

# POINT LEPREAU NUCLEAR GENERATING STATION

## Annual Compliance Report

### ANNUAL REPORT ON ENVIRONMENTAL PROTECTION - 2023

ACR-07000-2023

Rev. 1



**For Information**

Proprietary

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## Document Approval

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## Executive Summary

This report describes the 2023 results of the environmental monitoring program for the Point Lepreau Nuclear Generating Station (PLNGS).

In 2023, 1398 samples were analyzed to monitor environmental radiation around Point Lepreau and across the province in general. There were 128 Quality Assurance (QA) samples.

The analyses indicate that radiation dose from PLNGS releases continues to be well below the public dose limit (1000 microsieverts per annum) and well below the design and operating target for PLNGS (50 microsieverts per annum).

<i>Source of Dose to the Representative Person</i>	<i>Individual Dose (<math>\mu\text{Sv}\cdot\text{a}^{-1}</math>)</i>
PLNGS airborne releases	0.80
PLNGS liquid releases	0.07

Reports are issued to other regulators for non-radioactive hazardous releases. These reports are described in this report in *Section 8*.

The Station is aligned to the Canadian Standards Association (CSA) standards *N288.4-10, Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills* and *N288.5-11, Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills* and *N288.7-15 Groundwater protection programs at Class I nuclear facilities and uranium mines and mills*.

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## 1.0 Introduction

This document describes the results of the Radiation Environmental Monitoring Program (REMP) and summarizes the reports for non-radioactive hazardous releases for the year 2023, as required by *Section 3.5 of CNSC REGDOC-3.1.1, Reporting Requirements for Nuclear Power Plants*.

The REMP for 2023 was described in *IR-03541-HF02, Radiation Environmental Monitoring Program (REMP)*. The requirement for the REMP is stated in *EXP-03400-0001, Radiation Protection Expectations and Directives*, and *SR-79100-3010, Solid Radioactive Waste Management Facility Safety Report*. The underlying reason for the program is the large inventory of radionuclides that are present onsite. The program operates in conjunction with *SDP-01368-P077, Monitor and Control Effluents*, a program which monitors and controls effluents at their source. The Derived Release Limits (DRLs) are calculated in *RD-01364-L001, Derived Release Limits for Radionuclides in Airborne and Liquid Effluents*.

As part of its overall Management System, PLNGS has an Environmental Management System (EMS) (*SI-01365-P101, Developing and Maintaining the Environmental Management System (EMS)*) in place that is registered to National Standards of Canada, *CAN/CSA-ISO 14001, Environmental Management Systems*. All activities, products and services that could impact the environment and their associated aspects have been identified and logged in a database. This database forms the foundation for the EMS. Environmental assessment and improvement programs have been developed for the Significant Environmental Aspects (SEA) to ensure continual improvement.

All activities that support PLNGS are controlled by the PLNGS Management System. The environmental radiation monitoring program falls under the primary process *PRR-00660-SU-2, Provide Environmental Services*.

All radionuclide analyses of environmental samples in 2023 were performed in the Fredericton Health Physics Laboratory at 420 York Street, Fredericton, NB.

## 1.0 Introduction, Continued

The Radiation Environmental Monitoring Program for PLNGS fulfills several objectives. These are to:

1. Permit the estimation of dose to the Representative Person and populations from the radioactive releases from PLNGS and its Solid Radioactive Waste Management Facility (SRWMF). This estimation of dose is achieved through the analyses of environmental and effluent samples.
2. Provide data to confirm compliance of PLNGS and the SRWMF with release guidelines and regulations and to provide public assurance of compliance. These provisions are achieved through the publication of the annual report on the NB Power website.
3. Establish and maintain the capability for environmental monitoring so that an effective response can be made to emergency conditions. This response is assured by maintaining the resources to step up the monitoring program during increased releases that are only likely during an accident. The ability to interpret the data and make recommendations is also maintained.
4. Maintain a database to facilitate the detection of trends. The database is maintained by storing all results on a computer program that has the capability of reporting desired subsets of data.
5. Verify or refine environmental models used in the calculation of Derived Release Limits (DRLs). Verification is achieved by comparing the theoretical dispersion factor with one calculated empirically. In addition, other exposure routes to the public are continually evaluated.
6. Determine the fate of released radioactive materials to show whether any pathway to humans has been overlooked. The deposition of radioactive material is determined through the collection and analysis of sample media outside of the established program. In addition, any results that are not consistent with effluent results are investigated.

The capability of the radiation monitoring laboratory is assessed through the QA program and through the daily analytical checks. These checks demonstrate the accuracy and consistency of analyses.

The following sections will briefly describe the program. Details are provided on PLNGS releases, results of analyses, dose estimates, and the quality assurance program.

## 2.0 PLNGS Radioactive Release Data

Releases from PLNGS continue to be at low levels as indicated in Table 2.01. By the time these releases reach the edge of the exclusion zone, they are diluted below the detection limits of most of the analytical procedures.

**Table 2.01: Radionuclides Detected in Effluents**

<b>Nuclide</b>	<b>Gaseous Effluent DRL (Bq·a<sup>-1</sup>)</b>	<b>Release (Bq)</b>	<b>DRL (%) *</b>	<b>Liquid Effluent DRL (Bq·a<sup>-1</sup>)</b>	<b>Release (Bq)</b>	<b>DRL (%) *</b>
H-3	2.4E+17	1.71E+14	7.02E-02	4.5E+19	1.82E+14	7.78E-04
C-14	1.2E+16	1.12E+11	8.97E-04	3.7E+14	2.72E+09	9.92E-04
Ar-41	2.6E+17	1.86E+13	7.16E-03	-----	-----	-----
Mn-54	-----	-----	-----	1.2E+13	7.60E+06	6.47E-05
Fe-59	-----	-----	-----	3.0E+12	2.39E+06	7.98E-05
Co-60	-----	-----	-----	1.0E+13	3.51E+08	4.10E-03
Kr-85m	2.3E+18	3.08E+11	1.32E-05	-----	-----	-----
Kr-87	4.1E+17	2.33E+11	5.74E-05	-----	-----	-----
Kr-88	1.1E+17	7.25E+11	6.64E-04	-----	-----	-----
Sr-90	1.7E+12	1.03E+06	6.03E-05	5.9E+15	1.96E+05	3.35E-09
Zr-95	-----	-----	-----	2.9E+14	5.37E+07	1.96E-05
Nb-95	-----	-----	-----	8.1E+14	1.20E+08	1.67E-05
Mo-99	-----	-----	-----	2.4E+16	3.20E+06	1.33E-08
Tc-99m	-----	-----	-----	7.4E+17	7.96E+07	1.09E-08
Ru-106	-----	-----	-----	9.4E+13	1.90E+06	2.03E-06
Ag-110m	-----	-----	-----	4.7E+12	4.58E+07	1.00E-03
Sb-122	-----	-----	-----	4.1E+14	1.37E+07	3.35E-06
Sb-124	-----	-----	-----	1.3E+14	3.22E+08	2.79E-04
Sb-125	-----	-----	-----	5.0E+14	8.34E+07	1.85E-05
I-131	3.9E+13	2.72E+07	7.07E-05	3.4E+13	2.94E+06	8.73E-06
I-135	-----	-----	-----	2.5E+15	4.71E+05	1.87E-08
Xe-133	1.2E+19	9.03E+12	7.89E-05	-----	-----	-----
Xe-133m	1.3E+19	1.56E+11	1.25E-06	-----	-----	-----
Cs-134	-----	-----	-----	8.6E+13	7.44E+04	8.62E-08
Xe-135	1.4E+18	4.22E+12	2.90E-04	-----	-----	-----
Xe-135m	8.3E+17	1.40E+11	1.69E-05	-----	-----	-----
Sn-113	-----	-----	-----	4.1E+12	1.93E+06	4.72E-05
Cs-137	-----	-----	-----	2.1E+14	5.16E+06	2.72E-06
Xe-138	8.4E+16	3.71E+11	4.46E-04	-----	-----	-----
Gd-153	-----	-----	-----	4.0E+15	4.16E+06	1.05E-07
Gd-159	3.9E+16	-----	-----	7.2E+15	1.92E+07	2.67E-07
Tb-160	-----	-----	-----	6.2E+14	1.60E+07	2.61E-06
Ac-228	-----	-----	-----	1.4E+17	7.48E+05	5.20E-10
I-132	-----	-----	-----	4.4E+16	5.60E+06	1.30E-08
I-133	-----	-----	-----	1.0E+15	3.79E+05	3.76E-08
Zn-65	-----	-----	-----	9.7E+12	5.15E+05	5.30E-06
Cr-51	-----	-----	-----	1.8E+16	3.36E+06	1.87E-08
Nb-94	-----	-----	-----	3.5E+14	1.04E+06	3.00E-07
Ru-103	-----	-----	-----	9.3E+13	4.50E+05	4.82E-07
Na-24	-----	-----	-----	2.2E+15	2.84E+05	1.32E-08
Te-132	-----	-----	-----	6.7E+13	5.60E+06	1.30E-08
Sc-46	-----	-----	-----	-----	4.35E+04	1.10E-07
Alpha	-----	3.07E+06	-----	-----	1.58E+07	-----
Beta	-----	8.57E+07	-----	-----	1.02E+08	-----
<b>Total</b>			<b>8.00E-02</b>	<b>Total</b>		<b>7.42E-03</b>

\* To calculate % DRL for releases from some locations and during outages, an adjustment is made to compensate for different flow rates and/or points of release.

### 3.0 Sample Media, Locations and Frequencies (REMP)

The data contained in this report are for samples collected from January 1 to December 31, 2023, with some overlap for air, precipitation and thermo-luminescent dosimeter (TLD) samples. During this time, the media analyzed, and their frequency of collection were as indicated in Table 3.01. Sample collection usually takes place once each week throughout the year. The number of each sample type collected in 2023 and the major radionuclide measurements performed on that sample type are listed in Table 3.02.

The miscellaneous sample group includes samples that are not routinely collected.

The major sample locations sampled in 2023 are listed in Table 3.03 (details in *Appendix C*) and shown in Figures 3.01 to 3.06. An “Indicator” site is one within the possible influence of PLNGS releases. A “Reference” site is outside the influence of PLNGS releases.

Sample locations for mobile seafood species (lobster, fish, etc.) collected in the Lepreau area are specified as accurately as reasonably possible.

Milk is only collected and analyzed if there are dairy cows within five kilometers of PLNGS. None were identified during 2023.

### 3.0 Sample Media, Locations and Frequencies (REMP), Continued

*Table 3.01: Schedule of Sample Collection and Analysis*

<i>Sample Medium</i>	<i>Typical Frequency</i>
<b><i>Atmospheric Sampling</i></b>	
Airborne Particulates	Monthly (integrated sample)
Airborne Iodines	Monthly (integrated sample)
Water Vapour	Monthly (integrated sample)
Carbon Dioxide	Monthly (integrated sample)
Ambient Gamma Measurements (TLDs)	Quarterly (integrated sample)
Gaseous Effluent Monitor (GEM) Particulates	Weekly (integrated sample)
<b><i>Terrestrial Sampling</i></b>	
Ambient Gamma Measurements (TLDs)	Quarterly (integrated sample)
Milk - commercial dairy - dairy farms	Quarterly (only performed if dairy cows are located within 5 km of PLNGS)
Well Water	Semi-annually and annually (residential)
Pond, Puddle and Surface Water	Quarterly
Fresh Water Sediment	Every 5 years
Berries	Weekly in Season
Garden Vegetables	Weekly in Season
Vegetation	Quarterly
Soil	Quarterly
Monitoring Well Water (Near Plant)	Annually
Precipitation	Monthly (integrated sample)
Deer	Annually When Available
<b><i>Marine Sampling</i></b>	
Seawater	Quarterly
Clams	Quarterly (if indicator sample can be obtained)
Fish	Quarterly (if indicator sample can be obtained)
Lobster	Semi-annually (if indicator sample can be obtained)
Periwinkles	Quarterly
Aquaculture Salmon	Quarterly (if indicator sample can be obtained)
Dulse	Quarterly When Available
Other Sea Plants	Quarterly
Sediment	Quarterly (marine bottom every 5 years)
Ambient Gamma Measurements of Intertidal Zone	Quarterly
Liquid Effluent Monitor (LEM) Composite Water	Monthly Composite (integrated sample)

### 3.0 Sample Media, Locations and Frequencies (REMP), Continued

*Table 3.01: Schedule of Sample Collection and Analysis, Continued*

<i>Sample Medium</i>	<i>Typical Frequency</i>
<i>Solid Radioactive Waste Management Facility</i>	
Bore Hole Water	Three Times Per Year
Parshall Flume Water	Weekly
Ambient Gamma Measurements (TLDs)	Quarterly (integrated sample)
<i>Hemlock Knoll Regional Sanitary Landfill</i>	
Ambient Gamma Measurements (TLDs)	Quarterly (integrated sample)

### 3.0 Sample Media, Locations and Frequencies (REMP), Continued

*Table 3.02: Sample Information*

<i>Sample Medium</i>	<i>Number of Samples</i>	<i>Radionuclide Measurements</i>
<b><i>Atmospheric Sampling</i></b>		
Airborne Particulates	95	gamma emitters & gross alpha/beta
Airborne Iodines	95	Iodine-131
Water Vapour	95	Tritium
Carbon Dioxide	48	Carbon-14
Ambient Gamma Measurements (TLDs)*	100*	gamma exposure
GEM Particulates	53	Strontium-89,90 & gamma emitters
<b><i>Terrestrial Sampling</i></b>		
Ambient Gamma Measurements (TLDs)*	100*	gamma exposure
Well Water	21	gamma emitters & tritium
Pond, Puddle and Surface Water	31	gamma emitters & tritium
Berries	6	gamma emitters
Garden Vegetables	15	gamma emitters
Vegetation	73	gamma emitters
Soil	36	gamma emitters
Monitoring Well Water (Near Plant)	36	gamma emitters & tritium
Precipitation	47	gamma emitters & tritium
<b><i>Marine Sampling</i></b>		
Seawater	16	gamma emitters & tritium
Clams	6	gamma emitters
Fish	2	gamma emitters
Lobster	2	gamma emitters
Periwinkles	8	gamma emitters
Aquaculture Salmon	4	gamma emitters
Dulse	4	gamma emitters
Other Sea Plants	5	gamma emitters
Sediment	40	gamma emitters
Ambient Gamma Measurements of Intertidal Zone	40	gamma exposure
LEM Composite Water	14	Strontium-89,90, gamma emitters, gross alpha/beta

\*The same TLD measures gamma dose from radionuclides in the air and on the ground.

### 3.0 Sample Media, Locations and Frequencies (REMP), Continued

*Table 3.02: Sample Information, Continued*

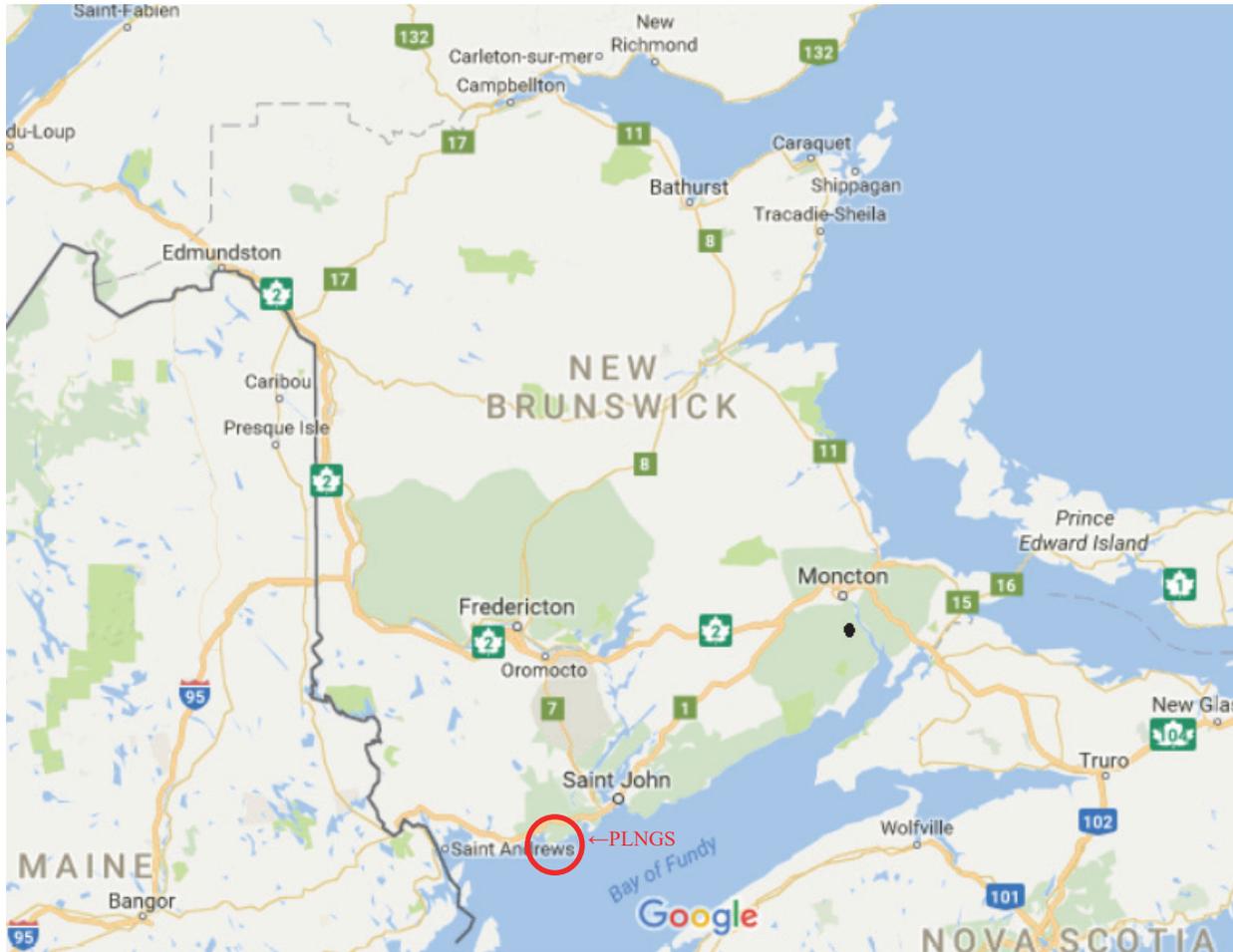
<i>Sample Medium</i>	<i>Number of Samples</i>	<i>Radionuclide Measurements</i>
<b><i>Solid Radioactive Waste Management Facility</i></b>		
Bore Hole Water	105	gamma emitters & tritium
Parshall Flume Water	156	gamma emitters & tritium
Ambient Gamma (TLDs)	184	gamma exposure
<b><i>Hemlock Knoll Regional Sanitary Landfill</i></b>		
Ambient Gamma (TLDs)	16	gamma exposure
<b><i>Quality Assurance</i></b>		
Internal	88	gamma emitters, tritium Strontium-89,90, alpha/beta, carbon-14
External	40	gamma emitters, tritium Strontium-89,90, alpha/beta, carbon-14

### 3.0 Sample Media, Locations and Frequencies (REMP), Continued

*Table 3.03: General Location Codes*

<i>Code</i>	<i>Location</i>
A	West of Pennfield Ridge
B	Pennfield to New River Beach (inclusive)
C	Lepreau and Lepreau Harbour
D	Little Lepreau and Little Lepreau Basin
E	Maces Bay
F	Welch Cove
G	Pt. Lepreau lighthouse and surrounding area
H	Duck Cove
I	PLNGS site – northeast quadrant
J	PLNGS site – southeast quadrant
K	PLNGS site – southwest quadrant
L	PLNGS site – northwest quadrant
M	PLNGS
N	Dipper Harbour
P	East of Dipper Harbour East to Musquash
Q	Lorneville
S	Saint John and surrounding area
T	Taymouth
X	Fredericton and surrounding area
Y	Hemlock Knoll Regional Sanitary Landfill

### 3.0 Sample Media, Locations and Frequencies (REMP), Continued



**Figure 3.01: Location of PLNGS within the Province of New Brunswick (Colour)**

### 3.0 Sample Media, Locations and Frequencies (REMP), Continued



**Figure 3.02: PLNGS and Immediately Surrounding Area (Colour)**

### 3.0 Sample Media, Locations and Frequencies (REMP), Continued

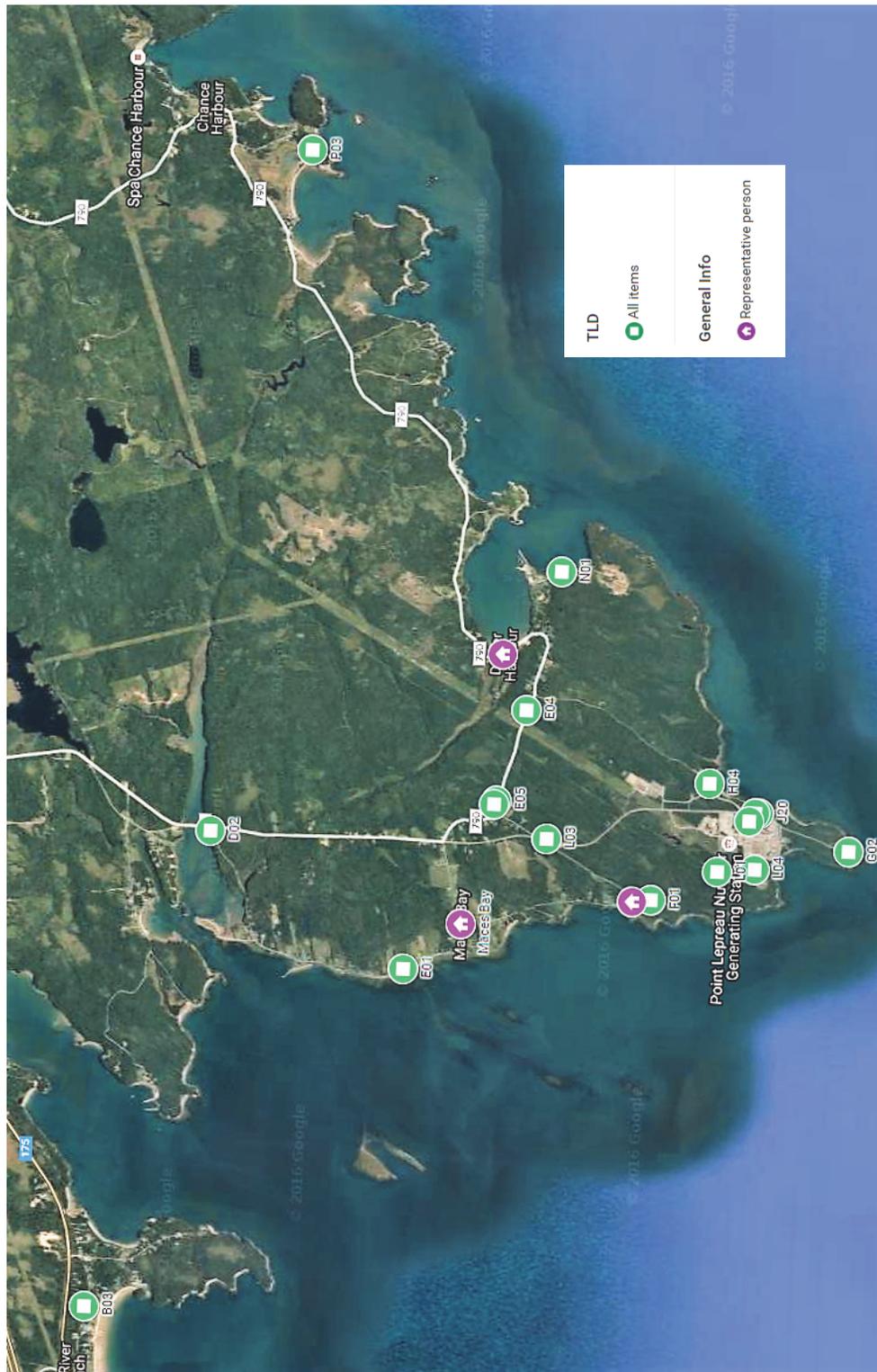


Figure 3.03: TLD Monitoring Sites at and around PLNGS (Colour)

