24/7 readiness of monitoring stations, which is particularly difficult in more remote or Northern locations, and depends on the timely approval of travel and delivery of IT assets. According to program representatives, there have been ongoing challenges related to procurement of computers and other IT equipment.

Additional operational challenges have included the need to repair isolated monitoring stations (for example, those hit by lightning strikes, or impacted by exposure to salty, moist air from the ocean). Risks from monitoring equipment not being operational could include losing certification from the Technical Secretariat of the CTBTO, and losing surveillance credibility by not fulfilling international expectations.

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14 It has not entered into force due to the non-ratification of eight specific states.
To help ensure the quality of data obtained through the surveillance systems, the Radiation Surveillance Division operates a Quality Management System that complies with the requirements of ISO 9001:2008 for measuring radioactivity levels in environmental samples. Compliance with this ISO standard is regularly reviewed and validated by a third party. In addition, proficiency tests are performed “to assess the competency of the participating laboratories within the scope of their CTBT-specific activities, to identify any analytical problems, to support certification and to provide a regular forum for technology transfer in this area” (BSI Group America, 2011), (Moutou, 2014), (Dean, 2014).

Health Canada’s surveillance systems have proven effective in detecting multi-scale radionuclide events from both within and outside of Canada. Although several events are outside the time period of this evaluation, important examples include Health Canada’s detection of: the Fukushima nuclear power plant accident in Japan in 2011; the Democratic People’s Republic of Korea nuclear weapon test in 2006; radioactive excreta processed at the Chapeau Waste Treatment plant in Petawawa in 2003; and, the Acerinox scrap metal reprocessing plant accident in Spain in 1998.

There is evidence that some Canadians have had a difficult time trying to find or interpret Health Canada’s most current surveillance data, in addition to distinguishing the differences amongst its three surveillance networks. As one example, a YouTube video with ~1,600 hits asks the question “where do I find real-time monitoring, testing data for milk, water, air quality in Canada? I can't seem to find it”, and expresses disappointment with Health Canada’s communication to Canadians. Another viewer indicated that he/she was able to find the link to the data only after calling Health Canada about the issue.

**Case Study**

Health Canada’s surveillance products are made available on the Fukushima Ocean Radionuclide Monitoring (InFORM) website – a monitoring network that includes academic, government, non-governmental organizations and citizen scientists “working to acquire data, assess radiological risks to Canada’s oceans associated with the Fukushima nuclear disaster and rapidly, appropriately and effectively disseminate this information to the public” (http://fukushimainform.ca/about/).

**Research and guidelines to assess and manage the health impacts of radiation**

Health Canada has contributed to protecting Canadians from radiation by undertaking assessments of risk associated with actual or predicted levels of radiation in the environment, as well as research to support the assessment and management of radiation health risks. This includes assessing the risk associated with levels of radionuclides in the environment (for example, assessing the risk associated with the radiation levels due to the Fukushima accident using data from the RSD), and leading and participating in research projects related to the detection of radiation in the environment and improving the detection of radiation exposure in people to inform proper medical intervention. Health Canada led projects such as the ‘Identification of Biomarkers of Alpha Particle Radiation Exposure’ to identify robust and sensitive biological markers of alpha-particle radiation exposure from fingermarks, blood, and saliva for the purposes of developing tools to rapidly detect exposure to special nuclear material. Examples of projects that Health Canada contributed to as a partner are discussed in Outcome 3.
Case Study

As a result of public concern about the safety of consuming seafood from the Pacific Ocean following the nuclear accident in Fukushima, Health Canada performed analyses of the radioactive content of fish samples from Canada’s west coast, and published results in academic journals. For example, A Report on Radioactivity Measurements of Fish Samples from the West Coast of Canada (Chen, et al., 2015), and Evaluation of Radioactivity Concentrations from the Fukushima Nuclear Accident in Fish Products and Associated Risk to Fish Consumers (Chen, Evaluation of Radioactivity Concentrations from the Fukushima Nuclear Accident in Fish Products and Associated Risk to Fish Consumers, 2015). In order to improve the ability of Canadians to obtain these results, Health Canada paid open access fees to allow unrestricted online access. These two articles were ranked at the top of the journal’s ‘most read articles’ list (during December 2015) (Journal of Radiation Protection Dosimetry). In addition, in 2012, Health Canada led a scientific project to determine if radioactive contamination originating from Fukushima had affected two food species in arctic Canada: caribou and beluga whales. Results indicated that the food sources were still safe to eat.

Health Canada also developed, and contributed to the development of radiological guidance documents that help protect Canadians from radiation, and assessed situations where radiation may have an impact on the public and the environment, such as the assessment of projects under the Canadian Environmental Assessment Act, 2012 and dose assessments in the event of a nuclear emergency (KellySears, ERHSD Mandate Review: Radiation Protection Bureau: Final Report, 2015). For example, Health Canada: developed ‘Guidance for Evaluating Human Health Impacts in Environmental Assessments: Radiological Impacts’ (draft January 2015) and contributed to radiological impact analyses within eight Environmental Assessments; worked to update the ‘Canadian Guidelines for Protective Actions during a Nuclear Emergency’; and, developed the ‘Canadian Guide on Medical Management of Radiation Emergencies’ (2015) as well as online learning modules to enhance the Canadian medical community’s state of readiness to respond to nuclear exposures. In 2011, Health Canada participated, along with other members of the Federal Provincial Territorial (FPT) Radiation Protection Committee, to update the Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials (NORM)15. These guidelines set out principles and procedures for the detection, classification, handling and material management of NORM in Canada, and also include guidance for compliance with federal transportation regulations (The Canadian NORM Working Group of the Federal Provincial Territorial Radiation Protection Committee, 2011). Several external key informants commented positively about the Guidelines for NORM, including Health Canada’s knowledge and expertise in the area. One respondent indicated that the guidelines are used not only in Canada, but around the world.

Health Canada’s Total Diet Study, led by the Bureau of Chemical Safety, provides estimated levels of exposure to chemicals that Canadians in different age and sex groups accumulate through the food supply (Health Canada, 2009). The Radiation Health Assessment Division contributed to the Total Diet Study by providing assessments of radionuclides present in food. According to one external key informant, Health Canada provided good solid baseline information from their Total Diet Study.

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15 Relevant radioactive elements include uranium, thorium and potassium, and any of their radioactive decay products, such as radium and radon. These elements are present in the earth's crust and within the tissues of living beings. Although concentrations in most natural substances are low, higher concentrations may arise as the result of human activities.
Given its role in radiation health assessment, Health Canada co-chairs the FPT Radiation Protection Committee (along with co-chairs from the CNSC and a Province or Territory).

4.4.2 Outcome #2: The Program supports the Government of Canada in its preparedness and ability to respond to nuclear emergencies and threats

Evidence suggests that Health Canada is well positioned to respond to nuclear emergencies and threats. There are formalized roles and responsibilities both within and outside the federal government, and plans have been tested and improved upon to address issues identified through simulated and real emergency scenarios.

Health Canada demonstrated its ability to respond to a nuclear emergency following the nuclear power plant accident in Fukushima. The state of emergency preparedness appears to have improved following its response to and lessons learned from Fukushima. However, concerns were identified, particularly in relation to the timeliness and coordination of public communications in an emergency.

Preparedness and Response to Nuclear Emergencies

Health Canada leads the Government of Canada's preparedness activities for radiological and nuclear emergencies. Nuclear emergency preparedness includes activities done before an emergency happens to ensure readiness to respond quickly and appropriately to an event. This includes activities such as: preparing and maintaining emergency plans and procedures; designating response personnel and ensuring they are suitably equipped to carry out their duties through training, drills, and exercises; and, establishing and testing mechanisms to activate, coordinate and carry out the response actions required during an emergency (Health Canada, 2015).

The Minister of Health is responsible for preparing the Federal Nuclear Emergency Plan (FNEP), which is an annex to the overarching Federal Emergency Response Plan (FERP). The FNEP is the primary federal plan governing nuclear emergencies and it describes the federal government's preparedness and coordinated response to a nuclear emergency, including:

- the federal government's aim, authority, emergency organization and concept of operations for handling a nuclear emergency;
- the framework of federal emergency preparedness policies, the planning principles on which the FNEP is based, and the links with other relevant documents;

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16 The FNEP applies not only to emergencies involving nuclear power plants and nuclear-powered vessels, but other nuclear emergencies such as the malicious use of nuclear materials or satellite re-entry that could impact any province or territory.

17 FERP provides the governance structure to facilitate an integrated Government of Canada response and is designed to harmonize federal efforts with those of the provinces/territorial governments, nongovernmental organizations, and the private sector.
• the federal responsibilities of participating organizations that have a role to play in preparing for a nuclear emergency; and,
• provincial annexes that describe the interface between the federal and provincial emergency management organizations (Health Canada, 2014).

The roles and responsibilities for 18 federal organizations are defined in the FNEP (Health Canada, 2014). The FNEP also contains Annexes that describe the interface between the federal and provincial/territorial emergency management organizations and the planning arrangements for providing coordinated federal support to provinces/territories affected by nuclear emergencies. A unified governance framework, as well as the definition of roles and responsibilities is of importance because expertise, capabilities and responsibility for nuclear emergency response is not centralized in one federal institution, but rather spread throughout various departments and jurisdictions and, as such, coordination of these various parties is required. There are currently provincial annexes to the FNEP for Ontario, Québec, and New Brunswick as they have nuclear power stations, and for Nova Scotia and British Columbia because they have ports which are visited by nuclear-powered vessels (Health Canada, 2014). Guidelines and manuals have also been developed to assist in clarifying roles, responsibilities and processes, for example: a Director’s Manual for the Director of RPB; a Duty Officer Manual for FNEP Duty Officers; and, a Technical Assessment Group (TAG) manual for the TAG, a multi-departmental group composed of technical experts from designated FNEP federal government institutions.

Under the FNEP, Health Canada chairs two committees that assist in coordinating relevant emergency preparedness stakeholders: the Interdepartmental Radiological-Nuclear Emergency Management Coordinating Committee; and, the Federal/Provincial/Territorial Radiological-Nuclear Emergency Management Coordinating Committee (FPT Committee). Other ad-hoc committees may be established as required to address specific areas of nuclear emergency preparedness such as capacity building, exercise planning or inter-jurisdictional cooperation.

External key informants were positive about Health Canada’s approach to coordinating emergency preparedness activities. Many commented on the strength of the relationship their organization has with Health Canada, and on Health Canada’s collaborative processes. In addition, the availability of Health Canada staff, both face-to-face and through other forms of communication, was noted. The FPT Committee under the FNEP was cited as an effective means of providing support to the provinces.