### 3.0 Sample Media, Locations and Frequencies (REMP), Continued

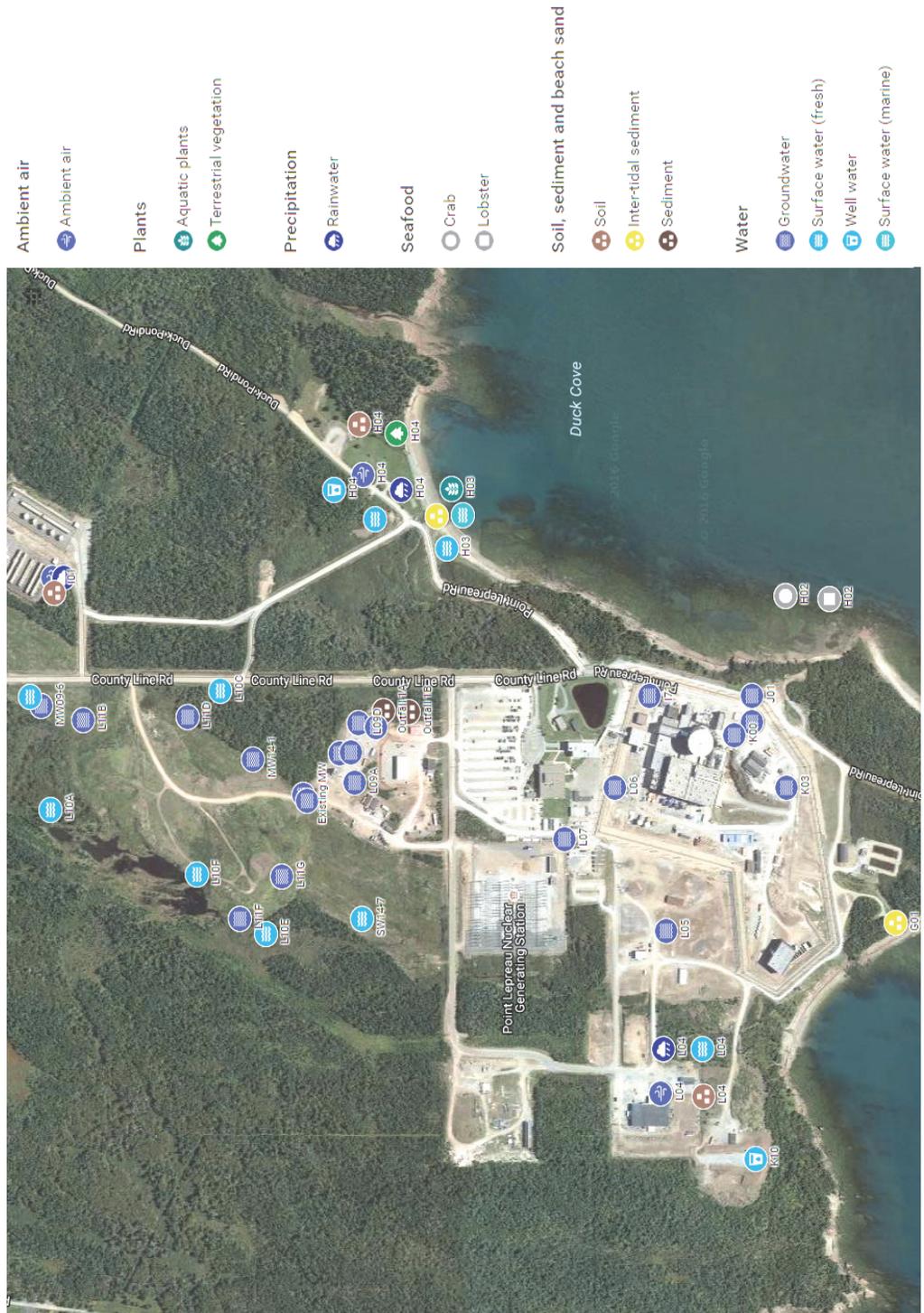


Figure 3.04: Environmental Monitoring on the PLNGS Site (Colour)

### 3.0 Sample Media, Locations and Frequencies (REMP), Continued

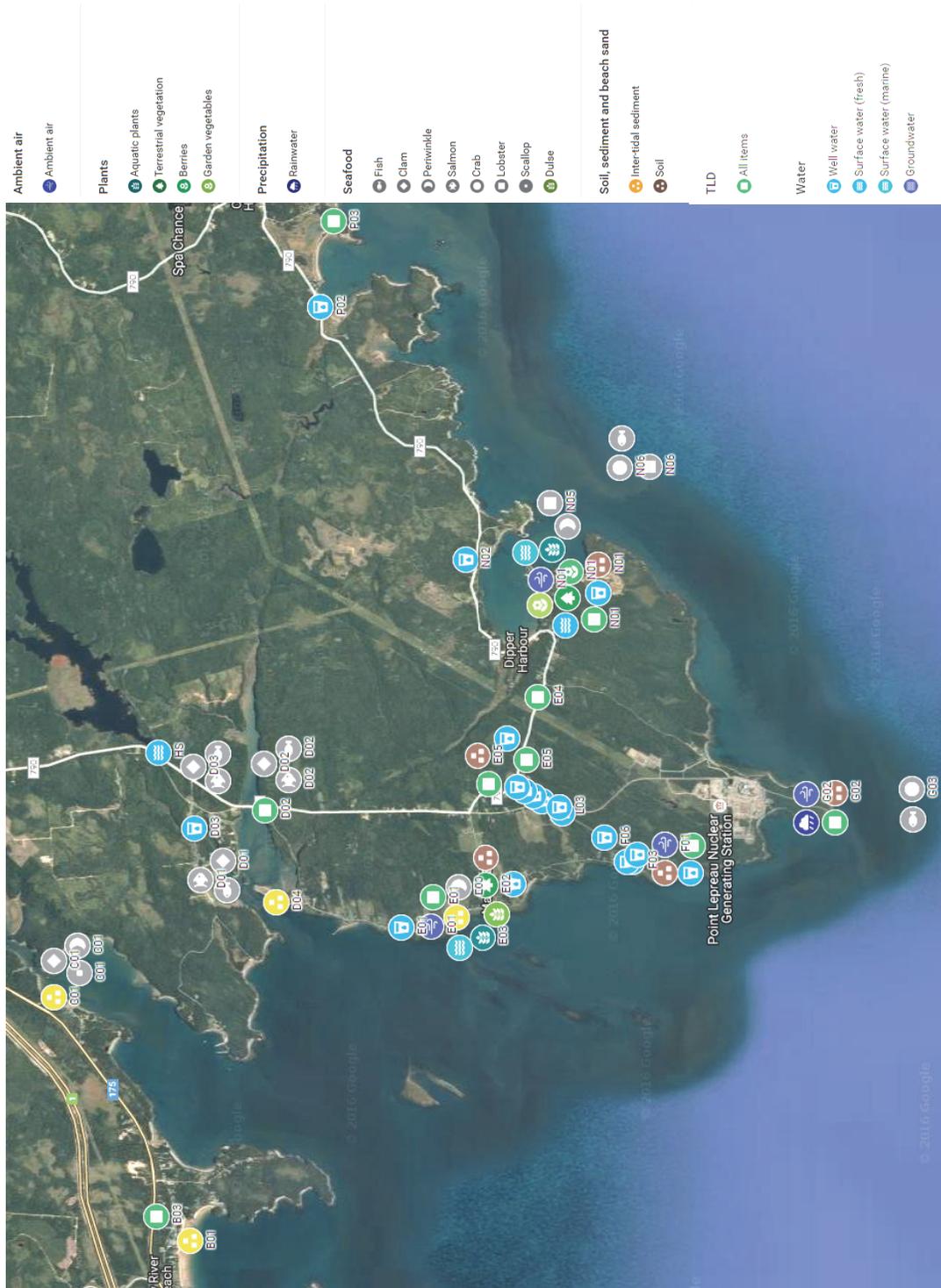
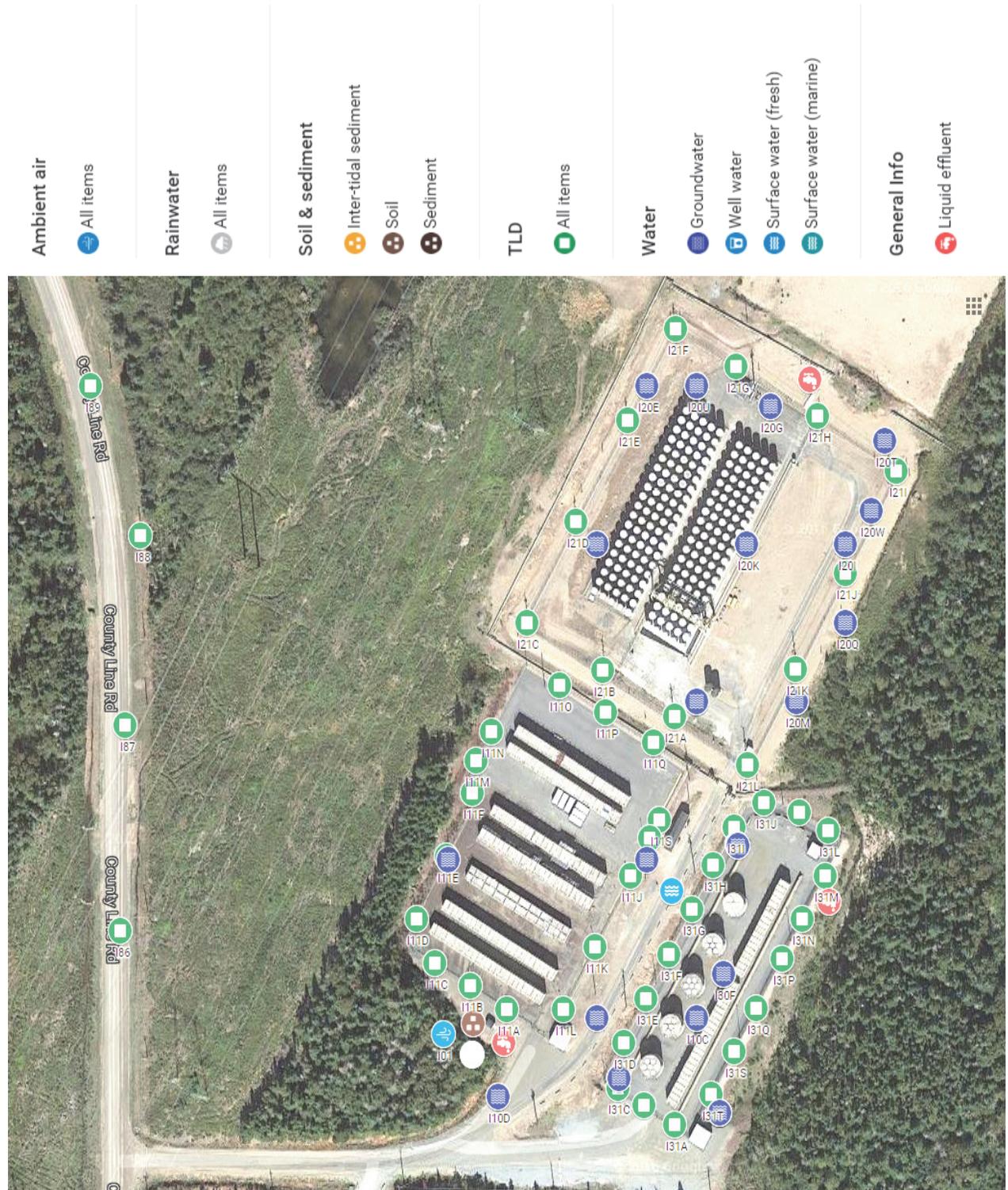


Figure 3.05: Environmental Monitoring on the Lepreau Peninsula (Colour)

### 3.0 Sample Media, Locations and Frequencies (REMP), Continued



**Figure 3.06: Environmental Monitoring at the Solid Radioactive Waste Management Facility (SRWMF) (Colour)**

## 4.0 Summary and Discussion of REMP Data

The following is a summary and discussion of the data on environmental samples collected for the year 2023.

Most samples contained low levels of naturally occurring K-40 or cosmogenic Be-7. Some samples contained Cs-137 (soils and sediments) from the atmospheric weapons tests of past years and international events (at Chernobyl and Fukushima). Tritium (in air and fresh water) is the only radionuclide originating from PLNGS that is detected consistently. In 2023, analyses that indicated releases traceable to PLNGS were:

- H-3 in airborne water vapour, rainwater, and fresh water.
- H-3 in Parshall flume and bore hole water from the Solid Radioactive Waste Management Facility (SRWMF).
- H-3 in water from onsite monitoring wells.

The only assessable radiation dose from PLNGS on the local population is that from tritiated water vapour in air. Offsite, the activity of H-3 in air ranged from less than  $2.19\text{E-}02 \text{ Bq}\cdot\text{m}^{-3}$  (below the lower limit of detection by the method used) to approximately  $1.3\text{E}+00 \text{ Bq}\cdot\text{m}^{-3}$  of air. The natural concentration of H-3 is up to  $7\text{E-}01 \text{ Bq}\cdot\text{L}^{-1}$  in most surface waters and up to  $1\text{E-}03 \text{ Bq}\cdot\text{m}^{-3}$  in air.

The natural concentration of C-14 in the atmosphere is approximately  $4\text{E-}02 \text{ Bq}\cdot\text{m}^{-3}$ . This level is usually detected by the sensitive analytical method used in the monitoring program.

Only detected radionuclides are listed in the following tables. (**Refer To** Tables A.01 to A.10 in *Appendix A* for detailed listings of detection limits. **Refer To** *Appendix C* for a listing of location codes for 2023). Most tables contain the following data:

**Column 1** - Shows the type of analysis or nuclide.

**Column 2** - Shows the total number of samples analyzed.

**Column 3** – Shows the mean of the detected values (i.e., values exceeding the CL) for all Indicator locations. Any measurement greater than the CL is considered detected at the 99% confidence level (an explanation of the statistical protocol is given in *Appendix A*).

**Column 4** - Shows the minimum of detected values (i.e., values exceeding the CL) for the indicator locations.

## 4.0 Summary and Discussion of REMP Data, Continued

**Column 5** - Shows the maximum of detected values (i.e., values exceeding the CL) for the indicator locations.

**Column 6** - Shows the ratio of the number of detected values to the total number of Indicator samples.

**Column 7** - Shows the mean of the detected values (i.e., values exceeding the CL) for the Reference location(s).

**Column 8** - Shows the minimum of detected values (i.e., values exceeding the CL) for the Reference location(s).

**Column 9** - Shows the maximum of detected values (i.e., values exceeding the CL) for the Reference location(s).

**Column 10** - Shows the ratio of the number of detected values to the total number of Reference samples.

### 4.1 Airborne Particulates

Of the 95 filters analyzed, gross alpha was detected on 95, gross beta on 95, and Be-7 on 67. None of these results are attributable to the operation of PLNGS.

Air is continuously monitored from the eight locations shown in Figure 3.05.

Gross alpha and gross beta measurements are an indication of total activity in the environment. This includes naturally occurring radon progeny, cosmogenic (Be-7), and anthropogenic sources of radiation. The maximum concentration of gross alpha in air in any of the indicator locations was  $1.14\text{E-}04 \text{ Bq}\cdot\text{m}^{-3}$  of air. The reference location gross alpha in air reached  $5.94\text{E-}05 \text{ Bq}\cdot\text{m}^{-3}$ . The maximum concentration of gross beta in air in any of the indicator locations was  $7.38\text{E-}04 \text{ Bq}\cdot\text{m}^{-3}$  of air. The reference location gross beta in air reached  $4.35\text{E-}04 \text{ Bq}\cdot\text{m}^{-3}$ .

When Sr-89,90 releases are low, the expected concentration of these radionuclides in environmental air samples is below the detection limit. The Gaseous Effluent Monitor (GEM) monitors PLNGS gaseous releases continuously at their source. The GEM filter was changed weekly. Fifty-three GEM filters were analyzed for Sr-89,90. If the weekly release is more than one percent of the weekly DRL, or if elevated beta activity is detected in environmental air samples, a Sr-89,90 analyses is performed on the environmental air particulate samples. Neither of these scenarios occurred in 2023.

Table 4.01 is a summary of detected radionuclides. Figures 4.01 and 4.02 show the gross beta results for each location throughout the year.

## 4.1 Airborne Particulates, Continued

*Table 4.01: Airborne Particulates (Bq·m<sup>-3</sup>)*

<i>Analysis Type</i>	<i>Total Number</i>	<i>Indicator Locations</i>				<i>Reference Location</i>			
		<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>	<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>
<i>ALPHA</i>	95	3.11E-05	5.25E-06	1.14E-04	83 of 83	3.43E-05	1.54E-05	5.94E-05	12 of 12
<i>BETA</i>	95	2.63E-04	1.33E-05	7.38E-04	83 of 83	2.63E-04	9.84E-05	4.35E-04	12 of 12
<i>Be-7</i>	95	1.42E-03	3.79E-04	3.30E-03	60 of 83	1.30E-03	6.70E-04	2.37E-03	7 of 12

## 4.1 Airborne Particulates, Continued

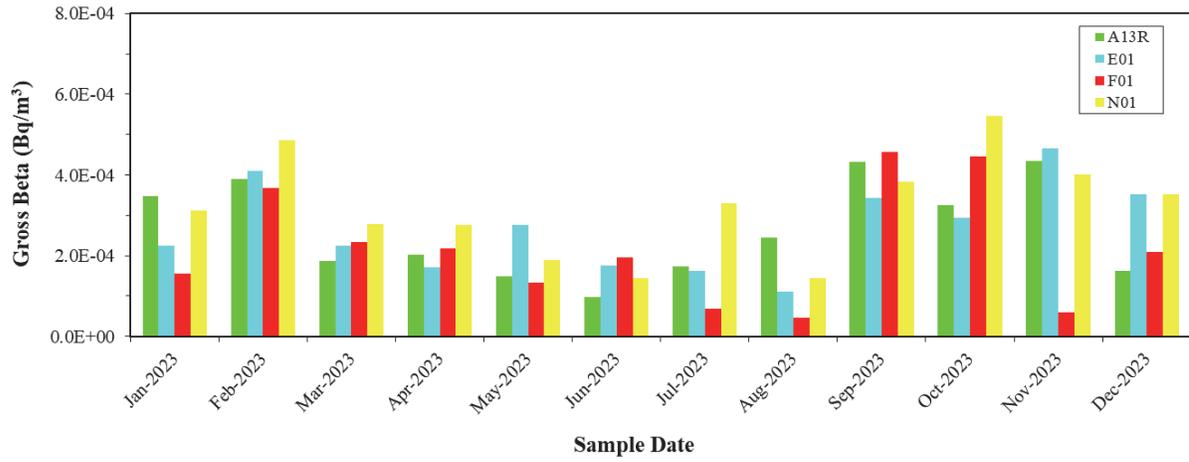


Figure 4.01: Gross Beta (Air Particulates) at Offsite Air Stations (Colour)

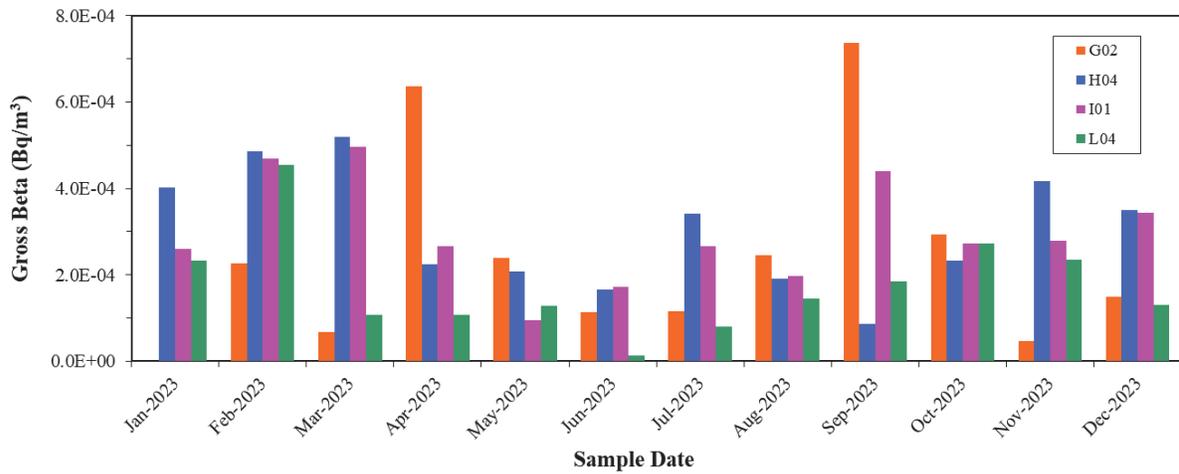


Figure 4.02: Gross Beta (Air Particulates) at Onsite Air Stations (Colour)

## 4.2 Airborne Iodines

No radioiodines were detected in any of the 95 samples analyzed.

Air is monitored continuously, using charcoal cartridges, from the eight locations shown in Figure 3.05. Once per month the cartridges are changed and analyzed.

Iodine-131 was consistently below the Critical Level (average  $1\text{E-}05 \text{ Bq}\cdot\text{m}^{-3}$ ).

## 4.3 Water Vapour

Tritium was detected in 79 of 83 samples collected from the air monitoring stations on the Lepreau peninsula, and in 4 of the 12 samples from the reference location.

Water vapour is collected continuously in molecular sieve canisters from the eight locations shown in Figure 3.05. Once a month the canisters are changed and analyzed.

The maximum concentration of tritium in air in any of the indicator locations was  $2.96\text{E}+00 \text{ Bq}\cdot\text{m}^{-3}$  of air (this was an on-site location). Tritium is detected occasionally at the reference location, even before PLNGS became operational. In 2023 the maximum concentration of tritium in air at the reference location was  $1.98\text{E-}01 \text{ Bq}\cdot\text{m}^{-3}$  of air.

Table 4.02 is a summary of the tritium data and Table 4.03 gives details of the tritium results by location. Figures 4.03 and 4.04 show the H-3 results for each location. “Less Than” values are plotted for non-detected results. Generally, locations to the northeast (H04, I01 and N01) have elevated H-3 measurements in the warmer months due to the predominant summer wind direction. This changes in the winter to impact the southwest locations (G02 and L04).

When H-3 releases are low, the expected H-3 concentration in other environmental samples is below the detection limit. If the weekly H-3 releases are more than one percent of the weekly DRL, a H-3 analysis is performed on berries and garden vegetables. Since the H-3 releases in 2023 were  $7.02\text{E-}02\%$  DRL (and in no week exceeded one percent of the weekly DRL), no further analyses were required. Figure 4.05 shows the weekly H-3 releases from PLNGS. Figure 4.06 compares the releases with the environmental air monitoring results. “Less Than” values are plotted for non-detected results.