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18 Indigenous Affairs and Northern Development Canada; Agriculture and Agri-Food Canada; Atomic Energy of Canada Limited; Canada Border Services Agency; Canadian Food Inspection Agency; Canadian Nuclear Safety Commission; Department of National Defence/Canadian Forces; Environment and Climate Change Canada; Fisheries and Oceans Canada; Global Affairs Canada; Human Resources and Skills Development Canada; Natural Resources Canada; Privy Council Office; Public Health Agency of Canada; Public Safety Canada/ Government Operations Centre; Royal Canadian Mounted Police; Transport Canada.
FNEP has been reviewed annually to facilitate consistency with the Federal Emergency Response Plan (FERP), as well as international obligations and standards for radiological/nuclear emergency management, which includes two international conventions from the IAEA (Convention on Early Notification of a Nuclear Accident and Convention on Assistance in Case of a Nuclear Accident or Radiological Emergency). Both conventions are intended to strengthen international cooperation to minimize radiological consequences and facilitate prompt assistance. Relevant international standards include the IAEA Safety Requirements “Preparedness and Response for a Nuclear or Radiological Emergency” (GSR Part 7, 2015), and Safety Guide “Arrangements for Preparedness for a Nuclear or Radiological Emergency” (GSG-2.1, 2007), which were developed with all IAEA member states. Annual reviews are meant to help ensure alignment with FERP; maintain operational processes consistent with departmental roles and responsibilities; and, incorporate lessons learned from exercises/emergencies. The fifth version of the FNEP, updated and approved by the Deputy Ministers’ Emergency Management Committee in 2012, included mandating a large scale, multi-jurisdictional exercise every 2-3 years.

Emergency exercises have been planned and implemented to test the effectiveness of planning efforts, to identify areas for improvement, and to ensure the FNEP remains operational, relevant and up-to-date. Planning for exercises was managed in cooperation with inter-jurisdictional committees with the objectives of: validating plans and procedures and testing performance; providing an opportunity for training in a realistic situation; and, exploring and testing new concepts and ideas for emergency arrangements19. Exercises also served as support and preparation for large public events (e.g., PanAm Games, Vancouver Olympics). The exercise program consisted of training, drills, and smaller-scale exercises leading up to a major exercise to test the coverage of all the aspects of the plan. The FNEP exercise program includes 5 types of exercises, which range in complexity from seminars/workshops to full scale simulations.

Over the period of the evaluation, six exercises of various types and sizes were carried out to validate updates to the FNEP and each included an action plan to correct weaknesses and gaps, using observations and lessons learned from participants in post-exercise examinations.

Exercises included:

- **INEX 4 (2011)**: an international table top exercise led by the OECD; Canada has participated in the INEX series since 2005.
- **RadEx (2012)**: a table top exercise designed for Global Initiative to Combat Nuclear Terrorism (GINCT).
- **Huron Challenge IV (2012)**: A large scale multi-emergency exercise, with a functional component focussed on Bruce Nuclear Generating Station in Ontario.

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19 Interdepartmental Radiological-Nuclear Emergency Management Coordinating Committee (IR-NEMCC), Federal/Provincial/Territorial Radiological-Nuclear Emergency Management Coordinating Committee (FPT-RNEMCC).
• **ValidEx TTX (2013):** a series of domestic exercises that included a table top exercise/orientation (TTX), a command post exercise (CPX) and a full scale exercise (FSX) to validate the latest FNEP; it also helped to inform the TAG manual/other FNEP operating procedures.

• **Cool Breeze (2013):** a table top exercise focussed on the FNEP escalation process mainly in relation to the Darlington Nuclear Generating Station in Ontario.

• **Exercise Unified Response (2014):** a full scale exercise designed to test the Government of Canada’s capacity to respond to a Category A emergency.

• **Exercise Intrepid (2015):** a full scale exercise hosted by Province of New Brunswick, that included a test of the coordination between the federal and provincial technical assessment groups.

Following each exercise, an examination of lessons learned was conducted. Lessons learned are collected through hot and cold washes\(^{21}\), surveys, interviews and document reviews. These are then compiled into After Action Reports. For example, for exercise Cool Breeze, all participants were involved in a hot wash and completed interdepartmental and TAG specific surveys. FNEP TAG players were invited to do a specific follow up survey. In addition, 6 FNEP TAG functional groups were externally evaluated using the FNEP TAG Manual and there were 5 core issues assessing tasking process/situational awareness/info exchange. All materials produced during the duration of the exercise (e.g., reports, maps, emails, and other items produced during FNEP TAG members/groups) were also reviewed, and self-evaluations were conducted with functional groups.

Both internal and external key informants commented on the importance of exercises to improve emergency preparedness, not only as a means to validate and improve plans, but also as a training opportunity for staff. One interviewee noted that collaboration on emergency exercises leads to improvements: “We have collaborated for the last and previous emergency exercises and each time it gets better.” Health Canada’s emergency preparedness is considered, by both internal and external interviewees, to have improved as a result of the experience gained through emergency exercises. For example, Exercise Unified Response, in May 2014, was noted to have contributed to a strengthened emergency response capability. In addition, both the Federal Interdepartmental After Action Report (Health Canada, 2015) and the After Action Report published by Ontario Power Generation (Ontario Power Generation) indicated that Exercise Unified Response had been a successful demonstration of preparedness for such a nuclear emergency. According to Program representatives, as a result of this exercise, actions were taken to develop better dose assessment tools and decision support tools, to improve monitoring and surveillance, and to implement ongoing maintenance of a roster of specialized personnel who can

\(^{20}\) Category A includes all major nuclear emergencies occurring at nuclear power plants in Canada that could or have led to off-site radiological consequences and could require the implementation of emergency plans by affected utilities, municipalities/regions and provinces (Health Canada, 2014).

\(^{21}\) A hot wash is a debrief conversation that occurs immediate after an exercise ends; a cold wash is a debrief conversation that occurs sometime after the end of the exercise to allow participants to reflect and collect thoughts/ideas/observations.
be called upon for emergency response capacity. Other areas for improvement identified through exercises included the need to: further clarify the roles of federal institutions, provide greater details on when particular plans get activated, and ensure public communications in an emergency are rapid and coordinated. It is unclear whether all of these areas have been addressed.

Case Study

Health Canada had an opportunity to demonstrate and test its ability to respond to a real emergency during the Fukushima nuclear accident. During this event, Health Canada led a multi-departmental TAG, in support of the broader federal response coordinated through Global Affairs Canada and Public Safety Canada, that assessed potential impacts in Japan and Canada, monitored the environment for radiation threats, provided data interpretations and health protection recommendations for decision makers, promoted federal coordination, and prepared content for communications (e.g., Joint Technical Assessments, for official use only, were prepared on trends in dose readings, food safety, and water safety with input from CNSC and Environment and Climate Change Canada) (Health Canada, 2011), (Health Canada, 2011). In addition, Health Canada provided emergency dosimeters to Japan, temporarily increased the data publishing frequency of all its monitoring networks over a 5 month period, and conducted research and performed impact assessments on the health effects of radionuclides in the environment (e.g., Fukushima’s impact on artic food species).

There were a number of issues across the broader departmental and federal response identified as a result of the Fukushima experience. Post-Fukushima analyses identified weaknesses, including: the FNEP was out of date so there was confusion over which federal emergency plans were being used, and the FNEP Technical Assessment Group was poorly integrated within the federal response structure; there was a lack of clarity on the roles of federal institutions within the FNEP; there were problems in ensuring rapid, coordinated public communications; there was a need to strengthen governance for nuclear emergency preparedness, and create a sustainable and ongoing nuclear exercise culture to maintain a high level of readiness; and, there was a need to improve communications internally, as well as with provinces and other partners (Health Canada, 2013), (Health Portfolio, 2011).

Fukushima was an international event with domestic implications, and thus highlighted communication complexities (e.g., among Public Safety Canada, the Department of Foreign Affairs and International Trade, CNSC, Health Canada and the provinces) (Health Canada, 2011), (Health Canada, 2011). Health Canada did attempt to address public fears, for example, by enhancing its website with guidance on potassium iodide pills (Health Canada, 2012) and temporarily increasing the frequency (from quarterly to daily and later to weekly) of its raw data summary reports from environmental radiation detection equipment (Health Canada, 2014). Additionally, Health Canada’s Senior Medical Advisor appeared on CBC to discuss Health Canada’s response and address questions about citizen demand for potassium iodide pills (Thibedeau, 2011), (Gully, 2011). However, issues around public communication were of particular concern to key informants. Both internal and external key informants indicated that Health Canada’s communications to the public during Fukushima were not timely or adequate, and that CNSC responded to fill the void. An external advisory committee report on the Fukushima response that was prepared for the CNSC concluded that there was no official federal government ‘voice’ to provide updates to the public (External Advisory Committee to the Canadian Nuclear Safety Commission, 2012).

Lessons learned from the Fukushima experience allowed for changes to Health Canada’s emergency preparedness. While the FNEP update process was initiated prior to the Fukushima accident, the Program updated the FNEP to address identified issues, and these are reflected in the 2012 version of the Plan. Changes included better alignment of the FNEP with the FERP, undertaking more frequent exercises, undertaking detailed reviews of emergency preparedness and response arrangements, and increasing focus on capacity to respond to severe accident scenarios (Health Canada, 2013). The increased number of simulated exercises gave more opportunities to validate the updated emergency response plans and procedures, and to strengthen relationships between multi-jurisdictional partners at the federal, provincial and municipal level (Health Canada, 2013), (KellySears, 2015). Health Canada’s emergency response capabilities are considered, by internal and external key informants, to have improved significantly as a result of the Fukushima experience, although concerns around public communication remain.
Several respondents suggested that Health Canada re-examine its role in the recovery phase of emergency management. Internal operational plans also articulate a need to re-examine the recovery element. According to the current FNEP, once the situation is under control and the emergency response phase is completed, a specific Minister of the Crown may be assigned to take over this phase for the federal level. The latest FNEP articulates that responsibility for recovery is largely within provincial/territory jurisdiction and the decision to transition to recovery will be taken by these authorities in case of an emergency occurring in or near Canada, and by federal-level authorities in the event of a far-field emergency.

Outside of issues with the recovery phase, IT issues were identified as a significant challenge to the effectiveness of emergency preparedness. There have been significant delays in procuring IT equipment that supports RPBs internal IT science networks. Several pieces of hardware and software are aging and in need of replacement or are outside warranty periods. In some cases, approvals for critical acquisitions have been pending for more than two years.

**Emergency Dosimetry**

As part of the FNEP, Health Canada is responsible for providing emergency dosimetry services in the event of a nuclear emergency. According to the Program, the commercial dosimetry operations cross-subsidise and provide the basis for emergency dosimetry services, while also maintaining the technical proficiency of staff.

In 2012, Health Canada took steps to improve emergency preparedness and response capacity by creating an emergency dosimetry kit of 5,000 pre-assembled InLight dosimeters that could be readied to be sent to the site of an emergency, should one occur (Health Canada, 2013). Pre-deployed emergency dosimetry kits, which contain InLight dosimeters, a portable reader, and electronic dosimeters are maintained at regional offices across Canada (Health Canada, 2013). Five kits are pre-positioned in the regions (Edmonton, Winnipeg, Toronto, Montréal, and Halifax) and Vancouver has confirmed that it will accommodate a kit in 2016-17.

In addition, NDS has participated in emergency preparedness exercises (including Connaught Ranges drill/exercise, Exercise Cool Breeze, and Exercise Unified Response) to test the readiness and identify potential improvements for dosimetry. For example, the 2014 ‘After Action report’ for Exercise Unified Response recommended that Health Canada should review options for integrating dosimetry service expertise into the FNEP Technical Assessment Group Human Monitoring Group (Ontario Power Generation, 2013). The Program is reportedly working to address such recommendations, although according to Program representatives, involvement of multiple partners is necessary to address recommendations so it is often a multi-year process and given limited resources, items must be prioritized.

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22 The recovery phase is the period where activities return to normal functions.
For individuals that are suspected of being exposed to high levels of radiation, the currently accepted method of biological dosimetry (dicentric chromosome assay), is a very in depth analysis that requires an extended period of time to process. For a nuclear emergency where large numbers of people might be exposed to radiation, a quicker method is desirable. Health Canada has led the development of the Quickscan method which creates efficiencies through the rapid scoring approach and produces dose estimates at a rate of up to six times faster than the conventional method. In addition, Health Canada leads the National Biological Dosimetry Response Plan (NBDRP)\(^{23}\), which is a national network of laboratories that can respond to a nuclear event for the purposes of rapid radiation dose estimation for crisis management and for long-term health risk assessment. In the event of a large-scale nuclear emergency, the NBDRP would help guide the actions of emergency officials, emergency responders and health care personnel by providing timely biological dose estimates (Dolling & Boreham, 2007). The Program’s annual testing of the NBDRP, which includes the participation of partnering labs and international inter-comparison activities, has contributed greater preparedness in responding to mass casualty events by informing the method of analysis to be used should a mass casualty radiation event occur. Since 2010, Health Canada has conducted 4 annual tests of the NBDRP. A recent journal article, which included authors from Health Canada, concluded that such annual intercomparisons are necessary to maintain a network of laboratories for emergency response biodosimetry. It found that individual laboratories performed comparably from year to year with only slight fluctuations in performance, and that the QuickScan method was proven to reduce the time of analysis without having a significant effect on the dose estimates (Wilkins, et al., 2015). The Program is currently working to increase awareness of Health Canada’s emergency radiobiology capabilities among regions, to help ensure that those who require testing in cases of mass casualty events can access the service. These capabilities are also registered as an international emergency response asset within the IAEA’s Response and Assistance Network (RANET) under the Convention on Assistance in Case of a Nuclear Accident or Radiological Emergency.

**Technical Resources and Tools**
The Program has developed or contributed to the development of several technical resources and methods to support the overall work regarding emergency preparedness and response. Examples include:

- To enhance the preparedness of medical first receivers and response personnel that may be required to treat casualties from a radiological/nuclear event, Health Canada delivers the Medical Emergency Treatment for Exposures to Radiation (METER) training and is developing a web-based version (MED-PREP). The radiobiology program contributed expertise to the development and delivery of the METER Radiobiology lecture and assisted with the development of the web-based training.

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\(^{23}\) The NBDRP is integrated into other Canadian emergency response initiatives such as the FNEP.
• The Canadian Guidelines for Protective Actions during a Nuclear Emergency are under development, in consultation with provinces and other federal departments, and will replace two existing guides: the Canadian Guidelines for Intervention during a Nuclear Emergency (2003) and the Canadian Guidelines for the Restriction of Radioactively Contaminated Food and Water Following a Nuclear Emergency (2000).

• Led by staff from Health Canada, the Department of National Defence and the Canadian Forces, with contributions from federal and provincial authorities and national and international reviewers, the Canadian Guide on Medical Management of Radiation Emergencies provides a common framework from which hospitals, public health authorities and emergency management organizations can base their response plans.

• Method detection examples include identifying biomarkers to detect alpha particle radiation exposure, or testing remote controlled technology, such as Compact Optically-Stimulated Luminescence Area Monitors (COSLAM) for use in applications where sensitive and unobtrusive radiation detection is needed.

• Methods to manage radiation exposure include partnering with Atomic Energy of Canada Limited (AECL) to identify Medical Countermeasures for Radioactive Materials, leading efforts to enhance the Canadian medical community’s state of readiness in a radiological/nuclear emergency (RN-MED-PREP), and offering a Federal Radiological Assessment Team workshop.

4.4.3 Outcome #3: The Program supports other national partners and stakeholders

Overall, the Program appears to be effective in terms of supporting partners and stakeholders nationally through the provision of data, research, technical advice, and services related to radiation protection. Key informants were generally positive about Health Canada’s contributions. However, annual reports on Occupational Radiation Exposure in Canada, and Health Canada research publications based on NDR data have not been produced since 2008 and 2001 respectively, due to issues with IT, staff complements and gaps in data. Issues around limited accessibility of data were raised by data users (e.g., provinces, OGDs).

Health Canada has contributed expertise, in the form of data, research and technical advice, to national partners and stakeholders both within and outside the federal government, for example: departments (e.g., Environment and Climate Change Canada; Natural Resources Canada; Global Affairs Canada; CNSC); networks and committees (e.g., National Biological Dosimetry Network; FPT Radiation Protection Committee); academia; and, other organizations (e.g., Ontario Power Generation).
Case Study

Examples of support to national partners related to the nuclear accident in Fukushima include:

- In 2011, the Program supported Global Affairs Canada (formerly DFAIT) in managing the international response to protect Canadians in Japan by coordinating federal technical input, providing daily situational reports, formulating recommendations for protective actions, and providing monitoring assets for Canadian embassy staff.
- In 2011, the Program deployed an additional 9 mobile radiation detection monitors along the Pacific coastline to enhance its surveillance capacities in British Columbia.
- In 2011, and again in 2012, the Program supported the Canadian Food Inspection Agency’s strategy to monitor the radiation levels of imported food from Japan, as well as domestic milk and fish off the coast of British Columbia. More than 200 food samples were tested by the Program.
- In 2011, the Program supported Emergency Management British Columbia by deploying a field team to Spring Island, British Columbia, which performed a radiological assessment of tsunami debris from Japan. Field and laboratory assessments performed on ocean debris and the adjacent shoreline showed that there was no detectable trace of radiation.
- Health Canada participates in the Integrated Fukushima Ocean Radionuclide Monitoring (InFORM) Network led by the University of Victoria, providing research and advice on health impacts. InFORM is funded by the Marine Environmental Observation Prediction and Response Network, which is hosted at Dalhousie University, and funded by the Government of Canada’s Networks of Centres of Excellence Program.
- Health Canada supported the Canadian Border Service Agency by measuring samples and materials they collected at the border. The laboratories determined whether these materials contained contaminants from the Fukushima accident. Health Canada further assisted by comparing results against established guidelines and advising on any health risks to Canadians (Health Canada, 2015).

Data

Data from the NDR on occupational exposures to radiation has supported the work of partners including researchers and the CNSC. The CNSC uses NDR data to verify and validate records provided by licensees. External key informants were positive about the usefulness of NDR data for this purpose. In addition, NDR data has been widely used to support the work of researchers. However, publications by external researchers have not used NDR data more recent than from 2008, the final year that Health Canada produced the ‘Annual Report on Occupational Radiation Exposure in Canada’. The purpose of the Annual Report was to provide statistics on occupational radiation exposures of monitored workers in Canada. These statistics were intended to assist regulatory authorities, organizations, and Canadians in comparing incurred occupational radiation exposures with national or provincial/territorial averages, as well as trends in similar occupations. Annual Reports for 2006, 2007 and 2008 are listed on the Health Canada website, although the links are not active. According to Program representatives, these reports have not been produced since 2008 as a result of: changes in federal government IT operations and privacy requirements; loss of personnel with epidemiological expertise; and questions about the NDR dataset set including missing records and duplicate records. Program representatives indicated that the NDR is currently undertaking staffing action, and that there is a renewed emphasis on the NDR dataset. Measures are being taken to improve and ensure the quality of the dataset, and the NDR is working with Atomic Energy of Canada Limited and Canadian Nuclear Laboratories to locate and integrate records from before 1956 in order to fill in the missing data.

24 Several research publications by external authors describe issues with the NDR data set (Ashmore, Gentner, & Osborne, 2010), (Zablotska, Lane, & Thompson, 2014). According to Program representatives, there were also concerns within RPB about the reproducibility of some of the analyses that were required for internal studies.
In addition, work is reportedly underway to correct known problems with the dataset (e.g., duplicate records) and to validate records, input/extraction/replacement routines, and methods for analysis.

In spite of the issues above, external data users were generally positive about NDR data quality and usefulness but believed access could be improved, for example, by reinstating direct access to data and through automation of the process for obtaining data. In the past, other government offices had direct access to the database but issues with IT and privacy requirements led to this access being removed. Some external key informants raised issues about the lack of direct access and its impact on their work (e.g., limiting their ability to undertake exploratory analyses). In terms of obtaining data from the NDR, the current process requires a request to be faxed or mailed to the NDR. This is seen by both internal and external key informants as an area that should be automated to improve the accessibility of the data.

Health Canada also produces data on levels of ionizing radiation in the environment using three distinct but complementary monitoring networks. Health Canada shares the monitoring data from these networks with national partners and is also able to access data from networks maintained by other national partners, for example, Environment and Climate Change Canada and Natural Resources Canada. Through its CTBT involvement, the Program is also able to access monitoring data from the CTBT International Monitoring System. The Program uses data from its own monitoring stations, and from information gathered through other complementary monitoring networks. In 2014, stakeholders like Ontario Power Generation began using the noble gas results generated by Health Canada to calculate the annual public dose, and the data used is further applied in Ontario Power Generation’s annual reports that are communicated at public events. Overall, Health Canada’s environmental monitoring data appears to have been adequate to meet the information needs of Health Canada and its partners, however, finite financial resources have required the Program to apply risk management principles to strategically address gaps in coverage for the entirety of Canada’s land area, which although large has a very low population density. For comparison, Canada uses 107 monitoring stations to cover ~10 million square kilometers of land area and a population density of 4, Germany uses ~1,800 monitoring stations to cover ~350 thousand square kilometres and a population density of 232, and the United States uses ~138 monitoring stations to cover ~9.5 million square kilometers and a population density of 35. International key informants noted that Canada’s CTBT and monitoring station strategies and technologies, while different from their own, are appropriate for the geographic and population density factors of the Canadian context. Nationally, one external key informant noted that they use the same instrumentation as Health Canada, so confer with Health Canada in regards to instruments, quality management programs, and harmonization on methodology.

Research, Technical Advice and Services
In addition to providing data, Health Canada undertakes research on a wide variety of issues related to radiation protection, which can be used by partners and stakeholders. Results have been shared directly with partners, by publishing in peer-reviewed journals (e.g., Radiation Protection Dosimetry; Journal of Radioanalytical and Nuclear Chemistry; Health Physics; Radiation Research; Nuclear Instrumentation and Methods; and, Analytical Chemistry), and by presenting results to external stakeholders at conferences and committees (e.g., the FPT
Health Canada has also contributed to research studies and other projects led by partners. Some examples of projects include: Evaluation of the annual Canadian biodosimetry network intercomparisons; assessments of radiological impacts to support environmental assessments; and, a tool for ‘Early Triage for Radiological and Nuclear Events’. Additional examples are provided in Appendix 3.

Although the NDR website lists 13 research publications produced by Health Canada, the dates of the publications range from 1983 to 2001. Program representatives indicated that the reasons for the lack of publications over the last 14 years are the same as those related to the production of the ‘Annual Report on Occupational Radiation Exposure in Canada’.