Airborne tritium releases continue to be well below station and regulatory limits. Tritium releases are related to operational activities at the Station, in particular maintenance, purification and venting of the moderator and primary heat transport systems.

### 4.3 Water Vapour, Continued

*Table 4.02: Water Vapour (Bq·m<sup>-3</sup>)*

<i>Analysis Type</i>	<i>Total Number</i>	<i>Indicator Locations</i>				<i>Reference Location</i>			
		<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>	<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>
<i>H-3</i>	95	6.72E-01	3.17E-02	2.96E+00	79 of 83	1.60E-01	7.19E-02	1.98E-01	4 of 12

### 4.3 Water Vapour, Continued

**Table 4.03: Tritium (Water Vapour) at Each Air Station (Bq·m<sup>-3</sup>)**

<i>Location Code</i>		<i>A13R</i>	<i>E01</i>	<i>F01</i>	<i>G02</i>	<i>H04</i>	<i>I01</i>	<i>L04</i>	<i>N01</i>
<i>Location</i>		<i>Saint Andrews</i>	<i>Maces Bay</i>	<i>Welch Cove</i>	<i>Lepreau Lighthouse</i>	<i>Duck Cove</i>	<i>SRWMF</i>	<i>Construction Stores</i>	<i>Dipper Harbour</i>
<i>Distance from PLNGS</i>		<i>47 km</i>	<i>4.5 km</i>	<i>1.6 km</i>	<i>1.0 km</i>	<i>0.75 km</i>	<i>1.2 km</i>	<i>0.55 km</i>	<i>3.7 km</i>
<b>Collection Start Date</b> The sample collection periods are approximately one month in duration. All sample stations are changed at the same time. The start date is the stop date for the previous sample.	01/01/2023	<2.94E-02	3.78E-01	1.31E+0	NA	9.05E-01	9.70E-01	1.57E+00	5.77E-01
	02/01/2023	<2.19E-02	3.17E-02	9.10E-01	2.88E-01	7.09E-01	6.11E-01	1.16E+00	2.81E-01
	03/01/2023	<3.52E-02	<4.31E-02	1.05E-01	1.77E-01	5.24E-01	2.70E-01	4.69E-01	1.01E-01
	04/01/2023	<9.97E-02	2.19E-01	2.40E-01	5.64E-01	9.74E-01	9.50E-01	5.21E-01	2.35E-01
	05/01/2023	<6.21E-02	1.19E-01	3.00E-01	4.05E-01	1.15E+00	6.03E-01	1.05E+00	3.30E-01
	06/01/2023	1.98E-01	2.36E-01	3.70E-01	1.46E-01	2.07E+00	1.52E+00	1.04E+00	4.83E-01
	07/01/2023	<1.34E-01	9.46E-02	5.82E-01	<1.34E-01	1.85E+00	2.88E+00	7.04E-01	7.95E-01
	08/01/2023	<1.92E-01	2.49E-01	4.22E-01	4.48E-01	2.96E+00	1.39E+00	1.66E+00	<1.55E-01
	09/01/2023	1.90E-01	1.19E-01	4.27E-01	4.47E-01	1.24E+00	4.49E-01	8.83E-01	4.02E-01
	10/01/2023	<6.21E-02	<6.29E-02	1.20E-01	5.46E-01	2.20E+00	7.44E-01	2.52E-01	1.38E-01
	11/01/2023	1.80E-01	1.51E-01	1.72E-01	6.35E-01	2.14E+00	7.52E-01	2.28E-01	2.29E-01
12/01/2023	7.19E-02	8.63E-02	9.86E-02	3.95E-01	8.82E-01	2.65E-01	1.14E-01	5.88E-02	

NA - Not Available.

Proprietary

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### 4.3 Water Vapour, Continued

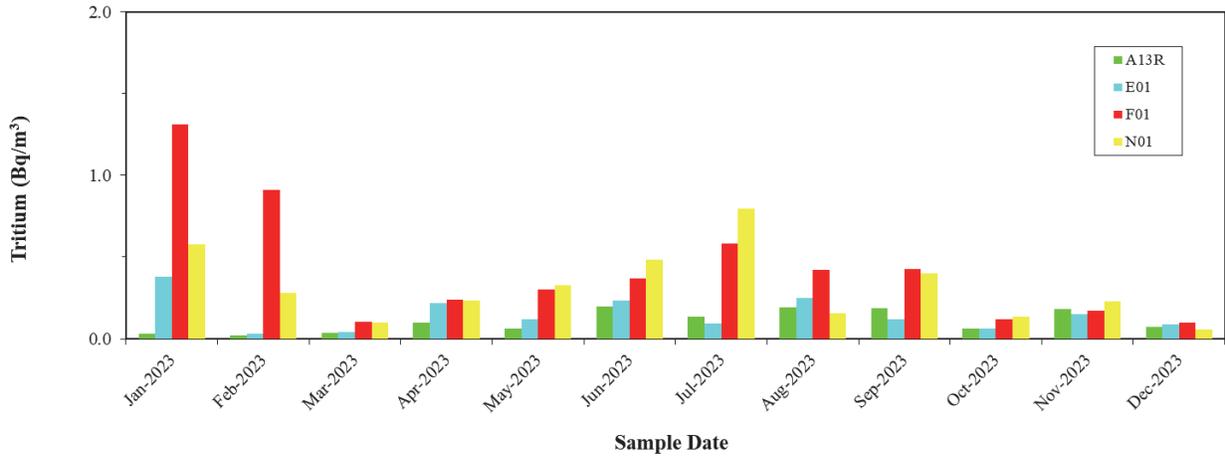


Figure 4.03: Tritium (Water Vapour) at Offsite Air Stations (Colour)

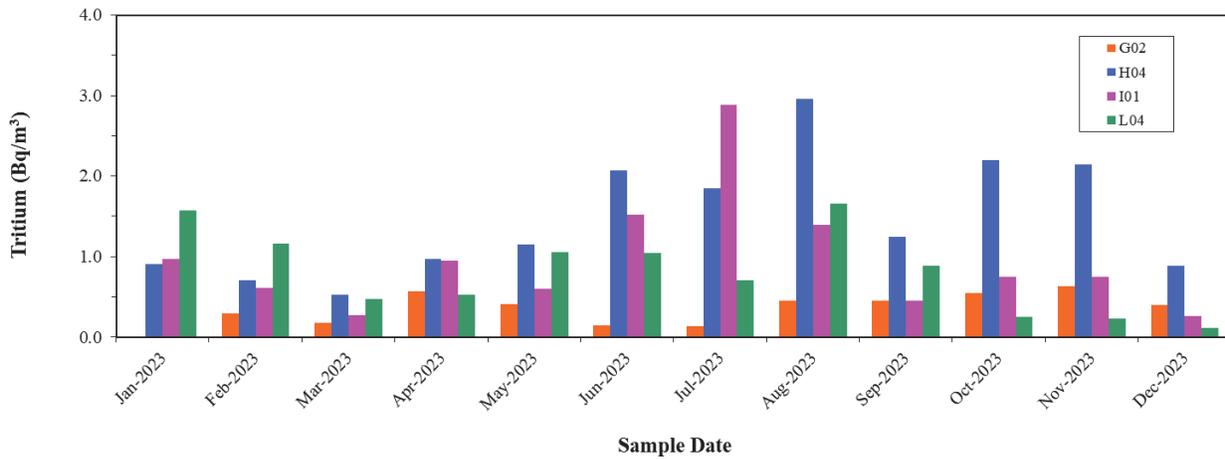


Figure 4.04: Tritium (Water Vapour) at Onsite Air Stations (Colour)

### 4.3 Water Vapour, Continued

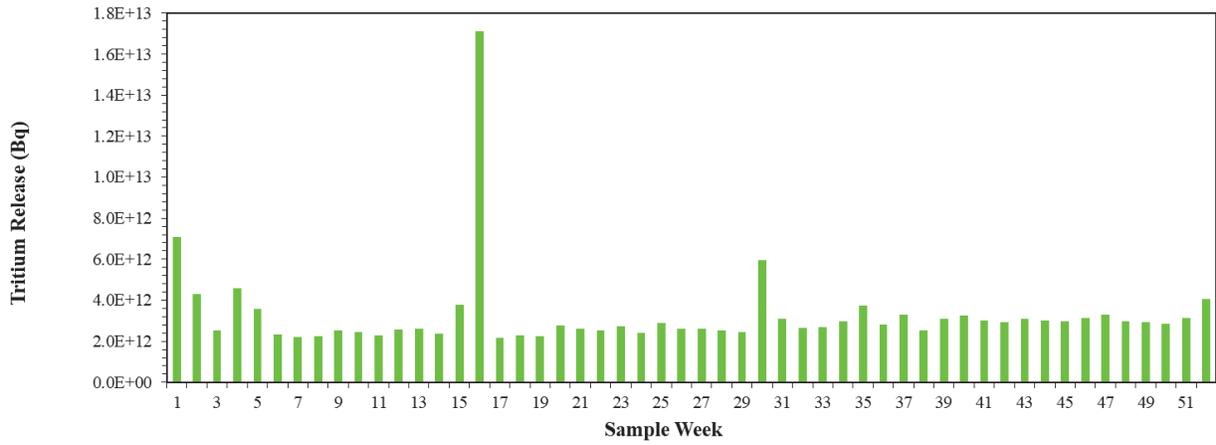


Figure 4.05: Gaseous H-3 Releases for 2023 (Colour)

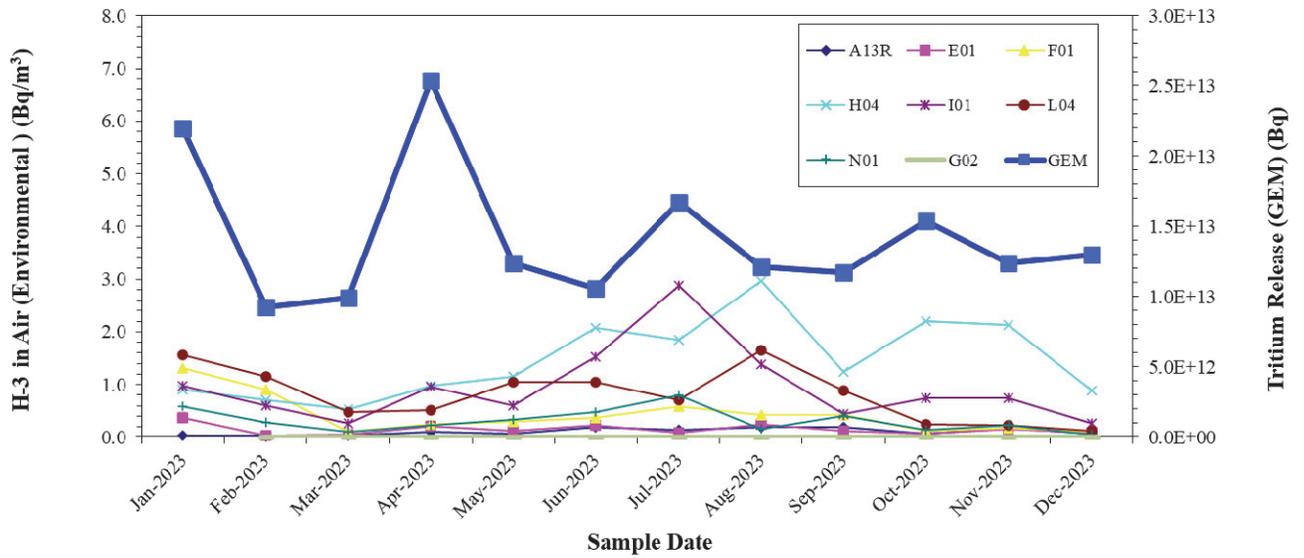


Figure 4.06: Gaseous H-3 Releases and H-3 (Water Vapour) Results (Colour)

## 4.4 Carbon Dioxide

Carbon-14 was detected in 31 of the 36 samples from the indicator locations and 8 of 12 of the samples from the reference location.

Air is continuously bubbled through a caustic solution at two onsite locations and two offsite locations. The caustic bubblers are changed monthly and returned to the lab for analysis.

The maximum concentration of gaseous C-14 in any of the indicator locations was  $1.46\text{E-}01 \text{ Bq}\cdot\text{m}^{-3}$ . The maximum concentration of gaseous C-14 in the reference location was  $9.1\text{E-}02 \text{ Bq}\cdot\text{m}^{-3}$ .

A summary of the analysis results is given in Table 4.04. Table 4.05 gives details of C-14 results (graphically shown in Figure 4.07).

When C-14 releases are low, the expected concentration of C-14 in other environmental samples is below the detection limit. If the weekly C-14 release is more than one percent of the weekly DRL, a C-14 analysis is performed on berries, milk, water, vegetation and garden vegetables. Since the C-14 releases in 2023 were  $8.97\text{E-}04\%$  DRL (and in no week exceeded one percent of the weekly DRL), no further analyses were required. Figure 4.08 shows the weekly C-14 releases from PLNGS. Figure 4.09 compares the releases with the environmental air monitoring results. “Less Than” values are plotted for non-detected results.

#### 4.4 Carbon Dioxide, Continued

*Table 4.04: Carbon Dioxide (Bq·m-3)*

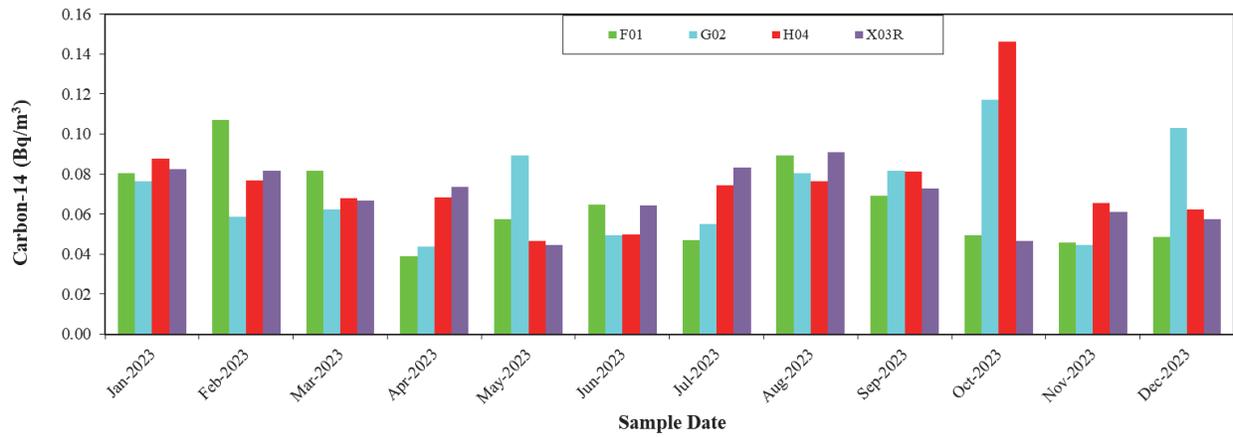
<i>Analysis Type</i>	<i>Total Number</i>	<i>Indicator Locations</i>				<i>Reference Location</i>			
		<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>	<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>
<i>C-14</i>	48	7.07E-02	3.9E-02	1.46E-01	31 of 36	6.88E-02	4.46E-02	9.1E-02	8 of 12

#### 4.4 Carbon Dioxide, Continued

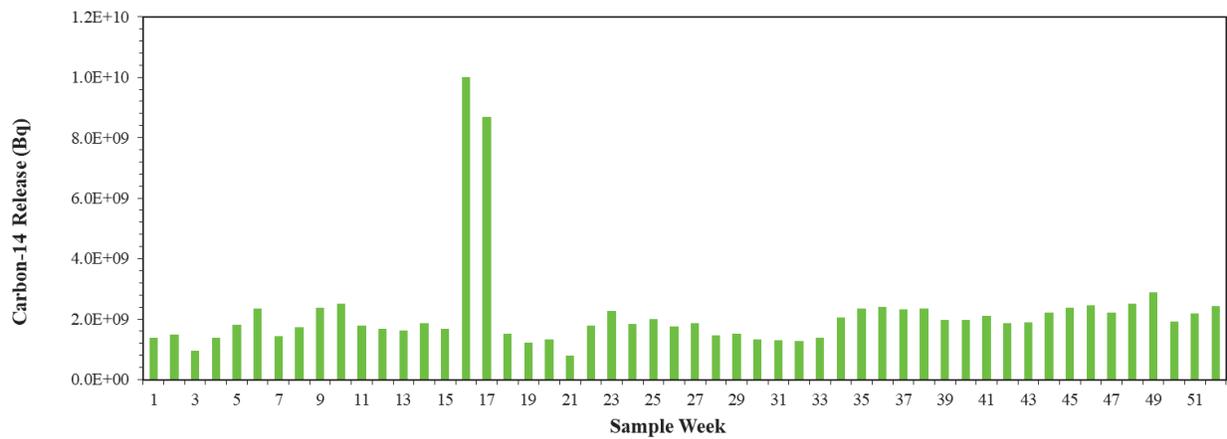
**Table 4.05: Carbon-14 (Carbon Dioxide) at Each Monitoring Location (Bq·m<sup>-3</sup>)**

<i>Location Code</i>		<i>F01</i>	<i>G02</i>	<i>H04</i>	<i>X03R</i>
<i>Location</i>		<i>Welch Cove</i>	<i>Lepreau Lighthouse</i>	<i>Former Information Centre Site</i>	<i>Fredericton Laboratory</i>
<i>Distance from PLNGS</i>		<i>1.6 km</i>	<i>1.0 km</i>	<i>0.75 km</i>	<i>100 km</i>
<b>Collection Start Date</b> The sample collection periods are approximately one month in duration. All sample stations are changed at the same time. The start date is the stop date for the previous sample.	01/01/2023	8.04E-02	7.63E-02	8.77E-02	<8.24E-02
	02/01/2023	1.07E-01	5.85E-02	<7.67E-02	8.15E-02
	03/01/2023	8.18E-02	<6.22E-02	<6.81E-02	6.66E-02
	04/01/2023	3.90E-02	4.36E-02	6.83E-02	<7.35E-02
	05/01/2023	5.76E-02	8.93E-02	4.65E-02	4.46E-02
	06/01/2023	<6.48E-02	4.93E-02	4.98E-02	<6.42E-02
	07/01/2023	4.71E-02	5.50E-02	7.45E-02	8.35E-02
	08/01/2023	8.92E-02	8.05E-02	7.64E-02	9.10E-02
	09/01/2023	6.91E-02	8.19E-02	8.11E-02	7.29E-02
	10/01/2023	<4.95E-02	1.17E-01	1.46E-01	<4.64E-02
	11/01/2023	4.57E-02	4.46E-02	6.55E-02	6.09E-02
	12/01/2023	4.84E-02	1.03E-01	6.22E-02	5.76E-02

## 4.4 Carbon Dioxide, Continued



**Figure 4.07: Carbon-14 (Carbon Dioxide) (Colour)**



**Figure 4.08: Gaseous C-14 Releases for 2023 (Colour)**

## 4.4 Carbon Dioxide, Continued

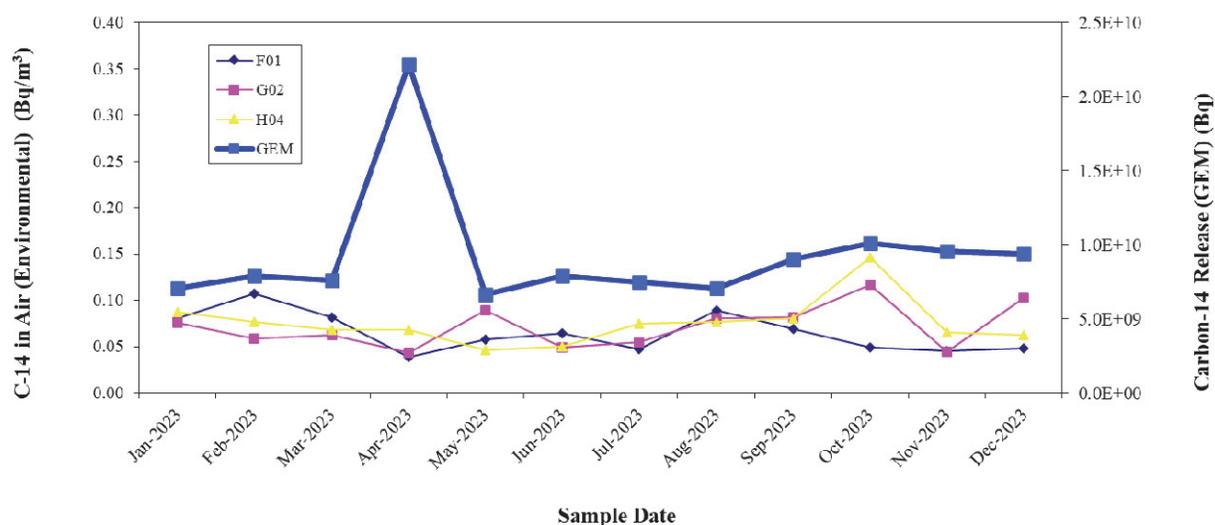


Figure 4.09: Gaseous C-14 Releases and C-14 (Carbon Dioxide) Results (Colour)

## 4.5 Ambient Gamma Measurements (TLD)

Gamma exposure measurements were slightly lower offsite compared with onsite. The elevated measurements were at the locations near the SRWMF and reactor building.

Ambient gamma radiation is measured by TLDs at the 75 locations shown in Figures 3.03 to 3.06. Forty-six of these locations are near the SRWMF. TLDs are changed quarterly.

The average annual measurement at the SRWMF ( $994 \mu\text{Gy}\cdot\text{a}^{-1}$ ) is higher than other onsite locations ( $711 \mu\text{Gy}\cdot\text{a}^{-1}$ ). The measurements onsite, excluding the SRWMF, are not significantly different from those at offsite locations ( $700 \mu\text{Gy}\cdot\text{a}^{-1}$ ) including the reference location ( $689 \mu\text{Gy}\cdot\text{a}^{-1}$ ).

Data are given in Table 4.06. Measurements at the SRWMF locations (I11A to I11T on the perimeter fence of the SRWMF-Phase 1, I21A to I21L on the perimeter fence of the SRWMF-Phase 2 and I31A to I31T on the perimeter fence of the SRWMF-Phase 3) are mostly due to low-level waste, used fuel emplacement and refurbishment components, and not to station releases. There were 10 concrete canisters filled and sealed throughout 2023. A small, but indefinable, portion of the measurement on the TLDs at the SRWMF is due to enhanced natural radiation from the aggregate used in making the concrete structures. Figure 4.10 compares the reference location results with the results for other locations.