Case Study

Health Canada staff published technical articles on various methods and means to monitor radiation and many of the articles have applied surveillance experience from the nuclear emergency in Fukushima. Examples include:
- Discrimination of Nuclear Explosions against Civilian Sources Based on Atmospheric Xenon Isotopic Activity Ratios.
- Source term estimation of radioxenon released from the Fukushima nuclear reactors using measured air concentrations and atmospheric transport modeling.
- Testing of an automatic outdoor gamma ambient dose-rate surveillance system in Tokyo and its calibration using measured deposition after the Fukushima nuclear accident.
- Fukushima event reconstruction using modelling and isotope relationships.
- Development of a new aerosol monitoring system and its application in Fukushima nuclear accident related aerosol radioactivity measurement at the CTBT radionuclide station in Sidney of Canada.

Health Canada also supported national partners through terms defined in agreements or MOUs with a variety of national organizations. For example, there is an MOU with the Canadian Space Agency for biological dosimetry assessments of Canadian and European astronauts; and an MOU with Environment and Climate Change Canada that describes the arrangements for providing sample collection services, atmospheric modeling and support services to Health Canada to meet the Parties' responsibilities under the CTBT and the FNEP. A more detailed list of the various program MOUs is provided in Appendix 4.

External key informants were generally positive about Health Canada’s support to partners and stakeholders, and expressed satisfaction with the data, scientific expertise and services that the Program provides to national partners. Several external key informants commented on the value of Health Canada’s contribution to the measurement and characterization of radiation and its impacts on human health, and indicated that they rely on the scientific and technical expertise of the scientists in RPB. One external interviewee noted that Health Canada is effective at keeping national partners apprised of the international radiation protection scene, and at sharing national comments in international fora. A few interviewees noted that the MOUs in place have strengthened the complementarity and effectiveness of data collection, analysis, sharing and use. One external key informant noted that even though they do not have a formal agreement in place with Health Canada, “unofficially we understand that we are there to help each other”.

However, a few internal and external interviewees noted that the Program could be better positioned to further support the radiation protection activities of partners, for example, by streamlining internal government processes.
4.4.4 Outcome #4: The Program supports international radiation protection efforts

The Program is an active participant in a variety of international agreements and committees, and has supported a range of radiation protection and nuclear security efforts on the international stage, including nuclear non-proliferation efforts. External key informants were positive about Health Canada’s contributions internationally.

The Program has undertaken a wide range of activities that have supported international radiation protection efforts, for example, through provision of scientific expertise and technical data. In addition, Health Canada is a signatory to conventions and agreements related to international radiation protection.

Health Canada has supported international nuclear non-proliferation efforts through its contributions to the IMS, an element of the Verification Regime overseen by the CTBTO. The CTBT seeks a universal ban on all nuclear detonation as an effective means to stop further development of nuclear weapons. As discussed earlier, Health Canada’s contribution includes a radionuclide laboratory and four monitoring stations dedicated to radionuclide analysis. Health Canada’s monitoring stations, along with monitoring stations around the world, register data that is transmitted to the international data centre in Vienna for processing and analysis. The data are sent to countries that have signed the Treaty. Although outside the timeframe of the evaluation, it is worth noting that in 2006 Health Canada’s CTBT monitoring station located in Yellowknife was the first monitor in the world to positively detect and confirm that North Korea had contravened the CTBT by performing an underground nuclear test under clandestine conditions.

**Case Study**

Examples of support to international partners related to the nuclear accident in Fukushima include:

- The plume from Japan was monitored as it progressed around the world using both CTBT and national network systems, which provided a greater understanding of the emergency situation and an ability to be less conservative about the worst case scenario when providing advice (Health Canada, 2011).
- The Program provided monitoring data to the International Atomic Energy Agency in its role as the global focal point for nuclear emergency preparedness and response.
- Program personnel worked with international officials to publish technical articles in scientific journals on the topic of radiation surveillance methods. One example from the Journal of Environmental Radioactivity includes, “Source term estimation of radioxenon released from the Fukushima Dai-ichi nuclear reactors using measured air concentrations and atmospheric transport modeling” (Eslinger, et al., 2014).
- By request, Health Canada sent the Japanese government 75 personal dosimeters to support their emergency response.
- As part of the Fukushima follow-up assessment, program personnel participated in the IAEA Comprehensive Fukushima assessment working group on the emergency response (International Atomic Energy Agency) and contributed to the Fukushima assessment report produced by UNSCEAR.

Canada’s contributions to Japan related to Fukushima were formally recognized by the Government of Japan.
Health Canada is also a signatory to two IAEA conventions, has commitments under other international agreements, and maintains MOUs with foreign governments to support radiation-related scientific cooperation, emergency preparedness, and environmental monitoring. Examples are noted below.

The Convention on Early Notification of a Nuclear Accident is an IAEA convention that establishes a notification system for nuclear accidents which have the potential for international transboundary release that could be of radiological safety significance for another state. It requires states to report the accident's time, location, radiation releases, and other data essential for assessing the situation (International Atomic Energy Agency, 1986). Also, the Convention on Assistance in Case of a Nuclear Accident or Radiological Emergency sets out an international framework for co-operation among parties and with the IAEA to facilitate prompt assistance and support in the event of nuclear accidents or radiological emergencies. It requires states to notify the IAEA of their available experts, equipment, and other materials for providing assistance (International Atomic Energy Agency, 1987).

The International Health Regulations (IHR) are a legally binding framework for all World Health Organization (WHO) member states for notification and verification of events of public health concern, risk assessment and rendering assistance as well as for building the capacity of member states to be prepared for public health emergencies regardless of their origin, including chemical and radionuclear events. The establishment of an international biodosimetry network is a part of the WHO’s IHR implementation plan (William F. Blakely, 2009).

The following two arrangements illustrate the nature of scope of international agreements under this Program:

- MOU with the Radiation and Nuclear Safety Authority, Finland to formally establish scientific cooperation and inter-institutional relationships; collaborate on research and development in the field of environmental monitoring and emergency preparedness; cooperate in development of common data structures to enhance and facilitate the exchange of environmental monitoring data; co-operate in technical developments to enhance capabilities for CTBT verification including National Data Centre operation and laboratory analyses; and, generally broaden the scientific experience of both Parties.
- MOU with the Department of Energy of the United States of America regarding nuclear and radiological emergency management and incident response capabilities, to provide a framework for cooperation to enhance radiological and nuclear security for major public events and minimize the actual or potential radiological consequences to health, environment and property of an incident involving nuclear or radiological materials worldwide.

Health Canada has supported international radiation protection efforts by providing scientific expertise and technical data to various international partners, committees and working groups. Various examples are provided in Appendix 5.

In addition, the Health Canada biodosimetry service is registered as an asset to International Atomic Energy Agency Response and Assistance Network to provide assistance in the case of a nuclear or radiological incident where biodosimetry is required and the affected country does not
have enough or any biodosimetry capacity of their own (International Atomic Energy Agency, 2013). This supports the practical implementation of the International Atomic Energy Agency's "Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency".

In terms of nuclear preparedness and response, under the FNEP, Health Canada has the authority to initiate arrangements in support of not only federal, provincial or territorial partners, but also with international organizations. In the event of a nuclear emergency occurring abroad, elements of the FNEP may be implemented in support of the emergency response coordinated by Global Affairs Canada for the protection of Canadians and Canadian interests abroad, the management of Canada's diplomatic and consular relations, and the conduct of bilateral and multilateral relations.

External key informants were very positive about Health Canada’s international contributions, citing specific Health Canada staff as experts in their respective fields.

4.5 Performance: Issue #5 – Demonstration of Economy and Efficiency

Spending generally aligns to plans, with the majority of spending directed to dosimetry, emergency preparedness and surveillance activities. The operating and salary costs of providing dosimetry services are largely cost recovered; however, the Program does not recover all its costs when previous long term Program investments are taken into account. Looking to the future, Program representatives are concerned that sun-setting of some funding sources may affect emergency preparedness.

The Program has introduced efficiencies through leveraging the use of monitoring equipment and data, and through operational measures, although some opportunities to improve efficiency have been hampered by IT and staffing issues. Opportunities for improvement related to governance, human resources planning, and performance measurement were identified, for example, greater integration across divisions, enhancing staff complements and improving the articulation and measurement of outcomes.

The Treasury Board of Canada’s Policy on Evaluation (2009) and guidance document, Assessing Program Resource Utilization When Evaluating Federal Programs (2013), defines the demonstration of economy and efficiency as an assessment of resource utilization in relation to the production of outputs and progress toward expected outcomes. This assessment is based on the assumption that departments have standardized performance measurement systems and that financial systems link information about Program costs to specific inputs, activities, outputs and expected results. Since the approach to financial tracking and reporting is not done this way for radiation protection activities, the evaluation provided observations on economy and efficiency based on findings from the literature and document reviews, key informant interviews and available financial data. In addition, the findings below provide observations on the current approach to governance, and the adequacy and use of performance measurement information to support economical and efficient Program delivery and evaluation.
Observations on Efficiency and Economy

Expenditures
As shown in Table 9, overall spending averages approximately $15M annually, and has remained fairly stable over the five-year evaluation period. There was an overall 3% increase when comparing 2010-2011 to 2014-2015. The National Dosimetry Services Division is the largest expenditure area (34% of total expenditures) followed by the Nuclear Emergency Preparedness and Response Division (26%); the Radiation Surveillance Division (20%); the Radiation Health Assessment Division, including the National Dose Registry (15%); and, the Radiobiology Division (5%).

While the NDS has been cost neutral for the last 3 years due to cost recovery, revenues in earlier years covered only 55% to 82% of operating costs; the cumulative net loss since 2007-2008 was estimated at $11.4M (Health Canada, 2015). This was due mainly to significant Program investments over the past 8 years ($12.5M), largely to acquire operational equipment to replace aging dosimetry systems. Overall, the environmental scan of dosimetry providers from other countries indicates that the fees charged by the NDS appear lower than some other commercial providers found in the United States, and other government providers found in Australia and Great Britain.

Table 9: Variance between Planned Spending vs. Expenditures 2011-2012 and 2014-2015 ($M)

<table>
<thead>
<tr>
<th>Year</th>
<th>Planned Spending ($ millions)</th>
<th>Expenditures ($ millions)</th>
<th>Variance ($ millions)</th>
<th>% planned budget spent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Salary27</td>
<td>O&amp;M</td>
<td>Capital</td>
<td>TOTAL*</td>
</tr>
<tr>
<td>2010-2011</td>
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<td>$4.94</td>
<td>$0</td>
<td>$15.81</td>
</tr>
<tr>
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<td>2012-2013</td>
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<td>$14.65</td>
</tr>
<tr>
<td>2013-2014</td>
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</tr>
<tr>
<td>2014-2015</td>
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<td>$3.51</td>
<td>$0.03</td>
<td>$15.66</td>
</tr>
<tr>
<td>Total</td>
<td>$56.55</td>
<td>$17.85</td>
<td>$0.86</td>
<td>$75.24</td>
</tr>
</tbody>
</table>

Data Source: Financial data provided by Office of Chief Financial Officer, BSFO reviewed
* Numbers may not add to total due to rounding.

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25 Expenditures include those related to G8/G20 summits in 2010 and PanAm Games in 2015.
26 O&M costs provided do not include the purchase of dosimeters under a contract with Landauer (estimated at ~$2.7M O&M in 2010-2011) (Institute on Governance, 2013). Revenue/cost recovery figures for NDS are included in these figures but are not specifically noted.
27 This includes Salary and Employee Benefit Plans.
Over the five-year period of the evaluation, the overall variance in expenditures was minor, amounting to less than 1%. In terms of annual variances, the highest underspending was 2010-2011 (5%) and the highest overspending was 2013-2014 (4%), due to increased costs for emergency management previously reported under the Specialized Health Services Program (Health Canada). Overall, financial data indicated that a total of three divisions overspent, but all by less than 5% over 5 years: Radiation Surveillance Division, Radiation Health Assessment Division, and Radiobiology Division.

The variations in expenditures and their impact have been outlined in the Program’s operational plans. These documents indicated that: unplanned events (e.g., emergencies\(^{28}\), protracted delays in IT approvals) impact the overall ability to deliver planned programming; the cost of doing business is increasing operational costs; and, declining Public Security and Anti-Terrorism Initiative (PSAT) funding is impacting the area of emergency preparedness.

Operational plans also indicated human resource shortfalls in the emergency preparedness area. While there were periodic influxes of funding from one-time events over the period of the evaluation (e.g., PanAm Games, G8/G20, Vancouver Olympics\(^{29}\)), these are ending going forward. Internal studies have indicated that RPB does not have sufficient resources to fully meet emergency planning requirements, especially after the PSAT permanent funding reduction. Program representatives indicated that permanent reductions to ongoing funding from PSAT could impact Health Canada’s emergency preparedness planning, and suggested that the rising costs of running the Program also make it more difficult when taken together with static levels of funding. In addition, funds needed to run surveillance operations in the North and across Canada (e.g., higher costs for electricity to run monitoring stations, increasing travel costs), which support routine monitoring, CTBT activities, health assessment and emergency response, are an additional pressure on the organization.

**Efficiency Measures**

Health Canada has utilized several measures to enhance efficiency, including leveraging processes, systems and/or equipment of other agencies, and reducing duplication. For example, RSD uses data collected by others (such as Ontario Power Generation) to contribute to the Fixed Point Surveillance Network; the Radiobiology Division uses the QuickScan scoring method for emergencies and surge capacities to produces dose estimates at a rate up to six times faster than conventional method; and, NEPRD works closely with the Centre for Emergency Preparedness and Response (Public Health Agency of Canada) to more efficiently plan and organise emergency exercises. A more detailed list of examples is provided in Appendix 6.

\(^{28}\) According to Program representatives, as the Program is responsible for emergency preparedness and response, emergencies may impact the ability to deliver previously-planned programming, but the emergency response itself is a core deliverable of the program. If an emergency occurs, then the program adjusts its routine operations to ensure that it can deliver its core emergency response operations.

\(^{29}\) No specific funds were allocated to the program as part of the Vancouver Olympics, although funds were eventually received through re-allocations.
It appears that efficiency overall has been impeded by two primary issues: IT and staffing challenges. Internal Program representatives have indicated that the lack of authority within Health Canada for IT acquisitions, and cumbersome approval processes, have resulted in significant delays in maintaining hardware that supports RPB’s internal IT science networks. Several pieces of hardware and software are old and need to be replaced or are outside warranty periods. In addition, automation of several processes (NDR data requests and incoming files, NDS retrieval of customer service and client information, and RSD surveillance activities) could improve efficiency and accuracy but, according to Program representatives, the transition to Shared Services Canada has impeded the implementation of IT improvements/upgrades.

In terms of staffing challenges, both internal and external key informants raised concerns about human resource issues related to various Program areas. Key comments related to vulnerability in providing services as expertise is only “one deep”; challenges in meeting requirements due to a number of unfilled positions in the organizational structure; and, lack of epidemiologists to ensure appropriate capacity. Overall, numerous stakeholders commented on the need for succession planning strategies to maintain a sustainable Program capacity.

In addition to the above, a program representative indicated that there are further efficiency challenges associated with the Program being split across two operating locations.

**Observations on Program Governance and Performance Measurement**

**Governance**

In terms of governance, the grouping of radiation protection activities considered under this evaluation does not have an overarching governance structure to facilitate relations across RPB and CCRPB. There are, however, internal structures (e.g., Director level committee and the integrated operational planning process) that facilitate interaction between divisions.

There are a number of committees that integrate radiation protection activities with other agencies. For example, one external interviewee cited a federal ‘task group’ as an example of using pre-existing structure that RPB uses effectively. Another example is the active involvement in and leadership of the DG’s Event Response Committee, co-chaired by Public Safety, where RPB is seen by external interviewees as using its position on the committee to ensure that other government departments are aware of nuclear emergency and preparedness issues and their required the level of commitment. Also, the FPT Radiation Protection Committee was cited by interviewees in the radiation-nuclear field as a strong governance structure. This group consists of all of Canada’s radiation protection regulators, including Health Canada, CNSC, DND and all the relevant provincial partners. It provides an opportunity to harmonize the national approach to radiation protection, update all the members, share best practices, and have discussions on emerging issues. Additionally, according to Program representatives, the FPT Radiological-Nuclear Emergency Management Coordinating Committee and the Interdepartmental Radiological-Nuclear Emergency Management Coordinating Committee, which includes the federal and provincial FNEP partners, provide a strong governance structure for NEPRD.
Although the current approach to governance generally appears to be adequate, some internal interviewees noted that greater integration between the Program’s divisions would be beneficial, in particular for identifying research priorities and to take advantage of opportunities for synergies between some field operations.

**Performance Measurement**

There is no logic model or performance measurement strategy for radiation protection activities as a whole; however, draft logic models for divisions do exist (e.g., NDS, NEPRD, RSD, RHAD). The Program uses an Integrated Planning and Performance Reporting System (IPPRS) to develop operational plans, including joint projects between divisions and to monitor progress against operational plans. Internal interviewees were generally positive about the utility of this information (e.g., tracking of customer satisfaction and quality management metrics for NDS). External proxy measures may also be used by staff to determine the quality of their services. For example, external reviews by the CTBTO compare Health Canada’s performance against their standards and with laboratories around North America for areas requiring improvement (these laboratories also must meet ISO certification standards).

Three units within the RPB have Quality Management Systems (the NDS, the National Monitoring Section of the CRMN and the NCRC) and, as such, are subject to audits that are used to maintain certification and improve performance. The RPB Director’s Office provides a centralized internal audit function for these programs. The audits are conducted by a staff member who reports directly to the Director of RPB. The full schedule of these audits is included in IPPRS for reporting purposes. The results of the audits are reported to the Director who reviews and requires implicated Program areas to respond to any non-conformances.

In general, internal interviewees reported that they have the information they need to answer DM/ADM information requests and have a sense of how they’re doing through rough metrics and/or proxy measures. For example, internal interviewees refer to publications (and the number of citations), recognition for publications, invitations for presentations/lectures and membership on committees and working groups as indicative of the expertise and success of radiation protection activities. However, performance information is mainly output focussed.

A recent review of the Environmental Radiation & Health Sciences Directorate indicated that improvements could be made at the Directorate level to decrease silos and improve long-term strategic planning, including the identification of priorities and analysis of performance, particularly related to outcomes (KellySears, ERHSD Mandate Review: Radiation Protection Bureau: Final Report, 2015).
5.0 Conclusions

5.1 Relevance Conclusions

Exposure to ionizing radiation can occur from a variety of natural and human-made sources. Although radiation can be used for beneficial applications, it can also have negative impacts on human health including a range of somatic effects that are limited to the exposed individual and genetic effects that may affect subsequent unexposed generations. International issues, including the nuclear power accident in Fukushima and the recent claim by North Korea regarding nuclear warfare, have highlighted the importance of being ready for an emergency exposure situation that, although rare, can occur. As a result, there is an ongoing need for radiation protection activities to manage health risks associated with exposure to radiation and to support nuclear non-proliferation.

Although not explicitly mentioned in recent federal announcements about health, radiation protection activities are consistent with the Government of Canada’s priorities related to the health and safety of Canadians, and are aligned with Health Canada’s objective, “to inform and advise other government Departments, international partners, and Canadians in general about the health risks associated with radiation, and inform Canadians of strategies to manage associated risks”, as articulated in the 2014-2015 Health Canada Report on Plans and Priorities.

Most radiation protection activities are consistent with Health Canada’s roles and responsibilities under legislation (such as the Emergency Management Act, the Radiation Protection Regulations under the Nuclear Safety and Control Act, and the Canadian Environmental Assessment Act, 2012), and national and international agreements. However, there is no clear federal mandate for providing commercial dosimetry services and, although Health Canada was previously the only commercial dosimetry provider in the Canadian market, there are now other licenced private-sector companies that can provide comparable services. There is some duplication and lack of clarity regarding the roles of Health Canada versus the Canadian Nuclear Safety Commission for nuclear emergencies.

5.2 Performance Conclusions

5.2.1 Achievement of Expected Outcomes (Effectiveness)

Radiation protection activities have provided information to Canadians and other key stakeholders and partners, and contributed to protecting Canadians from health risks associated with radiation, by determining individuals’ exposure levels (through both personal dosimetry and biological dosimetry), by monitoring the concentration of ionizing radiation in the environment (through three complementary monitoring networks), and by producing research and guidelines to assess and manage the health impacts of radiation. The evaluation identified challenges related to communications to the public both in terms of day-to-day information provision (for example, providing environmental monitoring data to the public in near real-time and providing annual reports on occupational exposure), and crisis communications in an emergency.
Evidence suggests that Health Canada is well positioned to respond to nuclear emergencies and threats. Health Canada is responsible for the FNEP (the fifth version of which was approved in 2012), the primary federal plan governing nuclear emergencies. The FNEP contains formalized roles and responsibilities both within and outside the federal government, and plans have been tested and improved upon to address issues identified through simulated and real emergency scenarios. The state of emergency preparedness appears to have improved following Health Canada’s response to and lessons learned from the Fukushima nuclear accident. According to both internal and external key informants, as well as After Action Reports from the national, full-scale exercise Unified Response, Health Canada’s emergency response capabilities have improved significantly as a result of the Fukushima experience, although concerns around the timeliness and coordination of public communications in an emergency remain.

Overall, the Program appears to be effective in terms of supporting partners and stakeholders nationally through the provision of data, research, technical advice, and services related to radiation protection. External key informants were generally positive about Health Canada’s contributions and support to partners. However, annual reports on Occupational Radiation Exposure in Canada and Health Canada research publications based on NDR data have not been produced since 2008 and 2001 respectively, due to issues with IT, staff complements and gaps in data. Issues around limited accessibility of data were raised by data users (e.g., provinces, OGDs).

In terms of contributions outside of Canada, the Program is an active participant in a variety of international agreements and committees, and has supported a range of radiation protection and nuclear security efforts on the international stage, including nuclear non-proliferation efforts. External key informants were positive about Health Canada’s contributions internationally. Following the nuclear accident in Fukushima, Health Canada provided support to international partners, for example through environmental monitoring, research, and emergency dosimetry. Health Canada’s contributions to Japan related to Fukushima were formally recognized by the Government of Japan.
5.2.2 Demonstration of Economy and Efficiency

Overall spending averages approximately $15M annually, and has remained fairly stable over the five-year evaluation period. Spending generally aligns to plans, with the majority of spending directed to dosimetry, emergency preparedness and surveillance activities. The operating and salary costs of providing dosimetry services are largely cost recovered; however, the Program does not recover all its costs when previous long term Program investments are taken into account. Looking to the future, Program representatives are concerned that sun-setting of some funding sources may affect emergency preparedness.