## 4.5 Ambient Gamma Measurements (TLD), Continued

*Table 4.06: Ambient Gamma – TLD ( $\mu\text{Gy}$ ) (+/- 10%)*

<i>Location</i>	<i>1<sup>st</sup> Quarter</i>	<i>2<sup>nd</sup> Quarter</i>	<i>3<sup>rd</sup> Quarter</i>	<i>4<sup>th</sup> Quarter</i>	<i>Year</i>
<i>A13R</i>	1.51E+02	1.82E+02	1.81E+02	1.75E+02	6.89E+02
<i>B03</i>	1.41E+02	1.60E+02	1.54E+02	1.58E+02	6.13E+02
<i>C03</i>	2.00E+02	2.11E+02	2.14E+02	2.18E+02	8.43E+02
<i>D02</i>	1.61E+02	1.82E+02	1.78E+02	1.88E+02	7.09E+02
<i>E01</i>	1.45E+02	1.58E+02	1.59E+02	1.66E+02	6.28E+02
<i>E04</i>	1.62E+02	1.85E+02	1.92E+02	1.85E+02	7.24E+02
<i>E05</i>	1.63E+02	1.77E+02	1.78E+02	1.80E+02	6.98E+02
<i>E06</i>	2.30E+02	2.49E+02	2.55E+02	2.54E+02	9.88E+02
<i>F01</i>	1.19E+02	1.34E+02	1.33E+02	1.30E+02	5.16E+02
<i>G02</i>	1.74E+02	1.80E+02	1.96E+02	1.81E+02	7.31E+02
<i>H04</i>	1.37E+02	1.54E+02	1.54E+02	1.55E+02	6.00E+02
<i>H05</i>	1.10E+02	1.36E+02	1.16E+02	1.21E+02	4.83E+02
<i>I11A</i>	2.21E+02	2.44E+02	2.35E+02	2.47E+02	9.47E+02
<i>I11B</i>	2.26E+02	2.45E+02	2.33E+02	2.51E+02	9.55E+02
<i>I11C</i>	2.23E+02	2.39E+02	2.39E+02	2.36E+02	9.37E+02
<i>I11D</i>	2.15E+02	2.37E+02	2.33E+02	2.39E+02	9.24E+02
<i>I11E</i>	2.21E+02	2.31E+02	2.45E+02	2.41E+02	9.38E+02
<i>I11F</i>	2.27E+02	2.57E+02	2.46E+02	2.46E+02	9.76E+02
<i>I11J</i>	2.29E+02	3.24E+02	2.67E+02	2.43E+02	1.06E+03
<i>I11K</i>	2.11E+02	2.27E+02	2.28E+02	2.43E+02	9.09E+02
<i>I11L</i>	2.07E+02	2.28E+02	2.36E+02	2.41E+02	9.12E+02
<i>I11M</i>	2.14E+02	2.52E+02	2.49E+02	2.70E+02	9.85E+02
<i>I11N</i>	2.17E+02	2.43E+02	2.46E+02	2.68E+02	9.74E+02
<i>I11O</i>	2.33E+02	2.76E+02	2.62E+02	2.75E+02	1.05E+03
<i>I11P</i>	2.58E+02	3.05E+02	2.98E+02	2.90E+02	1.15E+03
<i>I11Q</i>	2.46E+02	3.09E+02	2.80E+02	2.81E+02	1.12E+03
<i>I11S</i>	2.27E+02	2.59E+02	2.47E+02	2.61E+02	9.94E+02
<i>I11T</i>	2.44E+02	2.89E+02	2.55E+02	2.59E+02	1.05E+03
<i>I21A</i>	2.19E+02	2.28E+02	2.38E+02	2.94E+02	9.79E+02
<i>I21B</i>	2.56E+02	2.75E+02	2.75E+02	2.82E+02	1.09E+03
<i>I21C</i>	1.98E+02	2.07E+02	2.14E+02	2.13E+02	8.32E+02
<i>I21D</i>	2.51E+02	2.73E+02	2.62E+02	2.90E+02	1.08E+03
<i>I21E</i>	2.37E+02	2.49E+02	2.51E+02	2.59E+02	9.96E+02
<i>I21F</i>	2.21E+02	2.07E+02	2.17E+02	2.17E+02	8.62E+02
<i>I21G</i>	2.17E+02	2.04E+02	2.23E+02	2.21E+02	8.65E+02
<i>I21H</i>	2.67E+02	2.81E+02	2.96E+02	3.14E+02	1.16E+03

## 4.5 Ambient Gamma Measurements (TLD), Continued

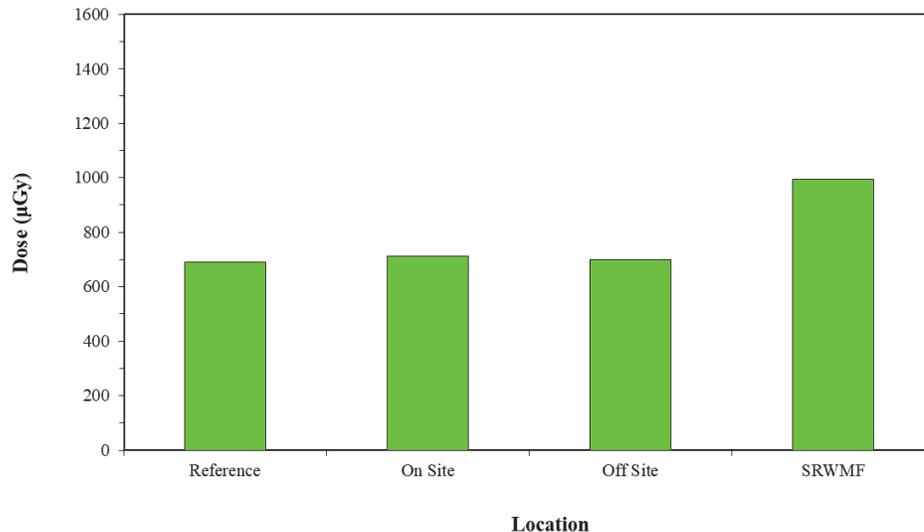
*Table 4.06: Ambient Gamma – TLD ( $\mu\text{Gy}$ ) (+/- 10%), Continued*

<i>Location</i>	<i>1<sup>st</sup> Quarter</i>	<i>2<sup>nd</sup> Quarter</i>	<i>3<sup>rd</sup> Quarter</i>	<i>4<sup>th</sup> Quarter</i>	<i>Year</i>
<i>I21I</i>	2.39E+02	2.42E+02	2.54E+02	2.98E+02	1.03E+03
<i>I21J</i>	4.52E+02	4.39E+02	4.36E+02	4.87E+02	1.81E+03
<i>I21K</i>	2.08E+02	2.22E+02	2.15E+02	2.46E+02	8.91E+02
<i>I21L</i>	2.05E+02	2.15E+02	2.12E+02	2.22E+02	8.54E+02
<i>I31A</i>	2.03E+02	2.17E+02	2.15E+02	2.31E+02	8.66E+02
<i>I31B</i>	2.21E+02	2.27E+02	2.32E+02	2.24E+02	9.04E+02
<i>I31C</i>	2.29E+02	2.44E+02	2.47E+02	2.43E+02	9.63E+02
<i>I31D</i>	2.51E+02	2.54E+02	2.61E+02	2.59E+02	1.02E+03
<i>I31E</i>	2.45E+02	2.48E+02	2.38E+02	2.59E+02	9.90E+02
<i>I31F</i>	2.82E+02	2.61E+02	2.70E+02	2.76E+02	1.09E+03
<i>I31G</i>	2.64E+02	2.50E+02	2.49E+02	2.71E+02	1.03E+03
<i>I31H</i>	2.48E+02	2.52E+02	2.62E+02	2.61E+02	1.02E+03
<i>I31I</i>	2.35E+02	2.45E+02	2.47E+02	2.54E+02	9.81E+02
<i>I31J</i>	2.38E+02	2.36E+02	2.55E+02	2.61E+02	9.90E+02
<i>I31K</i>	2.30E+02	2.49E+02	2.24E+02	2.54E+02	9.57E+02
<i>I31L</i>	2.13E+02	2.20E+02	2.34E+02	2.24E+02	8.91E+02
<i>I31M</i>	2.26E+02	2.40E+02	2.37E+02	2.40E+02	9.43E+02
<i>I31N</i>	2.23E+02	2.51E+02	2.40E+02	2.42E+02	9.56E+02
<i>I31P</i>	2.28E+02	2.44E+02	2.49E+02	2.48E+02	9.69E+02
<i>I31Q</i>	2.37E+02	2.77E+02	2.33E+02	2.50E+02	9.97E+02
<i>I31S</i>	2.33E+02	2.91E+02	2.29E+02	2.39E+02	9.92E+02
<i>I31T</i>	2.03E+02	2.14E+02	2.11E+02	2.18E+02	8.46E+02
<i>I86</i>	1.46E+02	1.65E+02	1.62E+02	2.10E+02	6.83E+02
<i>I87</i>	1.39E+02	2.00E+02	1.71E+02	1.67E+02	6.77E+02
<i>I88</i>	1.43E+02	1.70E+02	1.72E+02	1.67E+02	6.52E+02
<i>I89</i>	1.53E+02	1.75E+02	1.72E+02	1.75E+02	6.75E+02
<i>J20</i>	1.96E+02	1.86E+02	1.86E+02	1.94E+02	7.62E+02
<i>J35</i>	2.03E+02	2.27E+02	2.11E+02	2.25E+02	8.66E+02
<i>K01</i>	1.99E+02	1.98E+02	1.98E+02	2.01E+02	7.96E+02
<i>L01</i>	1.73E+02	1.88E+02	1.97E+02	1.98E+02	7.56E+02
<i>L03</i>	2.02E+02	2.14E+02	2.16E+02	2.20E+02	8.52E+02
<i>L04</i>	1.85E+02	1.91E+02	1.91E+02	1.96E+02	7.63E+02
<i>M02</i>	1.62E+02	1.61E+02	1.72E+02	1.69E+02	6.64E+02
<i>N01</i>	1.56E+02	1.77E+02	1.73E+02	1.75E+02	6.81E+02
<i>P03</i>	1.40E+02	1.60E+02	1.71E+02	1.69E+02	6.40E+02

## 4.5 Ambient Gamma Measurements (TLD), Continued

**Table 4.06: Ambient Gamma – TLD ( $\mu\text{Gy}$ ) (+/- 10%), Continued**

Location	1 <sup>st</sup> Quarter	2 <sup>nd</sup> Quarter	3 <sup>rd</sup> Quarter	4 <sup>th</sup> Quarter	Year
<b>YTL1</b>	1.27E+02	1.46E+02	1.44E+02	1.58E+02	5.75E+02
<b>YTL2</b>	1.29E+02	1.36E+02	1.45E+02	1.53E+02	5.63E+02
<b>YTL3</b>	1.52E+02	2.03E+02	2.80E+02	1.99E+02	8.34E+02
<b>YTL4</b>	1.49E+02	1.88E+02	2.51E+02	1.98E+02	7.86E+02



**Figure 4.10: Mean Ambient Gamma (TLD) Results 2023 (Colour)**

## 4.6 GEM Particulates (Sr-89,90)

When Sr-89,90 releases are low, the expected concentration of Sr-89,90 in environmental air samples is below the detection limit. The GEM monitors PLNGS gaseous releases continuously at their source. The GEM filter is changed weekly and sent to the Fredericton lab for analysis. Each of the fifty-three GEM filters was analyzed for Sr-89,90; the low level activity detected was well below station and regulatory limits.

## 4.7 Well Water

The Health Canada, 2010 *Guidelines for Canadian Drinking Water Quality* (Federal-Provincial-Territorial Committee on Drinking Water of the Federal-Provincial-Territorial Committee on Health and the Environment) recommends  $7.0\text{E}+03 \text{ Bq}\cdot\text{L}^{-1}$  as the maximum acceptable average concentration for H-3 in drinking water.

Of the 21 samples analyzed, 11 wells detected tritium (below the Health Canada guidelines). These results are attributable to the operation of PLNGS.

Water is collected annually at five locations and semi-annually at eight locations (*Figure 3.05*). Results are consistent with previous years at these locations.

Detected H-3 concentrations ranged from  $2.21\text{E}+01$  to  $7.8\text{E}+01 \text{ Bq}\cdot\text{L}^{-1}$ , with the highest concentration detected in an on-site well. Tritium from PLNGS releases washes out into precipitation and subsequently drains into some of the wells. Precipitation analyses (*Section 4.13*) indicate H-3 concentrations ranging from  $1.35\text{E}+01$  to  $7.81\text{E}+02 \text{ Bq}\cdot\text{L}^{-1}$  in 37 of 47 samples.

Gross alpha/beta analysis is performed if there are significant gamma emitters detected. Sr-89/90 analysis is performed if gross alpha/beta levels are twice the normal. Neither of these scenarios occurred in 2023.

Since C-14 releases are low, the expected concentration of C-14 in well water is below the detection limit. If the weekly C-14 releases are more than one percent of the weekly DRL, a C-14 analysis is performed on well water. Since the C-14 releases in 2023 were  $8.97\text{E}-04\%$  DRL (and in no week exceeded one percent of the weekly DRL), no further analyses were required. *Figure 4.08* shows the weekly C-14 releases.

*Table 4.07* is a summary of the detected radionuclides in well water. *Figures 4.11* shows the H-3 results for each sample. “Less Than” values are plotted for non-detected results. The H-3 measurements were made after samples had been allowed to sit for up to two weeks to reduce radioactive interference from the relatively abundant, but short half-life, radon progeny which are common in most well waters.

## 4.7 Well Water, Continued

*Table 4.07: Well Water (Bq·L<sup>-1</sup>)*

<i>Analysis Type</i>	<i>Total Number</i>	<i>Indicator Locations</i>				<i>Reference Location</i>			
		<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>	<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>
<i>H-3</i>	21	3.9E+01	2.21E+01	7.8E+01	11 of 19	ND	ND	ND	0 of 2

ND – Not Detected - the activity is less than or equal to the Critical Level (99% Confidence Level).

### 4.7 Well Water, Continued

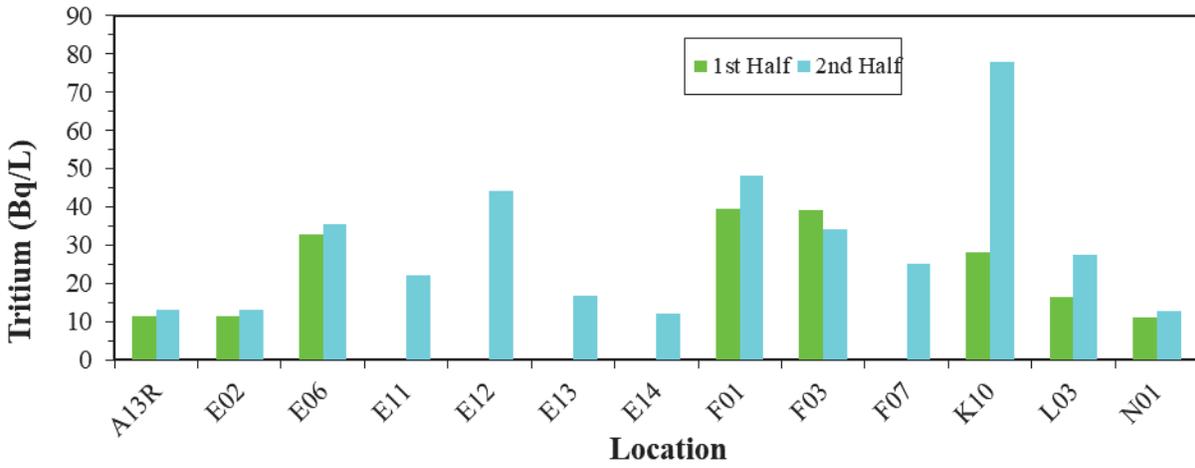


Figure 4.11: Tritium (Well Water) 2023 (Colour)

## 4.8 Pond/Puddle/Surface Water

Low levels of H-3 were detected in 34 of the 34 samples. No gamma emitters were detected in these samples.

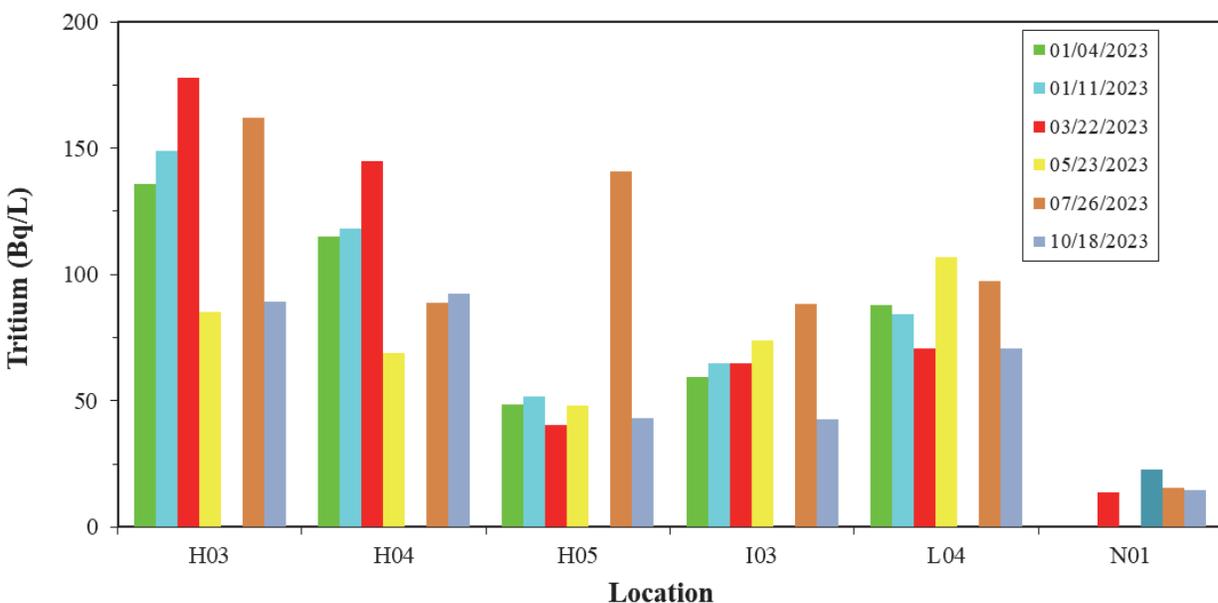
This category includes ponds, lakes, streams, and runoff samples. All these sampling locations are onsite except for one (N01).

Detected H-3 activities ranged from  $1.38\text{E}+01$  to  $1.78\text{E}+02$  Bq·L<sup>-1</sup>. Variability can be due to the size of the water reservoir and the length of time the sample has remained at the location. Tritium from PLNGS releases washes out into precipitation. Precipitation analyses (*Section 4.13*) indicate H-3 concentrations ranging from  $1.35\text{E}+01$  to  $7.81\text{E}+02$  Bq·L<sup>-1</sup> in 37 of 47 samples.

Gross alpha/beta analysis is performed if there are significant gamma emitters detected. This did not occur in 2023.

Since C-14 releases are low, the expected concentration of C-14 in water is below the detection limit. If the weekly C-14 releases are more than one percent of the weekly DRL, a C-14 analysis is performed on water. Since the C-14 releases in 2023 were  $8.97\text{E}-04\%$  DRL (and in no week exceeded one percent of the weekly DRL), no further analyses were required. Figure 4.08 shows the weekly C-14 releases.

Table 4.08 is a summary of the detected radionuclides in surface water. Figure 4.12 shows H-3 results for each location. “Less Than” values are plotted for non-detected results.



**Figure 4.12: Tritium (Pond/Puddle/Surface Water) 2023 (Colour)**

## 4.8 Pond/Puddle/Surface Water, Continued

**Table 4.08: Pond/Puddle/Surface Water (Bq·L<sup>-1</sup>)**

<i>Analysis Type</i>	<i>Total Number</i>	<i>Indicator Locations</i>				<i>Reference Location</i>			
		<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>	<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>
<b>H-3</b>	34	8.18E+01	1.38E+01	1.78E+02	34 of 34	*	*	*	*

\*There is no reference location.

## 4.9 Berries

Berries are sampled weekly when in season. Blueberries were collected from Pennfield, Lepreau, the SRWMF and Oxford, Nova Scotia.

Naturally occurring K-40 was detected in two of the six samples collected. These results are not attributable to the operation of PLNGS.

Since H-3 releases are low, the expected concentrations of H-3 in berries are below the detection limits. If the H-3 weekly releases are more than one percent of the weekly DRL, then H-3 analysis is performed on berries. Since the releases in 2023 were 7.02E-02% DRL for H-3 (and never exceeded one percent of the weekly DRL), no further analyses were required. Figure 4.05 shows the weekly H-3 releases.

Table 4.09 is a summary of the detected radionuclides in berries.

## 4.9 Berries, Continued

*Table 4.09: Berries (Bq·kg<sup>-1</sup>)*

<i>Analysis Type</i>	<i>Total Number</i>	<i>Indicator Locations</i>				<i>Reference Location</i>			
		<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>	<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>
<i>K-40</i>	6	9.69E+01	9.69E+01	9.69E+01	1 of 5	1.63E+01	1.63E+01	1.63E+01	1 of 1

## 4.10 Garden Vegetables

Garden vegetables are collected weekly in season. Most samples were taken from a local garden in Dipper Harbour (3 km NE of PLNGS). The remaining samples were taken from Lepreau Harbour (6 km SW of PLNGS).

As in most food samples, naturally occurring K-40 was detected in fourteen of the fifteen samples collected. These results are not attributable to the operation of PLNGS.

Since H-3 and C-14 releases are low, the expected concentrations of H-3 and C-14 in garden vegetables are below the detection limit. If the H-3 or C-14 weekly releases are more than one percent weekly DRL, then H-3 or C-14 analysis is performed on garden vegetables. Since the releases in 2023 were 7.02E-02% DRL for H-3 and 8.97E-04% DRL for C-14 (and in no week exceeded one percent of the weekly DRL), no further analyses were required. Figure 4.05 shows the weekly H-3 releases and Figure 4.08 shows the weekly C-14 releases.

Table 4.10 is a summary of the detected radionuclides in garden vegetables.

## 4.11 Vegetation

Vegetation samples are collected quarterly from three locations. One location is onsite and the remaining two are offsite (Dipper Harbour, Maces Bay). With the partnership of representatives of our First Nations communities, additional samples of cultural importance to First Nations were collected from the area (see *Appendix E*).

The environmental monitoring program at PLNGS has been augmented with the help of field monitors from the First Nations in New Brunswick. Through ongoing interaction with the First Nations, a comprehensive list of species of First Nations interest was developed based on what is present onsite. Samples of these species are acquired when available and incorporated into the PLNGS environmental monitoring program. Some species do not produce fruit every year, therefore some amount of flexibility in sampling frequency is natural. Species that are abundantly present onsite are sampled more frequently than those that are sparse. This is done to ensure that our sampling efforts do not negatively impact the plant resources present. When previously unidentified plant resources are discovered onsite, they are added to the sampling list and collected at a frequency that is appropriate for the resource.

Most vegetation samples consist of lichen and moss as they could concentrate a wide range of radionuclides and are sensitive indicators of radionuclides in the environment.

Cosmogenic Be-7 was detected in 19 of the 73 vegetation samples. Naturally occurring K-40 was detected in 11 of the 73 vegetation samples.

Table 4.11 is a summary of the detected radionuclides in vegetation.

## 4.11 Vegetation, Continued

**Table 4.10: Garden Vegetables ( $Bq \cdot kg^{-1}$ )**

<i>Analysis Type</i>	<i>Total Number</i>	<i>Indicator Locations</i>				<i>Reference Location</i>			
		<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>	<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>
<b><i>K-40</i></b>	15	1.5E+02	7.6E+01	3.7E+02	14 of 15	*	*	*	*

\*There is no reference location.