The Program has introduced efficiencies through leveraging the use of monitoring equipment and data, and through operational measures, although some opportunities to improve efficiency have been hampered by IT and staffing issues.

In terms of governance, the grouping of radiation protection activities considered under this evaluation does not have an overarching governance structure, although there are a number of committees that integrate radiation protection activities within Health Canada and with other agencies. Some internal interviewees noted that greater integration between the Program’s divisions and within the health portfolio overall would be beneficial. With respect to performance measurement, there is no logic model or performance measurement strategy for radiation protection activities as a whole, although draft logic models do exist at the divisional level. Internal interviewees were generally positive about the utility of existing performance information. However, performance information mainly relates to outputs, rather than outcomes.

6.0 Recommendations

Recommendation 1

Explore opportunities to enhance public communications and data access related to environmental and occupational monitoring information, and for emergency situations.

Issues related to communications to the public and access to data were identified in many activity areas, for example, radiation surveillance, emergency preparedness and the NDR. There is evidence that some Canadians have had a difficult time trying to find or interpret Health Canada’s most current surveillance data, in addition to distinguishing the differences amongst its three surveillance networks. For NDR data, the ‘Annual Report on Occupational Radiation Exposure in Canada’ has not been produced since 2008, and direct access to data for partners is no longer available. In terms of emergency preparedness, an After Action report following a FNEP exercise identified the need to ensure public communications are rapid and coordinated. Both external and internal key informants indicated that Health Canada’s communication efforts are not adequate or timely. Further, there is evidence that other groups, such as CNSC, took action to address gaps in information to the public during and following the accident at Fukushima.
Recommendation 2

Clarify, implement and communicate the appropriate roles and responsibilities related to nuclear emergency preparedness and response with CNSC.

The evaluation found concerns about duplication and a lack of clarity around the roles of Health Canada and the CNSC in some areas. The most common concern cited was in relation to communications to Canadians in emergencies. An external advisory committee report on the Fukushima response that was prepared for the CNSC concluded that there was no official federal government ‘voice’ to provide updates to the public. In addition, internal and external key informants had varying views on the roles associated with the Technical Advisory Group for emergencies and who should be the lead for the FNEP.

Recommendation 3

Examine options to address issues related to IT program support.

IT support issues were identified for a number of activity areas, including dosimetry services, surveillance, emergency preparedness and the NDR. In addition, potential efficiency improvements through the automation of several processes (NDR data requests and incoming files, NDS retrieval of customer service and client information, and RSD surveillance activities) have not been realized as a result of IT challenges.

Recommendation 4

In the longer term, consider options to reduce involvement in the provision of commercial dosimetry services.

The evaluation found that there is no federal mandate for the government to provide commercial dosimetry services. There are currently two private-sector companies that offer similar services in Canada. Some internal key informants raised issues related to the ability/willingness of private services to accommodate both official languages, meet privacy requirements, and take on smaller enterprises (e.g., dental clinics). This evaluation found that external commercial dosimetry providers are able to address these concerns (e.g., are already targeting smaller clients, are meeting privacy requirements of other countries, and, are providing services in multiple countries and languages).

When O&M and capital expenditures are taken into account, the NDS has not covered its costs over the past 8 years. Further, the NDS acts as a commercial provider within a government environment and, as such, is constrained in its: competitiveness (e.g., not able to solicit business, ability to change fee structure); responsiveness (e.g., may not be able to keep up with technological advances and information technology (IT) advances); and, ability to communicate with the public (e.g., as it may be seen to be seeking new customers).
Appendix 1 – Summary of Findings

Rating of Findings

Ratings have been provided to indicate the degree to which each evaluation issue and question have been addressed.

Relevance Rating Symbols and Significance:

A summary of Relevance ratings is presented in Table 1 below. A description of the Relevance Ratings Symbols and Significance can be found in the Legend.

Table 1: Relevance Rating Symbols and Significance

<table>
<thead>
<tr>
<th>Evaluation Issue</th>
<th>Indicators</th>
<th>Overall Rating</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>To what extent does the Program continue to address a demonstrable need and remain responsive to the needs of Canadians</td>
<td>• Evidence of health and/or environmental impacts related to radiation</td>
<td>High</td>
<td>There is an ongoing need for radiation protection activities to manage health risks associated with exposure to radiation. Exposure to ionizing radiation can occur from a variety of natural and human-made sources. Although radiation can be used for beneficial applications, it can also have negative impacts on human health including a range of somatic effects that are limited to the exposed individual and genetic effects that may affect subsequent unexposed generations. International issues, including the nuclear power accident in Fukushima and the recent claim by North Korea regarding nuclear warfare have highlighted the importance of being ready for an emergency exposure situation that, although rare, can occur.</td>
</tr>
<tr>
<td>• What are the health/societal needs contributing to the need for radiation protection?</td>
<td>• Expert/stakeholder assessment of ongoing need</td>
<td></td>
<td></td>
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<tr>
<td>• Have new needs emerged since the implementation of the Program?</td>
<td>• Evidence of demonstrated need over time and/or emerging issues related to radiation protection</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Expert/stakeholder assessment any emerging/new needs in radiation protection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alignment with Government Priorities</td>
<td>• Correspondence of radiation protection activities’ objectives with federal/GoC priorities</td>
<td>High</td>
<td>Although not explicitly mentioned in recent federal announcements about health, radiation protection activities are consistent with the Government of Canada’s priorities related to the health and safety of Canadians.</td>
</tr>
<tr>
<td>What are the federal priorities related to radiation protection? Are Program activities aligned with federal priorities?</td>
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</table>

Legend - Relevance Rating Symbols and Significance:

High  There is a demonstrable need for program activities; there is a demonstrated link between program objectives and (i) federal government priorities and (ii) departmental strategic outcomes; role and responsibilities for the federal government in delivering the program are clear.

Partial  There is a partial need for program activities; there is some direct or indirect link between program objectives and (i) federal government priorities and (ii) departmental strategic outcomes; role and responsibilities for the federal government in delivering the program are partially clear.

Low  There is no demonstrable need for program activities; there is no clear link between program objectives and (i) federal government priorities and (ii) departmental strategic outcomes; role and responsibilities for the federal government in delivering the program have not clearly been articulated.
### Evaluation Issue

<table>
<thead>
<tr>
<th>Evaluation Issue</th>
<th>Indicators</th>
<th>Overall Rating</th>
<th>Summary</th>
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</thead>
<tbody>
<tr>
<td>What are the Health Canada priorities related to radiation protection? Are Program activities aligned with Health Canada priorities?</td>
<td>• Correspondence of radiation protection activities’ objectives with strategic outcomes of Health Canada</td>
<td>High</td>
<td>Program activities are aligned with Health Canada’s objective, “to inform and advise other government Departments, international partners, and Canadians in general about the health risks associated with radiation, and inform Canadians of strategies to manage associated risks”, as articulated in the 2014-2015 Health Canada Report on Plans and Priorities.</td>
</tr>
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</table>

### Alignment with Federal Roles and Responsibilities

<table>
<thead>
<tr>
<th>Evaluation Issue</th>
<th>Indicators</th>
<th>Overall Rating</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are radiation activities aligned with federal roles and responsibilities?</td>
<td>• Correspondence of radiation protection activities with federal government/Health Canada roles and responsibilities</td>
<td>Low (NDS commercial)</td>
<td>Most radiation protection activities are consistent with Health Canada’s roles and responsibilities under legislation (such as the Emergency Management Act, the Radiation Protection Regulations under the Nuclear Safety and Control Act, and the Canadian Environmental Assessment Act, 2012), and national and international agreements. However, there is no clear federal mandate for providing commercial dosimetry services.</td>
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<td></td>
<td>• Evidence of duplication, overlap or coordination of roles or activities with other stakeholders/jurisdictions</td>
<td>High (other activities)</td>
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<tr>
<td></td>
<td>• Perceptions of key informants related to duplication of roles/activities and appropriateness of federal involvement</td>
<td>Partial</td>
<td>Although Health Canada was previously the only commercial dosimetry provider in the Canadian market, there are now other licenced private-sector companies that can provide comparable services. There is some duplication and lack of clarity regarding the roles of Health Canada versus the Canadian Nuclear Safety Commission during nuclear emergencies.</td>
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## Performance Rating Symbols and Significance:

A summary of Performance Ratings is presented in Table 2 below. A description of the Performance Ratings Symbols and Significance can be found in the Legend.

### Table 2: Performance Rating Symbols and Significance

<table>
<thead>
<tr>
<th>Issues</th>
<th>Indicators</th>
<th>Overall Rating</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>To what extent have Canadians been informed of and protected from</td>
<td>• Timeliness, quality and usefulness of NDS and radiobiology services</td>
<td>Progress Made</td>
<td>Radiation protection activities have provided information to Canadians and other key stakeholders and partners, and contributed to protecting Canadians from health risks associated with radiation, by determining individuals’ exposure levels (through both personal dosimetry and biological dosimetry), by monitoring the concentration of ionizing radiation in the environment (through three complementary monitoring networks), and by producing research and guidelines to assess and manage the health impacts of radiation. The evaluation identified challenges related to communications to the public both in terms of day-to-day information provision (for example, providing environmental monitoring data to the public in near real-time and providing annual reports on occupational exposure), and crisis communications in an emergency.</td>
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<tr>
<td>health risks associated with radiation?</td>
<td>• Extent to which the NDS and NDR meet regulatory requirements</td>
<td>Further Work Warranted</td>
<td>Radiation protection activities have provided information to Canadians and other key stakeholders and partners, and contributed to protecting Canadians from health risks associated with radiation, by determining individuals’ exposure levels (through both personal dosimetry and biological dosimetry), by monitoring the concentration of ionizing radiation in the environment (through three complementary monitoring networks), and by producing research and guidelines to assess and manage the health impacts of radiation. The evaluation identified challenges related to communications to the public both in terms of day-to-day information provision (for example, providing environmental monitoring data to the public in near real-time and providing annual reports on occupational exposure), and crisis communications in an emergency.</td>
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<td>• Extent to which risks to workers from ionizing radiation have been</td>
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<td>reduced/managed</td>
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<td>• Extent to which the program provides improved and more readily available</td>
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<td>methods and means to monitor radiation in the environment</td>
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<td>• Effectiveness of the program at communicating data to the public and</td>
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<td>authorities to support risk mitigation</td>
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<td></td>
<td>• Better and more readily available methods for assessing and managing</td>
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<td></td>
<td>radiation</td>
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<td></td>
<td>• Extent to which the program has helped Canadians to manage the risk of</td>
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<td>exposure to radiation</td>
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<td></td>
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<tr>
<td>To what extent does the Program help the Government of Canada in its</td>
<td>• Effectiveness of emergency management systems</td>
<td>Achieved</td>
<td>Evidence suggests that Health Canada is well positioned to respond to nuclear emergencies and threats. Health Canada is responsible for the FNEP (the fifth version of which was approved in 2012), the primary federal plan governing nuclear emergencies. The FNEP contains formalized roles and responsibilities both within and outside the federal government, and plans have been tested and improved upon to address issues identified through simulated and real emergency scenarios. The state of emergency preparedness appears to have improved following Health Canada’s response to and lessons learned from the Fukushima nuclear accident. According to both internal and external key informants, as well as After Action Reports from</td>
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<tr>
<td>preparedness and ability to respond to nuclear emergencies and threats?</td>
<td>• Extent to which emergency preparedness and response arrangements are</td>
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<td>based on sound and objective evaluation of the risks</td>
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<td>• Extent to which emergency arrangements are effectively coordinated</td>
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<td>among organizations</td>
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<td>• Extent to which the program is prepared to provide timely science-based</td>
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<td>evidence for decision making in an emergency</td>
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</table>

### Legend - Performance Rating Symbols and Significance:

- **Achieved**: The intended outcomes or goals have been achieved or met.
- **Progress Made; Further Work Warranted**: Considerable progress has been made to meet the intended outcomes or goals, but attention is still needed.
- **Little Progress; Priority for Attention**: Little progress has been made to meet the intended outcomes or goals and attention is needed on a priority basis.

March 2016

<table>
<thead>
<tr>
<th>Issues</th>
<th>Indicators</th>
<th>Overall Rating</th>
<th>Summary</th>
</tr>
</thead>
</table>
| How effective is the Program at supporting partners and stakeholders? | • Extent to which the program supports other partners and stakeholders (e.g., bureaux and other government departments), including uptake and data quality  
• Number of MOUs in place with other government departments  
• Views of KIs regarding effectiveness of support | Achieved | Overall, the Program appears to be effective in terms of supporting partners and stakeholders nationally through the provision of data, research, technical advice, and services related to radiation protection. External key informants were generally positive about Health Canada’s contributions and support to partners. However, annual reports on “Occupational Radiation Exposure in Canada” and Health Canada research publications based on NDR data have not been produced since 2008 and 2001 respectively, due to issues with IT, staff complements and gaps in data. Issues around limited accessibility of data were raised by data users (e.g., provinces, OGDs). |
| How effective is the program in supporting international radiation protection efforts? | • Extent to which the program supports international partners and stakeholders  
• Effectiveness in supporting international nuclear non-proliferation efforts  
• Number of MOUs with international partners  
• Results from participation in international committees (as chair, co-chair, participant)  
• Views of KIs | Achieved | The Program is an active participant in a variety of international agreements and committees, and has supported a range of radiation protection and nuclear security efforts on the international stage, including nuclear non-proliferation efforts. External key informants were positive about Health Canada’s contributions internationally. Following the nuclear accident in Fukushima, Health Canada provided support to international partners, for example through environmental monitoring, research, and emergency dosimetry. Health Canada’s contributions to Japan related to Fukushima were formally recognized by the Government of Japan. |
| Demonstration of Economy and Efficiency | • Evidence of /views on efficiencies or inefficiencies  
• Comparison of program budget allocation vs expenditures  
• Potential efficiencies/cost savings identified by key informants  
• Approaches taken in other jurisdictions implementing | Progress Made; Further Work Warranted | Overall spending averages approximately $15M annually, and has remained fairly stable over the five-year evaluation period. Spending generally aligns to plans. The operating and salary costs of providing dosimetry services are largely cost recovered; however, the Program does not recover all its costs when previous long term Program investments are taken into account. |

**Legend - Performance Rating Symbols and Significance:**
- **Achieved**: The intended outcomes or goals have been achieved or met.
- **Progress Made; Further Work Warranted**: Considerable progress has been made to meet the intended outcomes or goals, but attention is still needed.
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<table>
<thead>
<tr>
<th>Issues</th>
<th>Indicators</th>
<th>Overall Rating</th>
<th>Summary</th>
</tr>
</thead>
</table>
| Is there appropriate performance measurement in place? If so, is the information being used to inform senior management decision-makers? | • Evidence of implementation of a performance measurement system with baseline data and targets  
• Availability of timely and reliable performance data for measuring outcomes  
• Evidence that performance data is used in decision making  
• Perceived utility of performance data for decision making  
• Extent to which performance data is reported | Progress Made; Further Work Warranted | There is no logic model or performance measurement strategy for radiation protection activities as a whole, although draft logic models do exist at the divisional level. Internal interviewees were generally positive about the utility of existing performance information. However, performance information mainly relates to outputs, rather than outcomes. |
| Does the program have an effective governance structure in place?     | • Evidence of functioning internal and external governance structures,  
• Clearly defined and understood roles and responsibilities  
• Clearly defined processes for priority setting and decision-making  
• Evidence of effective working relationships among partners  
• Perceived effectiveness of governance structure | Progress Made; Further Work Warranted | The grouping of radiation protection activities considered under this evaluation does not have an overarching governance structure, although there are a number of committees that integrate radiation protection activities within Health Canada and with other agencies. Some internal interviewees noted that greater integration between the Program’s divisions would be beneficial. |

**Legend - Performance Rating Symbols and Significance:**

- **Achieved**
  - The intended outcomes or goals have been achieved or met.

- **Progress Made; Further Work Warranted**
  - Considerable progress has been made to meet the intended outcomes or goals, but attention is still needed.

- **Little Progress; Priority for Attention**
  - Little progress has been made to meet the intended outcomes or goals and attention is needed on a priority basis.
Appendix 2 – Evaluation Description

Evaluation Scope
The scope of this evaluation covered the period from April 1, 2010 to March 31, 2015 and included all activities undertaken by: the Radiation Protection Bureau’s Nuclear Emergency Preparedness and Response Division; the Radiation Surveillance Division; the National Dosimetry Services Division; sections of the Radiation Health Assessment Division (e.g., National Dose Registry, National Calibration Reference Centre); as well as the Consumer and Clinical Radiation Protection Bureau’s Radiobiology Division. The National Radon Program was excluded from this evaluation as it had previously been evaluated as part of the Clean Air Regulatory Agenda, and activities related to radiation emitting devices were excluded as they had previously been evaluated as part of the Evaluation of Consumer Products Activities.

Evaluation Issues
The specific evaluation questions used in this evaluation were based on the five core issues prescribed in the Treasury Board of Canada’s Policy on Evaluation (2009). These are noted in the table below. Corresponding to each of the core issues, evaluation questions were tailored to the Program and guided the evaluation process.

<table>
<thead>
<tr>
<th>Core Issues</th>
<th>Evaluation Questions</th>
</tr>
</thead>
</table>
| Relevance   | Assessment of the extent to which the Program continues to address a demonstrable need and is responsive to the needs of Canadians  
  • What are the health/societal needs contributing to the need for radiation protection?  
  • Have new needs emerged since the implementation of the Program? |
| Issue #1:   |                      |
| Continued Need for Program                       |
| Issue #2:  | Assessment of the linkages between Program objectives and (i) federal government priorities and (ii) departmental strategic outcomes  
  • What are the federal priorities related to radiation protection?  
  • What are the HC priorities related to radiation protection?  
  • Are current activities aligned with federal and HC priorities? |
| Alignment with Government Priorities               |
| Issue #3:  | Assessment of the role and responsibilities for the federal government in delivering the Program  
  • What are the federal roles related to radiation protection?  
  • Does the federal role and current activities duplicate the role of stakeholders? Are there any gaps or overlaps? |
| Alignment with Federal Role and Responsibilities   |
| Performance (effectiveness, economy and efficiency) | Assessment of progress toward expected outcomes (incl. immediate, intermediate and ultimate outcomes) with reference to performance targets and Program reach, Program design, including the linkage and contribution of outputs to outcomes  
  • To what extent have Canadians been informed of and protected from health risks associated with radiation?  
  • To what extent does the Program help the Government of Canada in its preparedness and ability to respond to nuclear emergencies and threats?  
  • How effective is the Program at supporting national partners and stakeholders?  
  • How effective is the Program in supporting international radiation protection efforts? |
| Issue #4:  |                      |
| Achievement of Expected Outcomes (Effectiveness)   |
Core Issues | Evaluation Questions
--- | ---
Issue #5: Demonstration of Economy and Efficiency | Assessment of resource utilization in relation to the production of outputs and progress toward expected outcomes
- Has the Program undertaken its activities in the most economical and efficient manner?
- Is there appropriate performance measurement in place? If so, is the information being used to inform senior management decision-makers?
- Does the Program have an effective governance structure in place?

Data Collection and Analysis Methods
Evaluators collected and analyzed data from multiple sources. Sources of information used in this evaluation included a literature review, document review, interviews and case studies.

Document and file review – Over 3,000 files pertinent to radiation protection activities were received from the Radiation Protection Program, and reviewed for information regarding the relevance (priorities, roles and responsibilities) and performance (efficiency, effectiveness) of activities. The main purpose of conducting a document review is to obtain a comprehensive understanding of the underlying theory of radiation protection activities within Health Canada, including its implementation and documented results over the five year period covered by the evaluation. The document and file review supports and corroborates findings from other methodological approaches (triangulation), increases the accuracy of findings, and acts as a validity measure.

Financial data review – A review of financial data from 2010-2011 to 2014-2015 was conducted on planned and actual activity expenditures. An analysis of financial data helps respond to questions of effectiveness, efficiency and economy.

Key informant interviews – interviews were completed with 45 stakeholders (Radiation Protection Bureau and the Consumer and Clinical Radiation Protection Bureau (n=15); other federal government departments or agencies (n=21); international representatives and external experts (n=5); provincial government representatives (n=3); and a nuclear power plant operator (n=1). Interview questionnaires were developed and tailored for each specific stakeholder group. Guides were based on the evaluation issues and questions identified in the Evaluation Matrix. They were developed using a semi-structured format, including probes where helpful. These semi-structured interviews were based on several key questions help to define the areas to be explored, and also allow the interviewer or key informant to diverge in order to pursue an idea or response in more detail. The flexibility of this approach, particularly when compared to structured interviews or focus groups, also allows for the discovery or elaboration of information that is important to participants but may not have been previously thought of as pertinent by the evaluation team. Interviews were conducted in person (when possible) or by telephone. They were recorded, with participant’s consent, and transcribed as necessary. Data was coded and analyzed with the aid of NVIVO software.

Case Study – a review of Health Canada’s response to the nuclear emergency in Fukushima, Japan was conducted to provide a context for evaluating radiation protection activities during a real, yet rare, emergency situation. The case study included a literature and document review of Health Canada’s response to events in Fukushima, Japan, as well as lessons learned. In addition, semi-structured interviews with key informants included an additional series of Fukushima related questions if they were identified as salient by an informant. The case study also reviewed available google analytics to assess public demand for online radiation protection information before, during and after a nuclear emergency.
**Literature review** – a search for Canadian and international literature from the past five years using the search terms of “ionizing radiation” and “radiation protection” was conducted, as well as an international review of literature pertaining to “dosimetry service providers” and “dose registries” in the United States, United Kingdom, France and Australia. The literature review supports and corroborates findings from other methodological approaches (triangulation), increases the accuracy of findings, and acts as a validity measure.