## 4.11 Vegetation, Continued

*Table 4.11: Vegetation (Bq·kg<sup>-1</sup>)*

<i>Analysis Type</i>	<i>Total Number</i>	<i>Indicator Locations</i>				<i>Reference Location</i>			
		<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>	<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>
<i>Be-7</i>	73	1.9E+02	5.6E+01	5.5E+02	19 of 73	*	*	*	*
<i>K-40</i>	73	1.5E+02	4.5E+01	2.4E+02	11 of 73	*	*	*	*

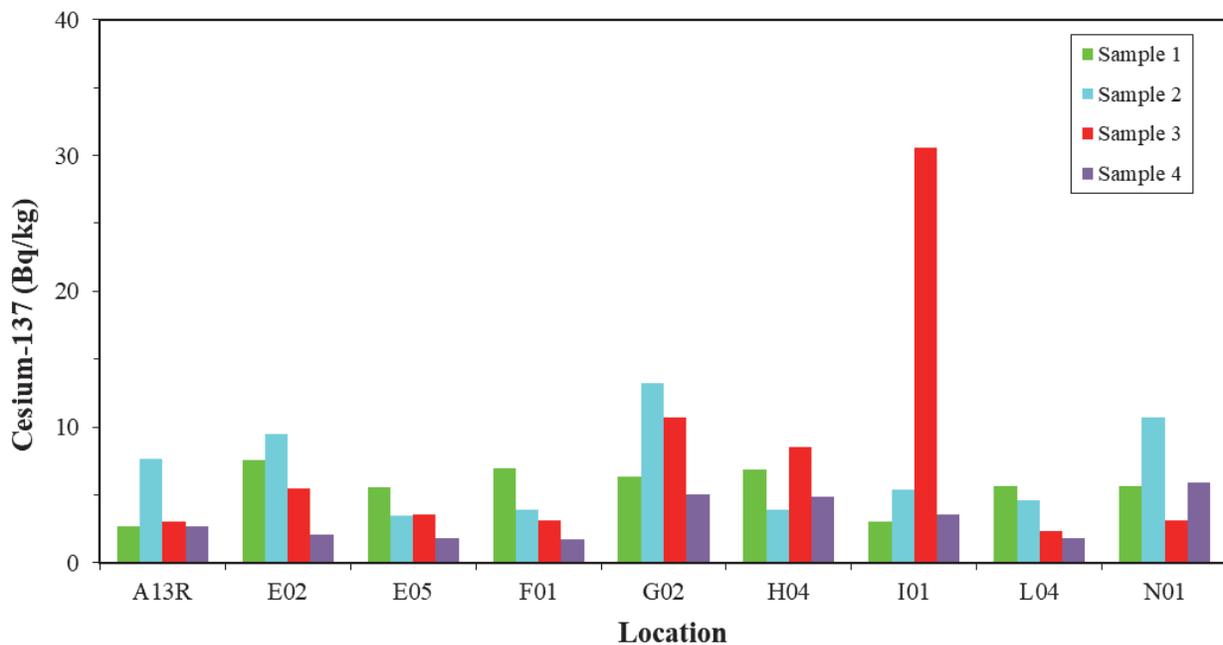
\* There is no reference location.

## 4.12 Soil

Soil samples are taken quarterly from the eight air monitoring location sites shown in Figure 3.05.

Thirty-two samples contained naturally occurring K-40 ( $2.39\text{E}+02$  to  $7.85\text{E}+02$   $\text{Bq}\cdot\text{kg}^{-1}$ ), 32 samples contained naturally occurring Ac-228 ( $1.05\text{E}+01$  to  $4.84\text{E}+01$   $\text{Bq}\cdot\text{kg}^{-1}$ ) and 21 samples contained Cs-137 ( $2.68\text{E}+00$  to  $3.06+01$   $\text{Bq}\cdot\text{kg}^{-1}$ ). Most Cs-137 results were at typical levels for the region. Cesium-137 from fallout of past atmospheric weapons tests and international events tends to accumulate in the organic layer of the soil. Most fluctuation in Cs-137 and K-40 levels seems to be due to the quantity of organic load in the sample. Levels seen in 2023 are comparable to those seen before PLNGS became operational. Cs-137 was not detected in gaseous effluents in 2023.

Table 4.12 is a summary of the detected radionuclides in soil. Figure 4.13 shows individual Cs-137. “Less Than” values are plotted for non-detected results.



**Figure 4.13: Cesium-137 (Soil) 2023 (Colour)**

## 4.12 Soil, Continued

*Table 4.12: Soil (Bq·kg<sup>-1</sup>)*

<i>Analysis Type</i>	<i>Total Number</i>	<i>Indicator Locations</i>				<i>Reference Location</i>			
		<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>	<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>
<i>Cs-137</i>	36	8.32E+00	3.54E+00	3.06E+01	19 of 32	5.15E+00	2.68E+00	7.63E+00	2 of 4
<i>Ac-228</i>	36	2.00E+01	1.05E+01	4.84E+01	28 of 32	1.78E+01	2.08E+01	2.17E+01	4 of 4
<i>K-40</i>	36	3.84E+02	2.39E+02	7.85E+02	28 of 32	4.11E+02	3.81E+02	4.42E+02	4 of 4

### 4.13 Precipitation

Precipitation is collected continuously at the four onsite air monitoring stations (locations shown in Figure 3.05). The samples are changed approximately monthly, depending on rainfall and freeze up.

Thirty-seven samples contained H-3 levels which spanned from 1.35E+01 to 7.81E+02 Bq·L<sup>-1</sup>. These results are attributed to PLNGS releases.

Since C-14 releases are low, the expected concentration of C-14 in water is below the detection limit. If the C-14 weekly releases are more than one percent of the weekly DRL, a C-14 analysis is performed on water. Since the C-14 releases in 2023 were 8.97E-04% DRL (and in no week exceeded one percent of the weekly DRL), no further analyses were required. Figure 4.08 shows the weekly C-14 releases.

Table 4.13 is a summary of the detected radionuclides in precipitation. Figures 4.03 and 4.04 show average monthly H-3 results and Figure 4.05 shows gaseous H-3 release. Figure 4.14 shows average monthly H-3 results and gaseous H-3 release. “Less Than” values are plotted for non-detected results.

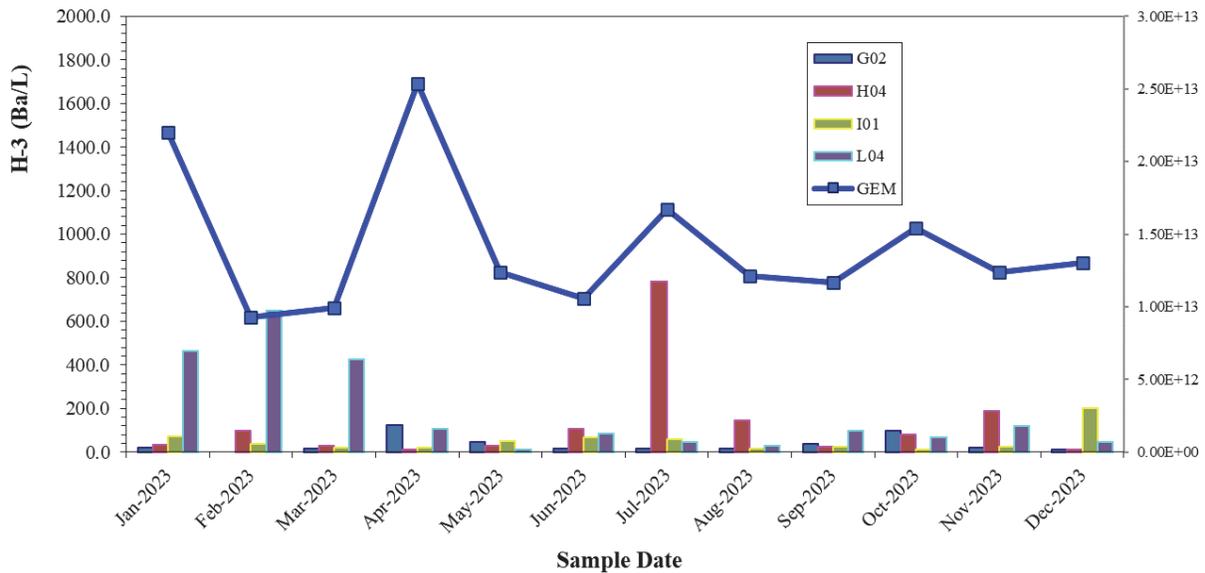


Figure 4.14: Gaseous H-3 Releases and Tritium (Precipitation) Results (Colour)

## 4.13 Precipitation, Continued

*Table 4.13: Precipitation (Bq·L<sup>-1</sup>)*

<i>Analysis Type</i>	<i>Total Number</i>	<i>Indicator Locations</i>				<i>Reference Location</i>			
		<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>	<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>
<i>H-3</i>	47	1.23E+02	1.35E+01	7.81E+02	37 of 47	*	*	*	*

\* There is no reference location.

## 4.14 Monitoring Well Water, Near Plant

Fourteen monitoring wells are typically sampled once per year. This frequency will be increased for some or all wells if H-3 concentrations greater than 7000 Bq·L<sup>-1</sup> are detected. As well, additional samples may be collected if an abnormal release is suspected, or an elevated result is obtained. No abnormal sample results were detected in environmental samples taken. Additional samples were taken in early 2023 to confirm readings near plant following station conditions.

Tritium concentrations averaged 3.81E+01 Bq·L<sup>-1</sup> ranging up to 1.38E+03 Bq·L<sup>-1</sup>. These results are attributed to PLNGS releases.

Table 4.14 is a summary of the detected radionuclides in monitoring well water. Figure 4.15 shows individual H-3 results. “Less Than” values are plotted for non-detected results.

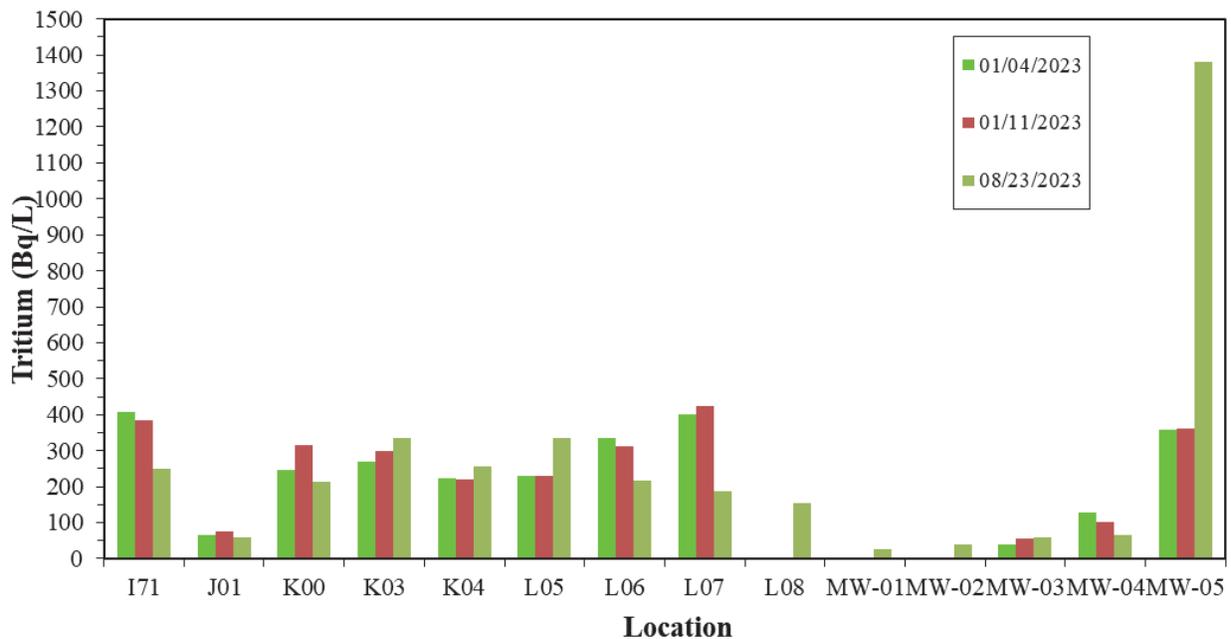


Figure 4.15: Tritium (Monitoring Well Water, Near Plant) 2023 (Colour)

#### 4.14 Monitoring Well Water, Near Plant, Continued

*Table 4.14: Monitoring Well Water, Near Plant (Bq·L<sup>-1</sup>)*

<i>Analysis Type</i>	<i>Total Number</i>	<i>Indicator Locations</i>				<i>Reference Location</i>			
		<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>	<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>
<i>H-3</i>	36	2.58E+02	3.81E+01	1.38E+03	35 of 36	*	*	*	*

\* There is no reference location.

## 4.15 Seawater

Seawater is collected quarterly from three locations close to PLNGS and one reference location near Saint John (shown in Figure 3.05).

Naturally occurring K-40 was detected ( $7.3\text{E}+00$  to  $1.1\text{E}+01$   $\text{Bq}\cdot\text{L}^{-1}$ ) in six samples. The K-40 results are not attributed to operation of PLNGS. Tritium was detected ( $1.28\text{E}+01$  to  $2.76\text{E}+01$   $\text{Bq}\cdot\text{L}^{-1}$ ) in four of the samples. The H-3 results are attributed to PLNGS operations. Calculations suggest that the 2023 average concentration of tritium in seawater, due to releases from PLNGS in the approved liquid pathway, would be about  $5\text{E}+00$   $\text{Bq}\cdot\text{L}^{-1}$  at the out-fall (samples are taken from the closest accessible shoreline nearby). This calculation considers the total tritium released over the year, the flow rate of the condenser cooling water (about  $2.5\text{E}+01$   $\text{m}^3\cdot\text{s}^{-1}$ ), and tidal mixing. A dilution factor of 20 is assumed for tidal mixing at the out-fall during normal coolant flows. For collection further away from the outfall, a tidal mixing factor of 40, or even higher, is more realistic. A factor of 40 would result in an average H-3 concentration of about  $2\text{E}+00$   $\text{Bq}\cdot\text{L}^{-1}$  in seawater during 2023 at the H03 location. In past years, when samples were taken soon after pumping out higher than usual amounts of H-3, the results were much less than the predicted levels. These results further confirm the conservatism in the calculation.

When C-14 and Sr-89,90 releases are low, the expected concentration of these radionuclides in seawater is below the detection limit. If the monthly releases are more than one percent of the monthly DRL, a C-14 or Sr-89,90 analysis is performed on seawater. Since the liquid releases in 2023 were  $9.92\text{E}-04\%$  DRL for C-14 and  $3.35\text{E}-09\%$  DRL for Sr-90 (and in no month exceeded one percent of the monthly DRL), no further analyses were required. Strontium-89 was not detected in releases. Figure 4.16 shows the monthly H-3 releases. Figure 4.17 shows the monthly C-14 releases.

Table 4.15 is a summary of the detected radionuclides in seawater.

## 4.15 Seawater, Continued

**Table 4.15: Seawater (Bq·L<sup>-1</sup>)**

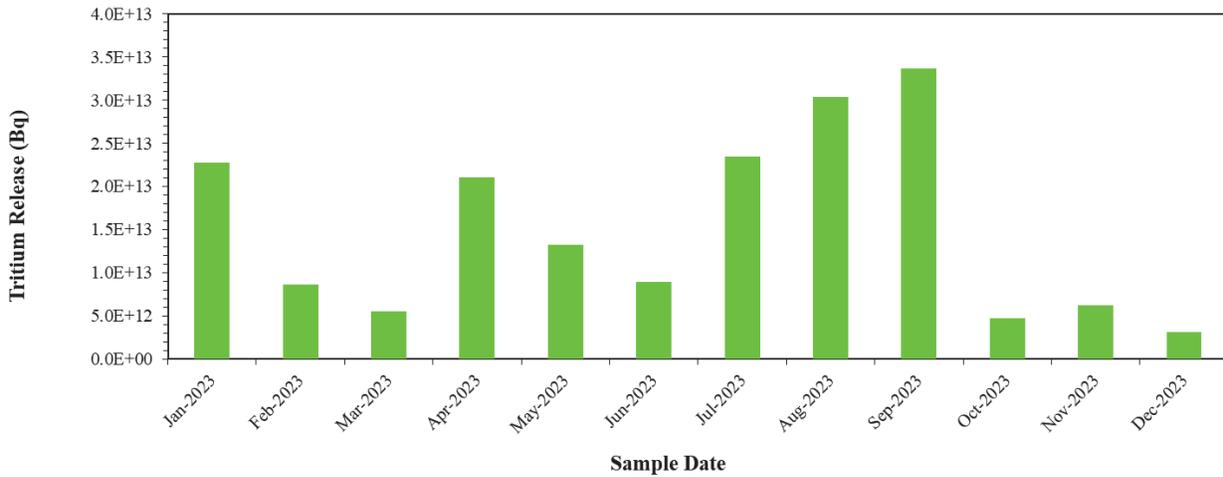
<i>Analysis Type</i>	<i>Total Number</i>	<i>Indicator Locations</i>				<i>Reference Location</i>			
		<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>	<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>
<i>H-3</i>	16	1.85E+01	1.28E+01	2.76E+01	3 of 12	1.64E+01	1.64E+01	1.64E+01	1 of 4
<i>K-40</i>	16	9.1E+00	7.3E+00	1.1E+01	6 of 12	ND	ND	ND	0 of 4

ND – Not Detected - the activity is less than or equal to the Critical Level (99% Confidence Level).

## 4.16 Tritium and C-14 Analyses of Seafood

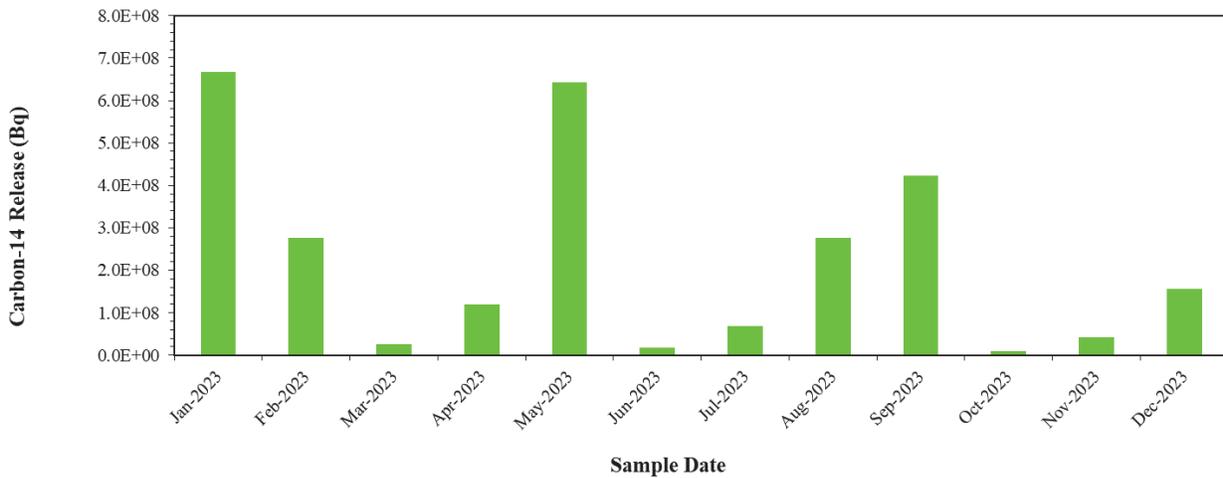
When H-3 and C-14 releases are low, the expected concentrations of these radionuclides in seafood are below the detection limit. If the monthly releases are more than one percent of the monthly DRL, a H-3 or C-14 analysis is performed on seafood. Since the releases in 2023 were  $7.78\text{E-}04\%$  DRL for H-3 and  $9.92\text{E-}04\%$  DRL for C-14 (and in no month exceeded one percent of the monthly DRL), no further analyses were required. Figures 4.16 and 4.17 show the monthly releases of these radionuclides from the Station in liquid effluents for 2023.

### 4.16 Tritium and C-14 Analyses of Seafood, Continued



**NOTE**  
The Monthly DRL for H-3 is 3.80E+18 Bq.

**Figure 4.16: Liquid H-3 Releases for 2023 (Colour)**



**NOTE**  
The Monthly DRL for C-14 is 3.1E+13 Bq.

**Figure 4.17: Liquid C-14 Releases for 2023 (Colour)**

## 4.17 Seafood

Potassium-40 is usually detected in these samples. The results are not attributable to the operation of PLNGS. Figure 3.05 shows the locations for most of these samples.

**Clams** – Six samples were collected (one from Pocologan and Lorneville, two each from St. Andrews and New River Beach). Data are shown in Table 4.16.

**Dulse** - Four samples were collected (two from Maces Bay, one from Grand Manan and Lepreau). Dulse is an edible seaweed that is a popular snack food in the area. Data are shown in Table 4.17.

**Fish** - The fish category now tends to be made up of haddock, if they are available at all. Two samples of haddock were collected close to Nova Scotia. Data are shown in Table 4.18.

**Lobster** – Two samples were collected (one from the Lepreau area and one from the Saint Andrews area). As recommended by the First Nations of New Brunswick, the liver (tomalley), was included in the sample. Data are shown in Table 4.19

**Periwinkles** – Eight samples were collected (four each from Dipper Harbor and Maces Bay). Data are shown in Table 4.20.

**Aquaculture Salmon** - Four samples were collected (one from the Lepreau area and three from Back Bay). Data are shown in Table 4.21.

#### 4.17 Seafood, Continued

**Table 4.16: Clams, Edible, Raw Mass (Bq·kg<sup>-1</sup>)**

<i>Analysis Type</i>	<i>Total Number</i>	<i>Indicator Locations</i>				<i>Reference Location</i>			
		<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>	<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>
<b>K-40</b>	6	5.4E+02	3.5E+02	7.0E+02	3 of 3	1.3E+03	1.3E+03	1.3E+03	1 of 3

**Table 4.17: Dulse, Wet Mass (Bq·kg<sup>-1</sup>)**

<i>Analysis Type</i>	<i>Total Number</i>	<i>Indicator Locations</i>				<i>Reference Location</i>			
		<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>	<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>
<b>K-40</b>	4	1.92E+02	2.75E+01	3.46E+02	3 of 3	2.53E+02	2.53E+02	2.53E+02	1 of 1

## 4.17 Seafood, Continued

**Table 4.18: Fish, Raw Mass ( $Bq \cdot kg^{-1}$ )**

<i>Analysis Type</i>	<i>Total Number</i>	<i>Indicator Locations</i>				<i>Reference Location</i>			
		<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>	<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>
<b>K-40</b>	2	*	*	*	*	1.53E+02	1.23E+02	1.83E+02	2 of 2

\* No indicator sample available.

**Table 4.19: Lobster, Edible, Cooked Mass ( $Bq \cdot kg^{-1}$ )**

<i>Analysis Type</i>	<i>Total Number</i>	<i>Indicator Locations</i>				<i>Reference Location</i>			
		<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>	<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>
<b>K-40</b>	2	7.0E+01	7.0E+01	7.0E+01	1 of 1	1.55E+02	1.55E+02	1.55E+02	1 of 1

## 4.17 Seafood, Continued

**Table 4.20: Periwinkles, Edible, Raw Mass ( $Bq \cdot kg^{-1}$ )**

<i>Analysis Type</i>	<i>Total Number</i>	<i>Indicator Locations</i>				<i>Reference Location</i>			
		<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>	<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>
<i>K-40</i>	8	ND	ND	ND	0 of 8	*	*	*	*

ND – Not Detected - the activity is less than or equal to the Critical Level (99% Confidence Level).

\*There is no reference location.