**Analysis** – Overall, data were analyzed by triangulating information gathered from the different sources and methods listed above. This included:

- Systematic compilation, review and summarization of data to illustrate key findings.
- Thematic analysis of qualitative data, and the use of Nvivo products.
- Statistical analysis of quantitative data from databases.
- Trend analysis of comparable data over time.
- Comparative analysis of data from disparate sources to validate summary findings.
Appendix 3 – Examples of Research, Technical Advice and Services

- Evaluation of the annual Canadian biodosimetry network intercomparisons – led by Health Canada to evaluate the importance of annual intercomparisons for maintaining the capacity and capabilities of a well-established biodosimetry network in conjunction with assessing efficient and effective analysis methods for emergency response.
- Testing the capacity of the National Biological Dose Response Plan – led by Health Canada to expand the NBDRP into a formalized medical and casualty management tool.
- Automated analysis for large amount gaseous fission product gamma-scanning spectra from nuclear power plant and its data mining – led by Health Canada to explore an automated analysis platform for the analysis of large amounts of gamma-spectra from the primary coolant monitoring systems of a CANDU reactor.
- Medical Countermeasures for Radioactive Materials – led by Atomic Energy of Canada Limited to find a treatment for removing inhaled radioactive particles from the lungs using drugs approved for human use in other applications.
- Early Triage for Radiological and Nuclear Events – led by International Safety Research, to develop a tool that will allow responders and receivers to use their existing radiation monitors to screen casualties of a radiological/nuclear event for radiological contamination that has been inhaled or ingested (internal contamination).
- Field validation of novel algorithms for imaging – led by Natural Resources Canada to develop imaging algorithms for production of high-quality radiation assessment maps from airborne collected measurements.
- Bayesian Inference for Source Reconstruction Demonstration – led by Environment and Climate Change Canada, with the goal of demonstrating the usefulness of a sensor-driven modeling paradigm for source term estimation based on a Bayesian inferential framework using actual case (or, real world) test data (e.g., Fukushima incident, North Korean nuclear tests) obtained from operational sensor networks (Defence Research and Development Canada, 2015).
- Environmental assessments – Health Canada provided expertise to assist responsible authorities, review panels and/or other jurisdictions for 8 assessments under the Canadian Environmental Assessment Act, 2012, based upon the document, ‘Guidance for Evaluating Human Health Impacts in Environmental Assessment: Radiological Impacts’.
- Emergency response – In response to the Fukushima-Daiichi nuclear emergency in Japan in March 2011, Health Canada led the federal technical assessment group and provided expertise, data, assessment, recommendations and communications to protect Canadians in Japan and in Canada, provided technical advice to the Canadian embassy in Japan, and provided monitoring data and assessment to the International Atomic Energy Agency to support the international emergency response.
Appendix 4 – MOUs with National Partners

- MOU with National Resources Canada regarding arrangements of satellite purchase and use in support of the FNEP.
- MOU with Environment and Climate Change Canada that describes the arrangements for the provision of sample collection services and atmospheric modeling and support services by Environment and Climate Change Canada to Health Canada to meet the Parties' responsibilities under the CTBT and the FNEP, as well as the role of both Parties for collaborative Research and Development projects.
- MOU with CNSC that includes provision of information; development or provision of standards, calibration and independent testing; operation of the NDR; cooperation regarding investigations, tests and studies; notification of findings; cooperation on environmental assessments under the Canadian Environmental Assessment Act, 2012; cooperation on radiological, nuclear emergencies and incidents; and, cooperation on the FPT Radiation Protection Committee and on international committees.
  - As part of the MOU between Health Canada and CNSC, Health Canada provides regulatory assurance for CNSC through performance testing of internal radiation dose measurement methods. The CNSC recognizes the National Calibration Reference Center for Bioassay and In Vivo Monitoring as a centre of excellence that provides them, and its dosimetry licensees, with regulatory assurances and performance tests to ensure the measurement of internal radiation doses is scientifically sound and accurate. For example, in 2014, 216 planned performance tests were completed and 283 test reports were delivered. According to documentary evidence and external key informants, the service provided to CNSC is satisfactory.
  - Biological dosimetry assessments of individuals suspected of having an overexposure to radiation are also under the terms of the MOU with the CNSC.
- MOU with the Canadian Space Agency for biological dosimetry assessments of Canadian and European astronauts.
- MOU with Ontario Power Generation for the Operation & Maintenance of its noble gas network.
- MOU with Ontario Ministry of Labour for the provision of support during nuclear/radiological emergencies and situations which may render one of the laboratories unable to carry out its functions and to formally establish scientific cooperation and inter-institutional relationships.
- MOU with the Department of Foreign Affairs and International Trade on the Installation and operation of a Fixed Point Radiation Surveillance System at the Canadian Embassy in Tokyo, Japan.
Appendix 5 – Examples of Contributions to International Radiation Protection Efforts

- Participated in IAEA committee to draft the “Cytogenetic Dosimetry: Applications in Preparedness for and Response to Radiation Emergencies, IAEA EPR-2011”. This document is the most widely referenced manual for biological dosimetry. It has been adapted into lectures for providing training to new laboratories.
- Delivered one of the IAEA training courses at the request of the IAEA in Bangkok Thailand, November 2014.
- Provided biodosimetry advice to laboratories in Korea, Taiwan, Saudi Arabia and Israel.
- Invited to participate in the IAEA Coordinated Research Project ‘Strengthening of Biological dosimetry in IAEA Member States: Improvement of current techniques and intensification of collaboration and networking among the different institutes’.
- Co-Chaired the Steering Committee for WHO BioDoseNet, and coordinated BioDoseNet participation in a European-led Biodosimetry intercomparison, ‘The capacity, capabilities and needs of the WHO BioDoseNet member laboratories’.
- Convened of the International Organization of Standardization working group on Biodosimetry.
- Invited to participate in a National Academies of Science committee to review the low dose radiation research program at the United States Armed Forces Radiobiology Research Institute.
- Provided research on the health impacts of environmental/low dose radiation to international radiation protection committees including UNSCEAR and IAEA.
- Contributed research to international human monitoring initiatives including the Global Health Security Initiative.
- Participates in Comprehensive Nuclear-Test-Ban Treaty Organisation (CTBTO) Working Group B providing input into the international harmonization activities emanating under the Treaty as well as supporting workshops throughout the year.
- Health Canada (RPB) is the recognized National Competent Authority under the IAEA’s Early Notification and Assistance Conventions. Participation to these IAEA Conventions is essential for fulfilling Canada’s international obligations as a member state. Both conventions were ratified by the government of Canada.
- The Director RPB was Canada’s representative to the IAEA’s Emergency Preparedness and Response Expert Group (EPREG). Its mandate was to provide advice to the IAEA Deputy Director General, Department of Nuclear Safety and Security by identifying and recommending new actions needed to ensure continuous and co-ordinated emergency preparedness and response enhancements; evaluating and prioritizing international emergency management initiatives for preparedness and response to radiological and nuclear incidents and emergencies; and, ensuring development of the emergency preparedness and response implementation strategies for proposed initiatives, including institutional arrangements to ensure sustainability of the international emergency preparedness and response framework. In 2015, the work of the EPREG was folded into the new IAEA Emergency Preparedness and Response Standards Committee, in which RPB represents Canada.
- RPB participates in multiple ISO Committees including:
• Nuclear Technology Committee (TC85):
  - Radiation Protection Subcommittee (SC2), Monitoring and Dosimetry for Internal Exposure (WG13), Standards for Measuring Radon and Thoron (WG 17), and Standards for Computational Dosimetry for Exposure during Air Travel (WG 21)
• Water Quality Committee (TC147):
  - Radioactivity measurement (SC3)
• RPB is a representative of the Government of Canada at the Organisation for Economic Cooperation Development (OECD) Nuclear Energy Agency (NEA) and through the Agency’s various working groups and teams including:
  • RPB is an active member of the Committee on Radiation Protection and Public Health (CRRPH), which identifies new and emerging issues in radiation protection, analyzes their possible implications, and recommends or takes action to address these issues to further enhance radiation protection regulation and implementation.
  • RPB is an active member of the Working Party on Nuclear Emergency Matters (WPNEM) and related Nuclear Energy Agency meetings dealing with nuclear emergency management and radiation protection. Its participation and contribution has resulted directly in the development of essential emergency guidance documents both in Canada and at the international level, new Canadian emergency response capabilities, critical international nuclear exercise participation, vital multi-national partnerships, and increased international harmonization
• RPB also participates in various networks and working groups under the World Health Organization (WHO):
  • RPB is part of the Radiation Emergency Medical Preparedness and Assistance Network (REMPAN) which fulfills the WHO's responsibility under the two international conventions on Early Notification and Assistance (IAEA, 1987). The Network consists of forty medical and research institutions specializing in diagnosis, monitoring, dosimetry, treatment, and long-term follow-up of radiation injuries, acute radiation syndrome, internal contamination and other radiopathology.
  • RPB is also part of the WHO Working Group on Internal Radiation Contamination. This group The Working Group addresses the management of internal radiation contamination following a radiological or nuclear emergency, focusing on population screening, internal contamination assessment, and medical management.
  • The WHO initiated a project to revise the “WHO 1999 Guidelines for Iodine Prophylaxis Following Nuclear Accidents” as a follow-up action from the Fukushima accident. RPB is involved in the revision of this document as a guideline development group member.
Appendix 6 – Examples of Efficiencies

- RPB uses nuclear accident scenarios from Canadian Nuclear Safety Commission and provincial emergency management authorities, and atmospheric modelling capabilities from Environment and Climate Change during emergencies to determine potential impacts on public health (Federal Nuclear Emergency Plan).
- RPB uses the aerial monitoring surveys from Natural Resources Canada during emergencies to provide maps of radioactive contamination (Canadian Safety and Security Program, 2015).
- RSD and NEPRD use data and expertise from Meteorological Service of Canada, in exchange for services and expertise. This is supported by a transfer of funds from RPB to Environment and Climate Change Canada.
- At the provincial level, RSD uses the data collected by Ontario Power Generation’s monitoring stations to contribute to the Fixed Point Surveillance Network associated with CTBT. RSD has access to live data and can publish this data quarterly for the public. In return, RSD provides the operation and maintenance. These arrangements create efficiencies by avoiding duplication and capitalizing on pre-existing infrastructure that leverages monitoring advantages to meet FNEP and CTBT needs.
- The Radiobiology Division has included practices that have demonstrated efficiencies, especially for emergencies and surge capacities (e.g., QuickScan scoring for Radiobiology that produces dose estimates at a rate up to six times faster than conventional method). They also regularly assess their own performance against similar European labs to identify inefficiencies or delays with biodosimetry screenings.
- RHAD uses the monitoring data from RSD to support its radiological risk assessments.
- NEPRD has used international guidelines and standards to ensure that best practices are considered for emergency planning and preparedness. The use of tools by the Technical Assessment Group (e.g., ‘Accident Reporting and Guidance Operational System’ (ARGOS), ‘SharePoint’, and ‘Outcomes’) are examples that improve the efficiency of web-mapping and modeling.
- NDS has introduced process efficiencies in the provision of commercial dosimetry services through investment in more automated technologies (e.g., InLight dosimeters).
- NEPRD works with the Centre for Emergency Preparedness and Response (Public Health Agency of Canada) to plan, develop and conduct nuclear emergency exercises.
- RSD has introduced the use of higher efficiency and better insulated generating systems for monitoring stations, including some facilities that use the heat generated by the instruments to contribute to heating the facility where it is located.
- The Radiobiology Division contributed to the development of a web module for Medical Emergency Treatment for Exposures to Radiation (METER) training.
- Health Canada and the CTBTO have contributed equally to the purchase of monitoring stations.
- As part of the Integrated Fukushima Ocean Radionuclide Monitoring (InFORM) project, volunteer citizen scientists have assisted in collecting environmental samples to be analyzed by Health Canada.
Appendix 7 References


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