**Table 4.21: Aquaculture Salmon, Raw Mass ( $Bq \cdot kg^{-1}$ )**

<i>Analysis Type</i>	<i>Total Number</i>	<i>Indicator Locations</i>				<i>Reference Location</i>			
		<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>	<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>
<i>K-40</i>	4	1.8E+02	1.8E+02	1.8E+02	1 of 1	1.73E+02	1.27E+02	2.19E+02	2 of 3

## 4.17 Seafood, Continued

**Table 4.22: Sea Plants, Wet Mass ( $Bq \cdot kg^{-1}$ )**

<i>Analysis Type</i>	<i>Total Number</i>	<i>Indicator Locations</i>				<i>Reference Location</i>			
		<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>	<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>
<i>K-40</i>	5	2.0E+02	1.6E+02	2.6E+02	5 of 5	*	*	*	*

\*There is no reference location.

## 4.18 Other Sea Plants

Potassium-40 was detected in five of the five samples analyzed. These results are not attributable to the operation of PLNGS.

Sea plants other than dulse are analyzed. Various species of seaweed (for example, *Ascophyllum*) occur on the rocks on the Point Lepreau peninsula and are collected quarterly. Sample locations are shown in Figure 3.05.

Naturally occurring K-40 ranged from  $1.6\text{E}+02$  to  $2.6\text{E}+02$   $\text{Bq}\cdot\text{kg}^{-1}$ . Data are shown in Table 4.22.

## 4.19 Sediment

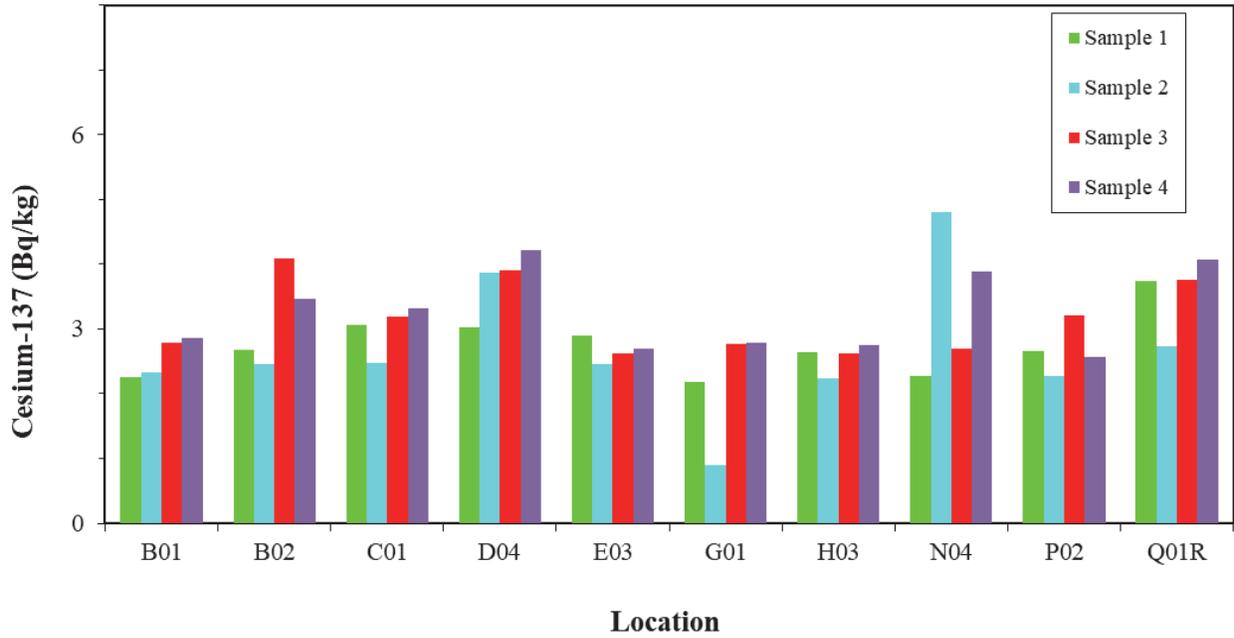
Sediments are collected quarterly from ten locations shown in Figure 3.05. The finer grains are analyzed by selective sieving of the material.

Forty samples contained K-40 ( $1.33\text{E}+02$  to  $1.09\text{E}+03$   $\text{Bq}\cdot\text{kg}^{-1}$ ) from the natural potassium in feldspar, a common mineral. One sample contained cosmogenic produced Be-7 ( $3.56\text{E}+01$   $\text{Bq}\cdot\text{kg}^{-1}$ ). Thirty-eight samples contained Ac-228 ( $9.26\text{E}+00$  to  $4.70\text{E}+01$   $\text{Bq}\cdot\text{kg}^{-1}$ ), a radioactive progeny of naturally occurring Th-232. None of these results are attributable to the operation of PLNGS.

No Cs-137 was detected in samples taken in 2023.

Table 4.23 is a summary of the detected radionuclides in sediment. Figure 4.18 shows individual Cs-137 results. “Less Than” values are plotted for non-detected results. In 2023, all values were “Less Than” values.

**4.19 Sediment, Continued**



**Figure 4.18: Cesium-137 (Sediment) 2023 (Colour)**

**4.19 Sediment, Continued****Table 4.23: Sediment (Bq·kg<sup>-1</sup>)**

<i>Analysis Type</i>	<i>Total Number</i>	<i>Indicator Locations</i>				<i>Reference Location</i>			
		<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>	<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>
<i>Be-7</i>	40	3.56E+01	3.56E+01	3.56E+01	1 of 36	ND	ND	ND	0 of 4
<i>Ac-228</i>	40	2.33E+01	9.26E+00	4.70E+01	34 of 36	2.22E+01	1.69E+01	2.79E+01	4 of 4
<i>K-40</i>	40	7.04E+02	1.33E+02	1.09E+03	36 of 36	6.67E+02	5.61E+02	8.23E+02	4 of 4

ND – Not Detected - the activity is less than or equal to the Critical Level (99% Confidence Level).

## 4.20 Ambient Gamma Measurements of Intertidal Zone

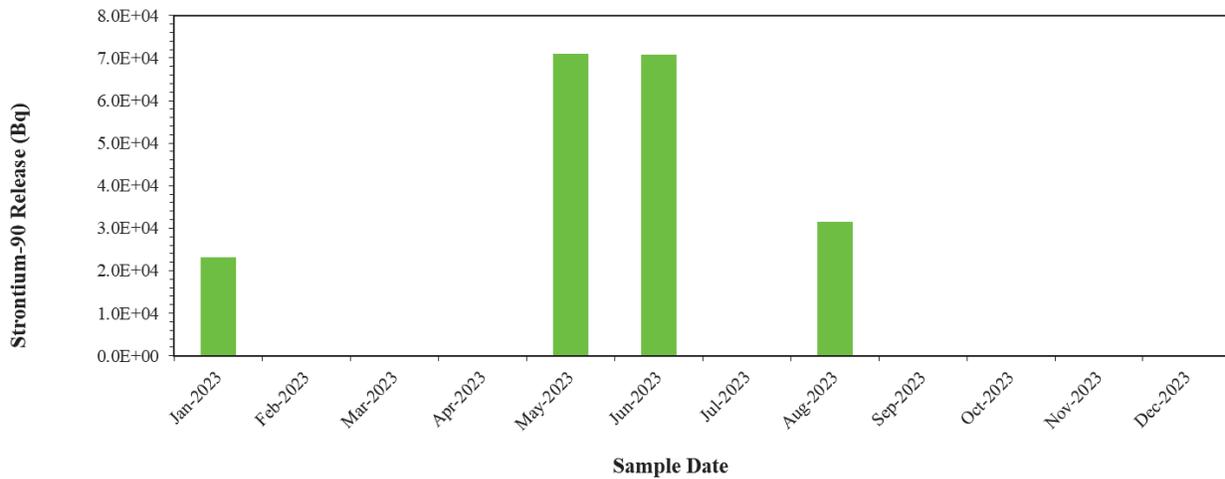
Environmental gamma survey measurements are made in the intertidal zone on beaches in the Lepreau area and at the reference location 28 km to the east-northeast (Figure 3.05). Beach surveys are performed, and grab samples of sediments are analyzed. Radiation values measured in 2023 were consistent with those measured prior to Point Lepreau Nuclear Generation becoming operational in 1982. These values are summarized in Table 4.24.

**Table 4.24: Ambient Gamma Measurements of Intertidal Zone – ( $\mu\text{Sv}\cdot\text{h}^{-1}$ )**

<i>Location</i>	<i>1<sup>st</sup> Quarter</i>	<i>2<sup>nd</sup> Quarter</i>	<i>3<sup>rd</sup> Quarter</i>	<i>4<sup>th</sup> Quarter</i>
<i>B01</i>	0.17	0.10	0.18	0.12
<i>B02</i>	0.14	0.16	0.20	0.11
<i>C01</i>	0.19	0.16	0.10	0.12
<i>D04</i>	0.60	0.80	0.90	0.70
<i>E03</i>	0.17	0.10	0.18	0.12
<i>G01</i>	0.14	0.16	0.20	0.11
<i>H03</i>	0.19	0.16	0.10	0.12
<i>N04</i>	0.60	0.80	0.90	0.70
<i>P02</i>	0.17	0.10	0.18	0.12
<i>Q01R</i>	0.14	0.16	0.20	0.11

## 4.21 LEM Composite Water (Sr-89,90)

When Sr-89,90 releases are low, the expected concentration of Sr-89,90 in seawater is below the detection limit. The Liquid Effluent Monitor (LEM) collects samples of PLNGS liquid releases at their source. A monthly composite is sent to the lab for analysis. Fourteen of these composites were analyzed for Sr-89,90. If the monthly releases are higher than one percent of the monthly DRL, a Sr-89,90 analysis is performed on seawater. Since the releases in 2023 were 3.35E-09% DRL (and in no month exceeded one percent of the monthly DRL) for Sr-90, and Sr-89 was not detected, no further analyses were required. Figure 4.19 shows the Sr-90 releases from PLNGS.



**NOTE**  
 The Monthly DRL for Sr-90 is 4.9E+14 Bq.

**Figure 4.19: Liquid Sr-90 Releases for 2023 (Colour)**

## 4.22 Bore Hole Water, SRWMF

Samples are taken three times per year from 35 drilled wells, if accessible and not dry.

Tritium was detected in 95 samples. Concentrations averaged  $1.16\text{E}+02 \text{ Bq}\cdot\text{L}^{-1}$  ( $3.95\text{E}+01$  to  $3.64\text{E}+02 \text{ Bq}\cdot\text{L}^{-1}$ ) near the Phase 1 facility,  $4.93\text{E}+01 \text{ Bq}\cdot\text{L}^{-1}$  ( $1.24\text{E}+01$  to  $1.49\text{E}+02 \text{ Bq}\cdot\text{L}^{-1}$ ) near the Phase 2 facility and  $7.86\text{E}+01 \text{ Bq}\cdot\text{L}^{-1}$  ( $2.80\text{E}+01$  to  $2.13\text{E}+02 \text{ Bq}\cdot\text{L}^{-1}$ ) near the Phase 3 facility. The H-3 results are attributable to the operation of PLNGS. Tritium washes out into precipitation and subsequently drains into some of the bore holes. Precipitation analyses (*Section 4.13*) indicate H-3 concentrations ranging from  $1.35\text{E}+01$  to  $7.81\text{E}+02 \text{ Bq}\cdot\text{L}^{-1}$  in 37 of 47 samples.

Results are presented in Tables 4.25 to 4.27. Figure 4.20 shows the H-3 activity at each bore hole for each sample. “Less Than” values are plotted for non-detected results.

## 4.22 Bore Hole Water, SRWMF, Continued

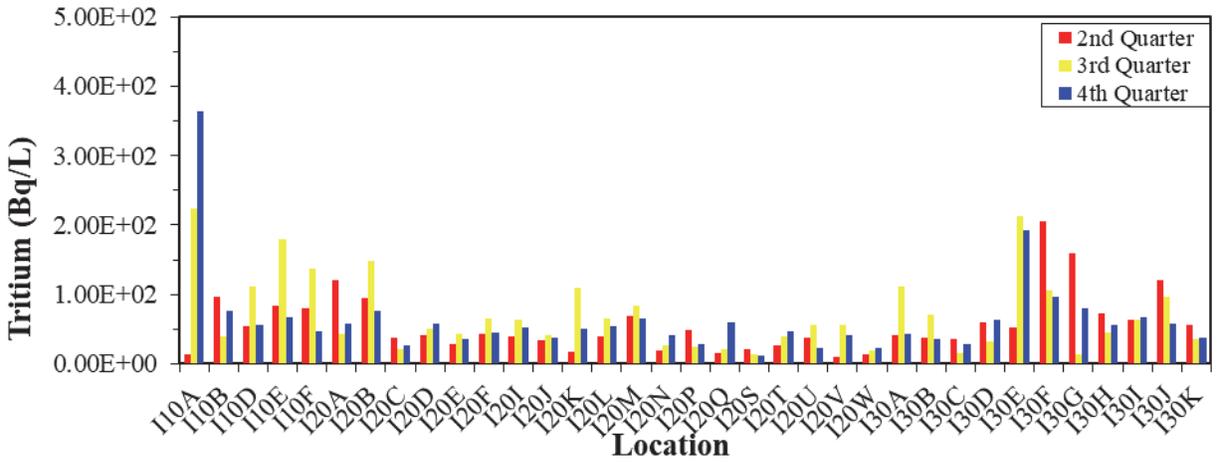


Figure 4.20: Tritium (Bore Hole Water, SRWMF) 2023 (Colour)

## 4.22 Bore Hole Water, SRWMF, Continued

**Table 4.25: Bore Hole Water, SRWMF - Phase 1 (Bq·L<sup>-1</sup>)**

<i>Analysis Type</i>	<i>Total Number</i>	<i>Indicator Locations</i>				<i>Reference Location</i>			
		<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>	<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>
<i>H-3</i>	15	1.16E+02	3.95E+01	3.64E+02	14 of 15	*	*	*	*

\* There is no reference location.

**Table 4.26: Bore Hole Water, SRWMF - Phase 2 (Bq·L<sup>-1</sup>)**

<i>Analysis Type</i>	<i>Total Number</i>	<i>Indicator Locations</i>				<i>Reference Location</i>			
		<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>	<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>
<i>H-3</i>	57	4.93E+01	1.24E+01	1.49E+02	50 of 57	*	*	*	*

\* There is no reference location.

## 4.22 Bore Hole Water, SRWMF, Continued

*Table 4.27: Bore Hole Water, SRWMF - Phase 3 (Bq·L<sup>-1</sup>)*

<i>Analysis Type</i>	<i>Total Number</i>	<i>Indicator Locations</i>				<i>Reference Location</i>			
		<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>	<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>
<i>H-3</i>	33	7.86E+01	2.80E+01	2.13E+02	31 of 33	*	*	*	*

\* There is no reference location.

## 4.23 SRWMF Parshall Flume Water

Of the 156 samples analyzed, H-3 was detected in 133 samples. These results are attributable to the releases from PLNGS (primarily) and to a lesser extent the material stored in the Phase 1 structures.

Rainwater and snow melt at the onsite SRWMF (Phases 1, 2 and 3) are obtained from drainage channels (flumes) constructed to collect surface runoff from these areas. Samples are collected and analyzed on a weekly basis.

There is little or no flow into or out of these collection locations during the winter months and values for H-3 tend to vary little from one week to the next except after heavy rain. The average H-3 value for each phase is:

- $2.00\text{E}+02 \text{ Bq}\cdot\text{L}^{-1}$  at Phase 1
- $9.68\text{E}+01 \text{ Bq}\cdot\text{L}^{-1}$  at Phase 2
- $1.21\text{E}+02 \text{ Bq}\cdot\text{L}^{-1}$  at Phase 3.

Tables 4.28 to 4.30 are summaries of the detected radionuclides in the flumes. Figure 4.21 compares the H-3 in the samples from the three facilities. “Less Than” values are plotted for non-detected results.

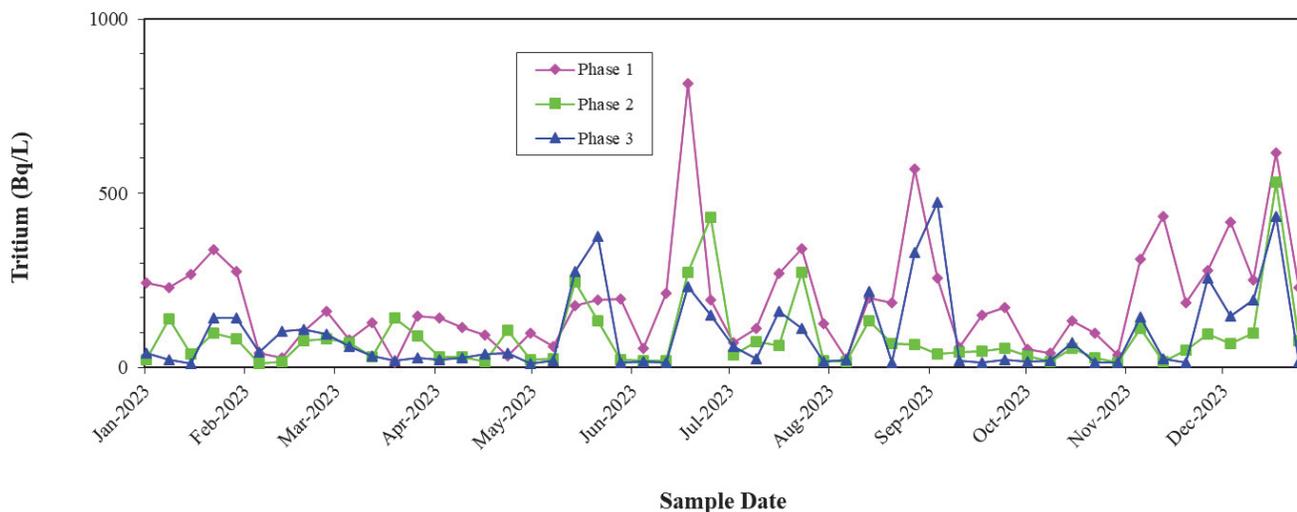


Figure 4.21: Tritium (Parshall Flume Water, SRWMF) 2023 (Colour)

### 4.23 SRWMF Parshall Flume Water, Continued

*Table 4.28: Parshall Flume Water, SRWMF - Phase 1 (Bq·L<sup>-1</sup>)*

<i>Analysis Type</i>	<i>Total Number</i>	<i>Indicator Locations</i>				<i>Reference Location</i>			
		<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>	<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>
<i>H-3</i>	52	2.00E+02	2.40E+01	8.14E+02	50 of 52	*	*	*	*

\* There is no reference location.

*Table 4.29: Parshall Flume Water, SRWMF - Phase 2 (Bq·L<sup>-1</sup>)*

<i>Analysis Type</i>	<i>Total Number</i>	<i>Indicator Locations</i>				<i>Reference Location</i>			
		<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>	<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>
<i>H-3</i>	52	9.68E+01	1.61E+01	5.31E+02	44 of 52	*	*	*	*

\* There is no reference location.

### 4.23 SRWMF Parshall Flume Water, Continued

*Table 4.30: Parshall Flume Water, SRWMF - Phase 3 (Bq·L<sup>-1</sup>)*

<i>Analysis Type</i>	<i>Total Number</i>	<i>Indicator Locations</i>				<i>Reference Location</i>			
		<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>	<i>Mean</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Detection Frequency</i>
<i>H-3</i>	52	1.21E+02	1.25E+01	4.74E+02	39 of 52	*	*	*	*

\* There is no reference location.

## **4.24 Hemlock Knoll Regional Sanitary Landfill Program**

PLNGS disposes of its non-active waste at the public landfill facility. The monitoring program includes dosimeter placement at key locations.

TLD results appear in Table 4.06 (location codes YTL1 to YTL4).

## **4.25 Meteorological Data**

The meteorological data for 2023 were collected at one-hour intervals and are presented in Table 4.31. Wind Rose data for 2023 are presented in Figure 4.22.

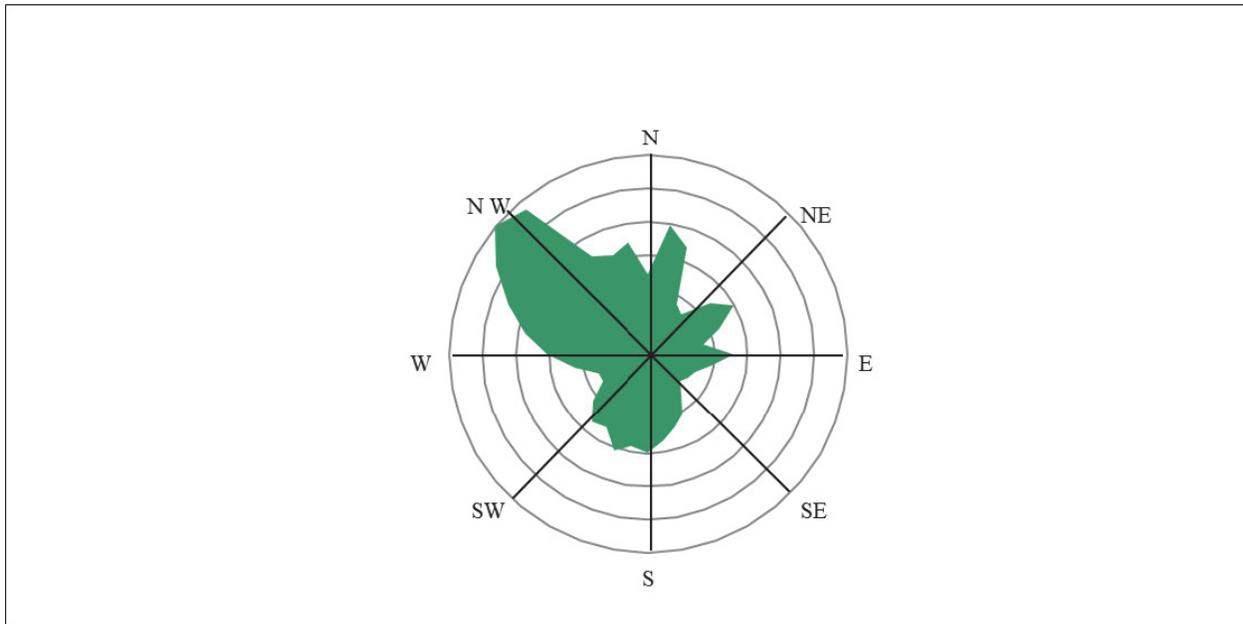
## 4.25 Meteorological Data, Continued

**Table 4.31: Meteorological Data for Point Lepreau (2023)**

<i>Month</i>	<i>Temperature</i>			<i>Wind Direction (Relative %)</i>							
	<i>Avg</i>	<i>Min</i>	<i>Max</i>	<i>N</i>	<i>NE</i>	<i>E</i>	<i>SE</i>	<i>S</i>	<i>SW</i>	<i>W</i>	<i>NW</i>
January	-1	-12	10	32	12	3	4	5	5	12	27
February	-4	-27	11	27	10	6	2	8	8	14	25
March	1	-12	8	20	11	14	5	6	5	9	31
April	6	-4	19	5	7	27	4	8	12	14	24
May	9	0	22	10	7	14	4	12	17	11	24
June	12	5	21	15	17	16	8	15	12	12	6
July	16	12	26	6	9	18	17	21	10	12	8
August	16	8	24	7	6	15	5	20	16	15	17
September	15	4	29	19	10	11	7	16	11	9	17
October	11	-2	20	21	7	9	3	20	13	9	18
November	3	-8	12	17	2	1	4	11	11	16	38
December	2	-13	14	21	12	3	6	11	8	16	24
<i>Average</i>	7.2	-4	18	17	9	11	6	13	10	12	22

\*Each compass direction covers  $\pm 22.5$  degrees.

## 4.25 Meteorological Data, Continued



**Figure 4.22: Wind Rose for Point Lepreau (2023) (Colour)**

## 5.0 Trends (REMP)

The following trends were observed in the historical data:

- Gaseous tritium releases in 2023 were less than the previous year, and remain below historic levels.
- Tritium continues to be detected, at levels well below the station and regulatory limits, in air and water samples (lower offsite than onsite).
- There continues to be a difference between onsite and offsite thermoluminescent dosimeter (TLD) measurements (lower readings offsite compared with onsite); TLDs also measure natural background radiation.
- The radionuclide concentration in most sample types continues to remain at pre-operational (background) levels due to the history of low releases.
- Public dose calculated for 2023 remains below historic levels.

As in the figures in *Section 4*, “Less Than” values are plotted for non-detected values. All location codes are described in *Appendix C*.

### 5.1 Dose from Airborne and Liquid Pathways

Radiation dose from PLNGS releases continues to be well below the public dose limit (1000 microsieverts per annum), and well below the design and operating target for PLNGS (50 microsieverts per annum). See Figure 5.01.

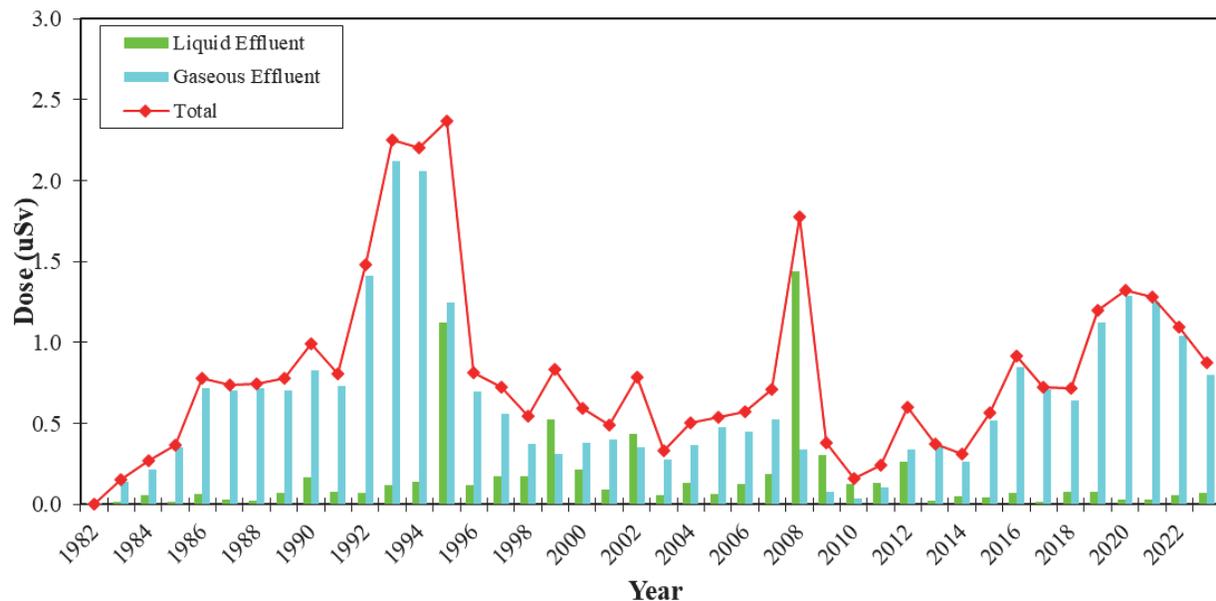
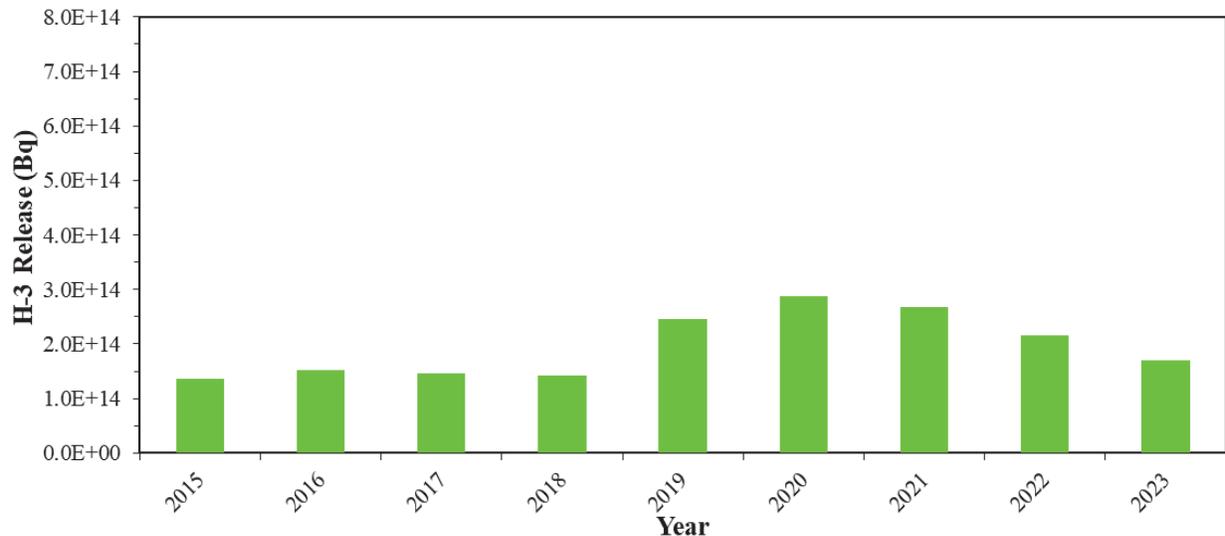


Figure 5.01: Dose from Airborne and Liquid Pathways (Colour)

## 5.2 Tritium (Water Vapour)

Station annual airborne tritium releases are shown in Figure 5.02. Figure 5.04 shows the airborne H-3 concentration at the onsite stations and the offsite locations are shown in Figure 5.03. The differences are due to sample point proximity to the station; lower readings are expected related to increased distance from the point release from the station.

Airborne tritium releases for 2023 were slightly decreased in comparison to the previous year. Tritium releases are related to operational activities at the Station, in particular maintenance, purification and venting of the moderator and primary heat transport systems.



**Figure 5.02: Airborne H-3 Releases (Colour)**

**NOTE**

The current annual DRL for H-3 is 2.4E+17 Bq/year.

## 5.2 Tritium (Water Vapour), Continued

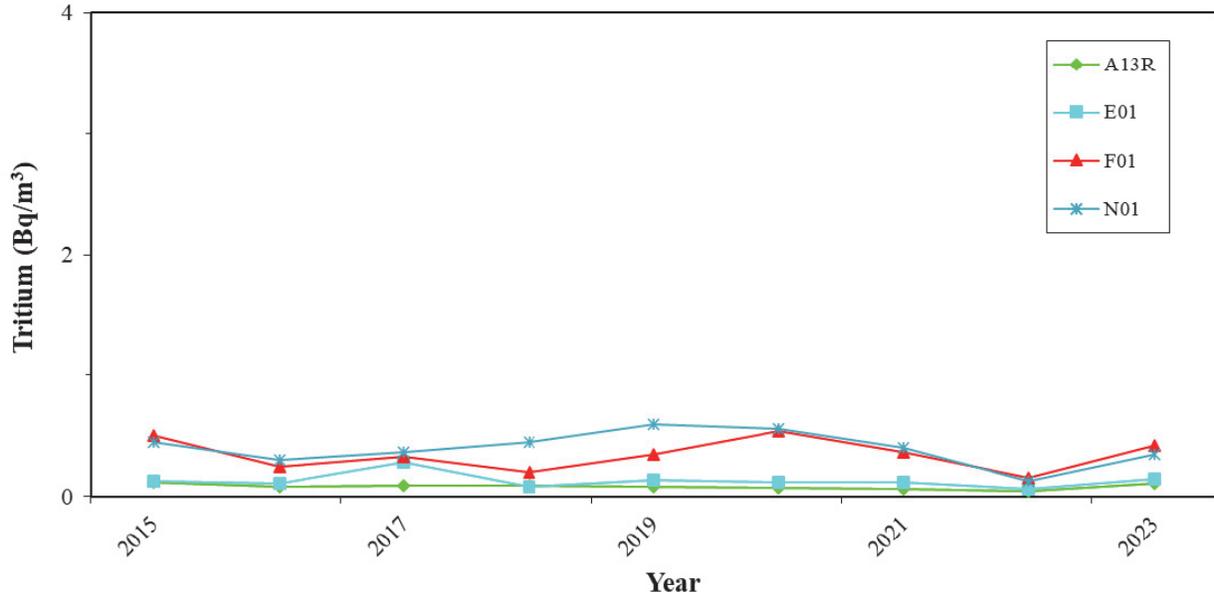


Figure 5.03: Tritium (Water Vapour) at Offsite Air Stations (Colour)

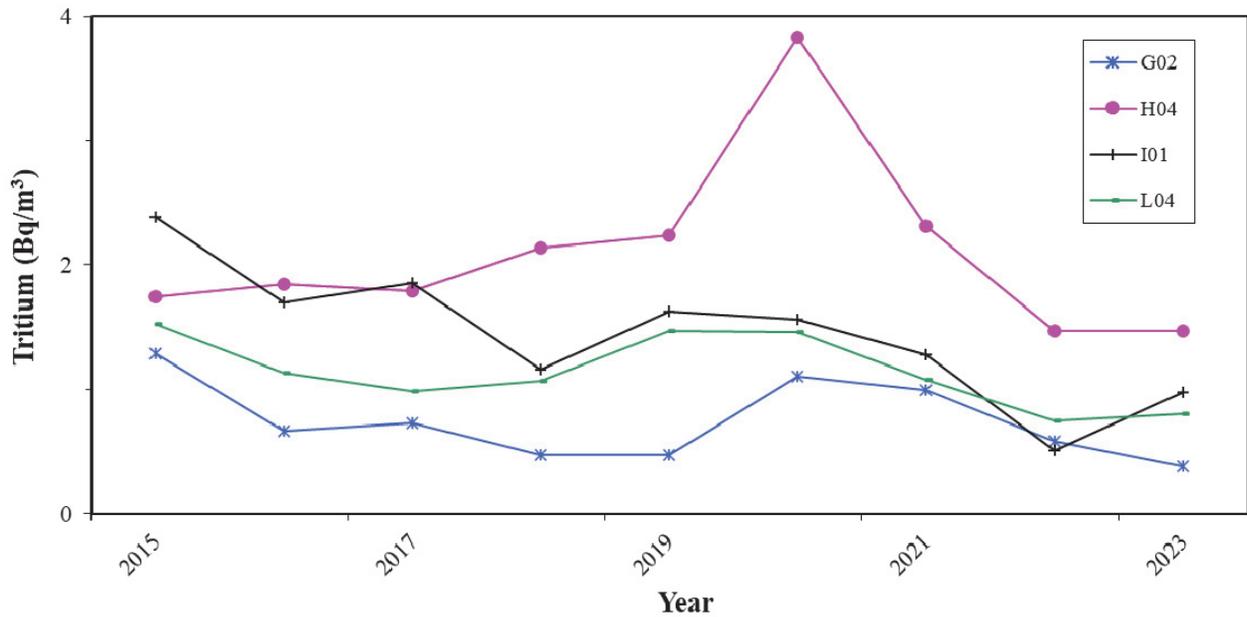


Figure 5.04: Tritium (Water Vapour) at Onsite Air Stations (Colour)

### 5.3 Cesium-137 (Soil)

Cesium-137 from the fallout of past atmospheric weapons tests and international events tends to accumulate in the organic layer of soil. Most fluctuation in Cs-137 levels seems to be due to the quantity of organic load in the sample.

The value plotted for each year in Figure 5.05 is the mean of all values for that year. “Less Than” values are plotted for non-detected values.

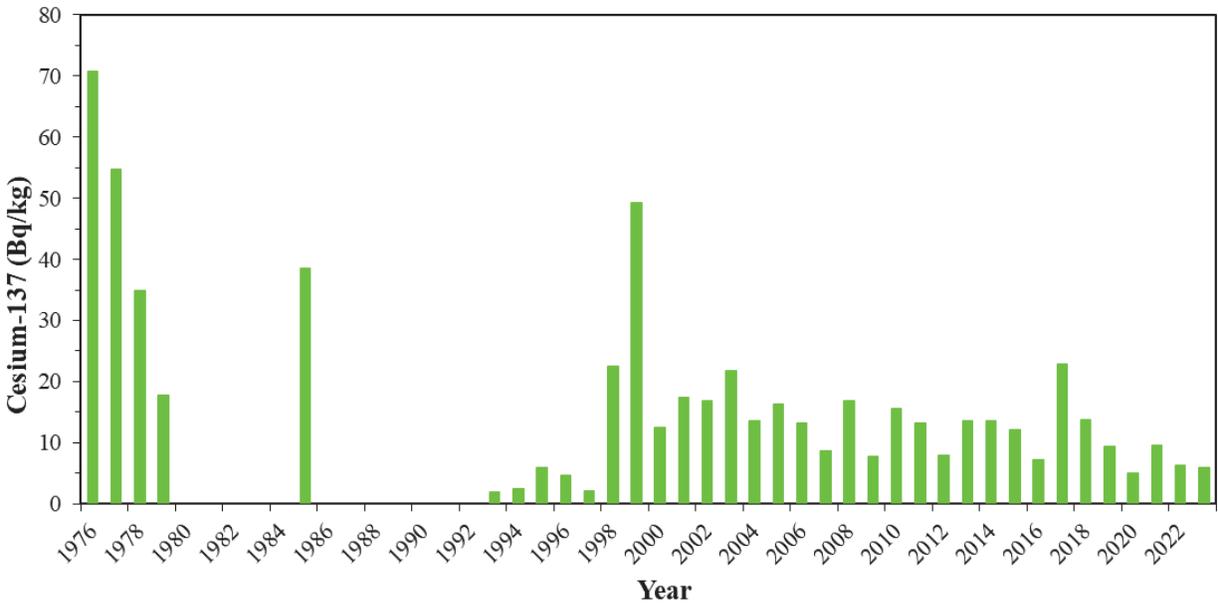


Figure 5.05: Cesium-137 (Soil) (Colour)

## 5.4 Tritium (Monitoring Well Water, Near Plant)

The trend for tritium activity in the monitoring wells is shown in Figure 5.06.

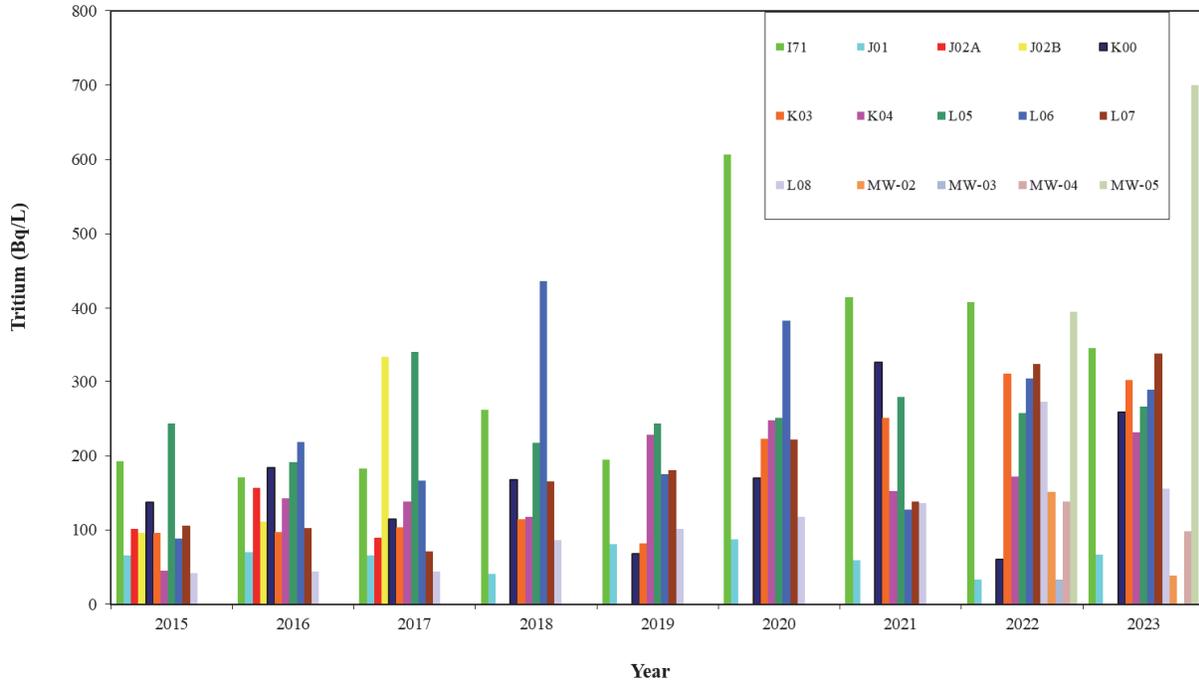


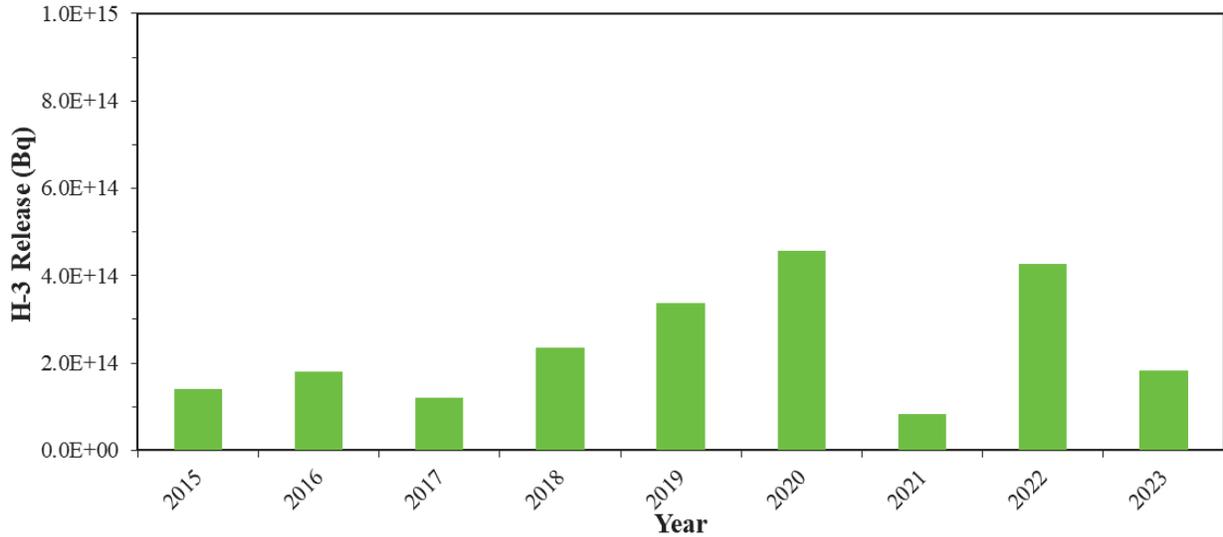
Figure 5.06: Tritium (Monitoring Well Water, Near Plant) (Colour)

## 5.5 Tritium and C-14 (Seawater)

Tritium releases to seawater for 2023 continue to be well below the station and regulatory release limits. Tritium releases are related to operational activities at the Station, in particular maintenance and outages (Figure 5.07).

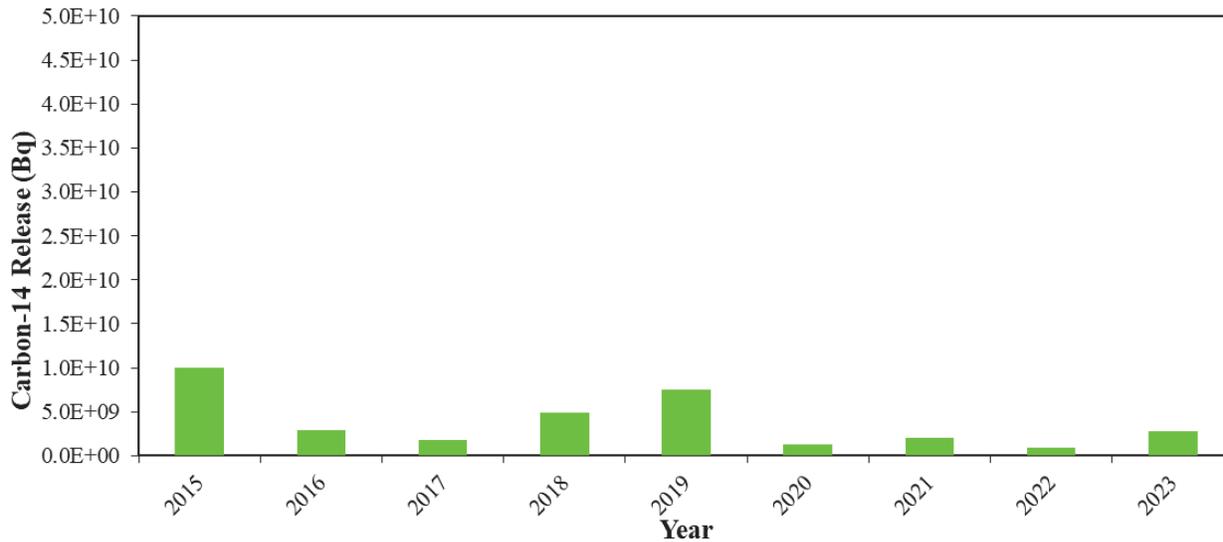
Carbon-14 releases to seawater are also related to Station operational activities. Releases of C-14 in liquid effluents in 2023 were also well below the station and regulatory limits and in the typical range. The expected concentration of C-14 in seawater is below the detection limit (Figure 5.08).

### 5.5 Tritium and C-14 (Seawater), Continued



**NOTE**  
 The current annual DRL for H-3 is 4.5E+19 Bq/year.

**Figure 5.07: Liquid H-3 Releases (Colour)**

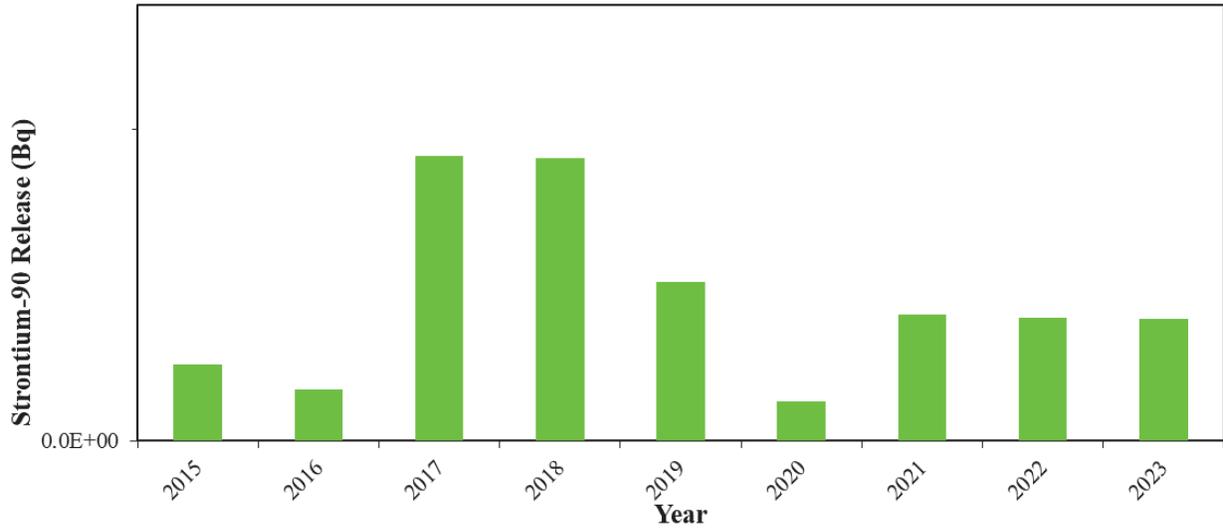


**NOTE**  
 The current annual DRL for C-14 is 3.7E+14 Bq/year.

**Figure 5.08: Liquid C-14 Releases (Colour)**

## 5.6 Strontium-90 (LEM Water)

The maximum values for Sr-90 still represent only a small fraction of the DRL and are due to activity slightly above the detection limit (Figure 5.09).



**NOTE**  
The current annual DRL for Sr-90 is 5.9E+15 Bq/year.

**Figure 5.09: Liquid Sr-90 Releases (Colour)**

## 5.7 Tritium (Parshall Flume Water)

The average tritium concentrations for the Parshall Flume Water H-3 values at the three Phases of the Solid Radioactive Waste Management Facility (SRWMF) were in the typical range and slightly less than the previous year (Figure 5.10).

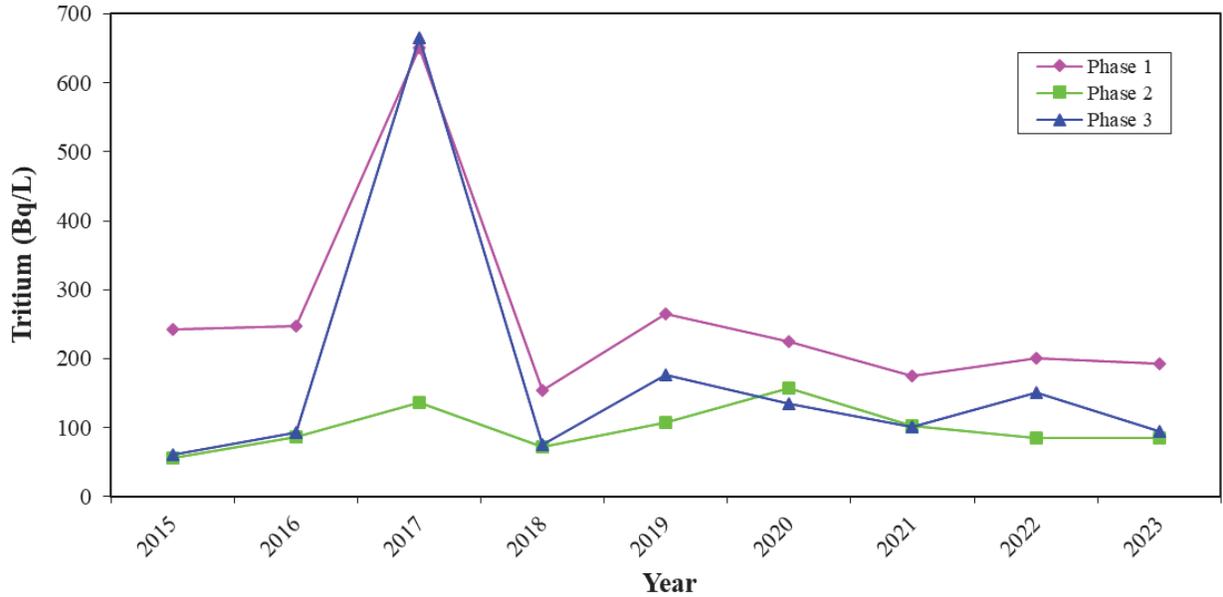


Figure 5.10: Tritium (Parshall Flume Water) (Colour)

## 6.0 Dose Estimation

The DRLs apply to the release point for each of the two effluent pathways for PLNGS: the ventilation stack for airborne releases; and, for liquid releases, the discharge point of the Condenser Cooling Water (CCW) duct into the Bay of Fundy. The releases are assumed to be continuous. All relevant exposure routes to the public are factored into the DRL calculations. Crossover routes between the two pathways are insignificant, and therefore they are not considered.

The DRL document identifies the Representative Person associated with radioactive airborne and liquid effluent releases from the PLNGS and documents the magnitude of activity of each nuclide released through either pathway in one calendar year that would cause the Representative Person to receive or be committed to the regulatory dose limit for a member of the public. This activity is called the Derived Release Limit (DRL) for that nuclide.

Dose estimates to members of the local communities that are based on the DRLs are conservative *CSA Standard N288.1-14, Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities*, which forms the basis for DRLs, includes conservative values for food intake and other parameters. In some cases, even more conservative site-specific data are used.

The detailed discussion of these pathways may be found in *RD-01364-L001, Derived Release Limits for Radionuclides in Airborne and Liquid Effluents*.

The airborne exposure pathways from PLNGS to the public are:

- internal from inhalation
- external from immersion in a plume
- external from contaminated ground (ground shine)
- internal from ingestion of contaminated well water
- external from immersion in contaminated well water
- internal from ingestion of contaminated soil, plants and animals.

The selection of Representative Person is based upon which local residential areas might receive a slightly higher exposure from airborne releases, and the potential of intakes based upon dietary and behavioral habits.

The combined small communities of Dipper Harbour and Welch Cove were selected as the representative group for all airborne releases. Dipper Harbour is 3.7 km northeast of the PLNGS stack and Welch Cove is 1.6 km northwest from the PLNGS stack.

A hypothetical family consisting of two adults, a ten-year-old child and a one year old infant is considered to be representative of the community.

## 6.0 Dose Estimation, Continued

The liquid exposure pathways from PLNGS to the public are:

- external from diving for sea urchins
- external from exposure to sediment while harvesting clams and dulse
- internal from ingestion of fish, lobster, clams, and dulse.

The selection of a Representative Person is based upon dietary and behavioral habits of residents. A representative family of two adults, a ten-year-old child and a one-year-old infant was selected.

The DRLs are based on *CSA Standard N288.1-14, Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities*. Station releases of a radionuclide at 100% DRL for a year would result in a dose to the Representative Person of 1000  $\mu\text{Sv}$ . In 2023 (Table 6.01), the liquid releases were 7.42E-03% DRL, which corresponds to 0.07  $\mu\text{Sv}$  to the Representative Person. Airborne releases for 2023 were 8.00E-02% DRL, which corresponds to a public dose of 0.8  $\mu\text{Sv}$ . Adjustments are made to the DRL based on operational considerations or release location. For example, a reduced CCW flow changes the dilution factor which decreases the DRL.

As shown in Table 6.02 and Figures 6.01 and 6.02, H-3 accounts for 87.8% of the dose from airborne releases; and 10.5% of the dose from liquid releases in 2023. The other major contributor to dose from airborne releases was Argon-41 (9%). The other major contributors to dose from liquid releases were C-14 (13.4%), Ag-110m (13.5%) and Co-60 (55.2%).

Because of the protective assumptions used in the DRL calculations, and the relatively low level of releases, the most exposed member of the public received less than the calculated dose of 0.87  $\mu\text{Sv}$ . This radiation dose may be compared with the individual natural radiation dose in Canada of approximately 2000 to 3000  $\mu\text{Sv}$  per annum. (TLDs show only the external, penetrating component, amounting to about 500 to 1000  $\mu\text{Sv}$ .) This includes natural dose contributions from ground, air, food and from an assumed low concentration of radon in homes. A significant fraction of Canadian homes contain natural radon levels that give a much larger radiation dose than the 2000 to 3000  $\mu\text{Sv}$ .

**Table 6.01: Annual Dose (2023)**

<i>Source of Dose to the Representative Person</i>	<i>Dose to the Representative Person (<math>\mu\text{Sv}\cdot\text{a}^{-1}</math>)</i>
PLNGS airborne releases	0.80
PLNGS liquid releases	0.07

## 6.0 Dose Estimation, Continued

**Table 6.02: Contribution of Radionuclides to Dose in Each Pathway (2023)**

<i>Radionuclide</i>	<i>Contribution to Dose (%) (from Airborne Releases)</i>	<i>Contribution to Dose (%) (from Liquid Releases)</i>
<b>H-3</b>	87.8	10.5
<b>C-14</b>	1.1	13.4
<b>Mn-54</b>	----	----
<b>Ar-41</b>	9	----
<b>Co-60</b>	----	55.2
<b>Fe-59</b>	----	1.1
<b>I-131</b>	----	----
<b>Zr-95</b>	----	----
<b>Nb-95</b>	----	----
<b>Ag-110m</b>	----	13.5
<b>Sb-124</b>	----	3.8
<b>Sn-113</b>	----	----
<b>All others</b>	2.1	2.6
<b>TOTAL</b>	<b>100</b>	<b>100</b>

**NOTE**

Only radionuclides contributing 1% or more are itemized.

## 6.0 Dose Estimation, Continued

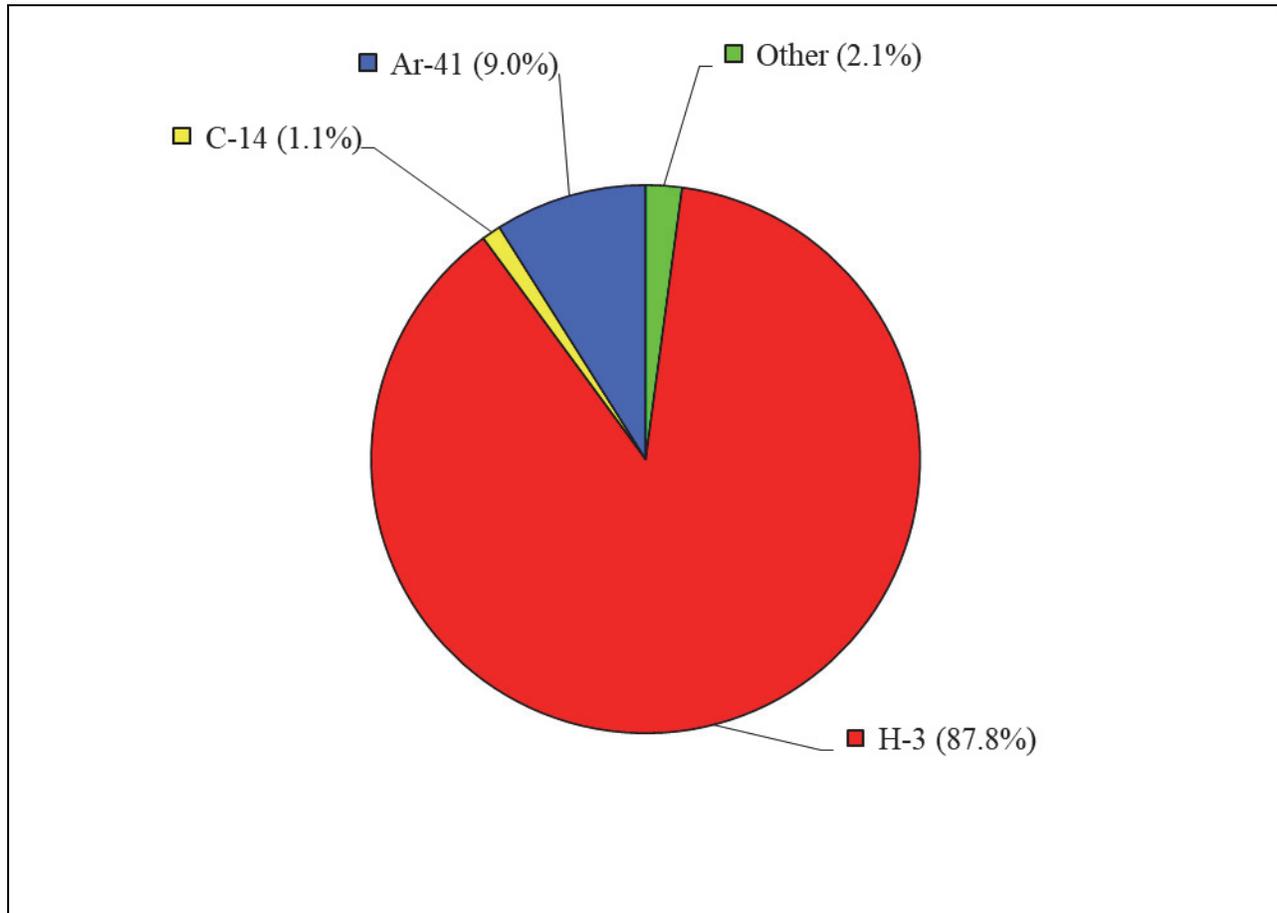
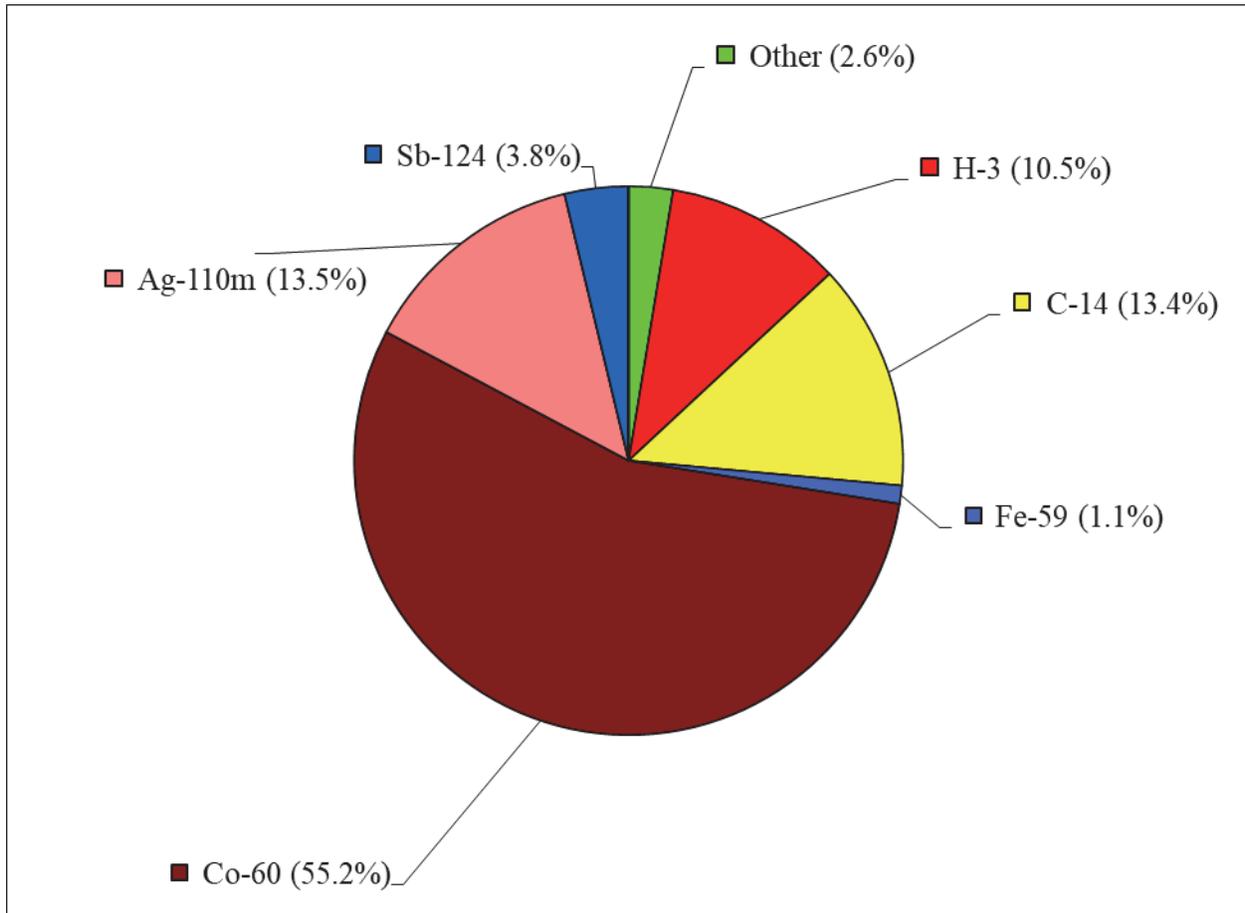


Figure 6.01: Contribution of Radionuclide to Total Dose (Airborne Pathway) - 2023 (Colour)

## 6.0 Dose Estimation, Continued



**Figure 6.02: Contribution of Radionuclide to Total Dose (Liquid Pathway) – 2023 (Colour)**

## 7.0 Quality Assurance Results (REMP)

The purpose of Quality Assurance is to provide confidence in the program and demonstrate that the program can meet its objectives. QA is a system whereby the laboratory can assure the regulator and NB Power that the laboratory is generating accurate and reproducible data. It encompasses:

- personnel
- procedures
- measurements
- sample integrity
- records
- annual review
- periodic (5 year) review
- program audits
- program improvement

This section describes how QA was achieved for the year 2023. The specific procedures can be found in *EXP-03541-0001, Standards, Expectations and Quality Assurance Requirements for Health Physics*. QA requirements were met in 2023.

### 7.1 Quality Control Checks

The main pieces of analytical equipment used in the REMF have a quality control (QC) check performed prior to operating. A background count is made each weekend to ensure the absence of contamination in the gamma spectrometer sample chamber. Key instrument parameters are checked, and the results are compared against tolerance limits, and are also compared with previous results to detect trends in performance. This ensures that the parameters are consistent and remain free from significant drift or random variation that could influence the analyses. A compilation of the results and statistical fluctuations is maintained, and from these data the upper and lower flag limits are determined. If any equipment exceeds these limits, it is not used for analytical work until the problem has been resolved. To perform the quality control checks, radiation sources traceable to US or Canadian standards (National Institute of Standards and Technology and National Research Council) are used.

The QC evaluations in the laboratory cover the following instruments:

1. Canberra Intrinsic Ge Gamma Spectrometer (DET1).
2. Canberra Intrinsic Ge Gamma Spectrometer (DET2).
3. PerkinElmer Tri-Carb 2910TR Liquid Scintillation Counter.
4. Protean WPC 9550 Alpha/Beta Counter.
5. Panasonic UD-716AGL TLD Reader.
6. Panasonic UD-7900 TLD Reader.

## 7.1 Quality Control Checks, Continued

Throughout the year there were some results outside expectations for each of the instruments (Table 7.01). Most of these involved only one of the six to eight parameters monitored for each system. All these results were resolved before analytical work resumed.

**Table 7.01: Quality Control Check Results**

<i>Instrument</i>	<i>Number of Parameters Monitored Per Check</i>	<i>Number of Checks</i>	<i>Number of Individual Parameters Tested</i>	<i>Number of Individual Parameters Outside Expected Limits</i>
Canberra Intrinsic Ge Gamma Spectrometer (DET1)	6	87	522	39
Canberra Intrinsic Ge Gamma Spectrometer (DET2)	6	277	1662	25
PerkinElmer Tri-Carb 2910TR Liquid Scintillation Counter	8	192	1536	3
Protean WPC 9550 Alpha/Beta Counter	8	128	1024	33
Panasonic UD-716AGL TLD Reader	7	95	665	0
Panasonic UD-7900 TLD Reader	7	100	700	0

### 7.1.1 Intrinsic Ge Gamma Spectrometer

A quality check of six system parameters is performed for both germanium gamma spectroscopy systems. Measurements are made of the energy centroids, full width half maxima (FWHM) and efficiencies of two widely separated photon energies of Eu-152. These show the accuracy and precision of the system relative to the defined limits of acceptance. A computer program processes the results to generate QC plots and performs statistical tests to detect out-of-range values. A 200,000 s background count is made each weekend to ensure the absence of contamination in the sample chamber. No contamination was detected.

### 7.1.1 **Intrinsic Ge Gamma Spectrometer**, Continued

The efficiency calibration of the gamma spectroscopy system completed once every two years and is checked annually. This is accomplished using calibration standards derived from a mixed nuclide standard traceable to the U.S. National Institute of Standards and Technology (NIST).

### 7.1.2 **Protean WPC 9550 Alpha/Beta Counter**

Planchet standards of Am-241, Tc-99 and Sr-Y-90 are analyzed prior to operating. Alpha and Beta discrimination allows the simultaneous analysis of alpha and beta activity on all samples analyzed. Planchet backgrounds are included in the QC checks.

### 7.1.3 **Panasonic UD-716AGL and UD-7900U TLD Readers**

In each of the two TLD readers, a set of 16 TLDs is exposed in the Panarad Irradiator and read out in the TLD reader. The mean of each of the four elements, dark current, reference light, reference element, and lamp flashes must all be within specified limits. The QA aspect of this system is covered in detail in the TLD procedures:

- *HPF-03541-TL03, Performing a Quality Control Check on Panasonic Automatic TLD Readers.*
- *HPF-03541-TL09, Performing Quality Assurance Testing of the Dosimetry System.*
- *HPF-03541-TL13, Processing Internal Quality Assurance Test Data.*

#### 7.1.4 Other Instruments

Other instruments (balances, pipettors) are checked or calibrated at least annually. As per *HPF-03541-EN34, Calibrating Equipment*. Frequencies of calibration are based on reproducibility of measurements and on time stability tests to ensure that the measurements are within the specified tolerances for accuracy.

The gamma survey and contamination meters are calibrated at PLNGS on an annual basis.

## 7.2 External Quality Assurance

The external quality assurance program consists of inter-comparisons with other laboratories to give independent verification of analytical performance. The frequency of each program may vary at the discretion of the sponsoring agency (see Table 7.03). Three such groups – Kinectrics, Eckert & Ziegler Analytics, and the National Research Council (NRC) - provide three percent of the sample load in the laboratory with blind samples. Results of our performance with these samples give an indication of the quality of measurements the laboratory can produce. The results are tabulated by medium in Tables 7.04 to 7.11.

The QA agent defines acceptable performance, generally in terms of an expected range. A result outside expectations signals the need to assess the procedures, analytical methods, or equipment calibrations. The average NB Power/QA Agent (ratio) for 2023 was 1.06. There were 17 results that were outside expectations out of 171 nuclide comparisons in the external QA program. The reasons are given in Table 7.02.

## 7.2 External Quality Assurance, Continued

**Table 7.02: External Quality Assurance Results Outside Expected Range**

<i>Medium</i>	<i>Nuclide</i>	<i>Number</i>	<i>Reason</i>
Filter	Sr-90	1	Just outside $\pm 3s$
Soil	Ce-141	1	Unknown
	Co-58	1	Just outside $\pm 3s$
	Co-60	2	Just outside $\pm 3s$
	Cs-134	1	Unknown
	Fe-59	1	Unknown
	Mn-54	1	Just outside $\pm 3s$
Water	Ce-139	1	Pass/Fail limits of $\pm 10\%$ compared to all others who use $\pm 3s$ . At $\pm 3s$ this would be a pass.
	Co-60	2	Pass/Fail limits of $\pm 10\%$ compared to all others who use $\pm 3s$ . At $\pm 3s$ this would be a pass.
	Hg-203	1	Unknown
	Sn-113	1	Pass/Fail limits of $\pm 10\%$ compared to all others who use $\pm 3s$ . At $\pm 3s$ this would be a pass.
	Sr-85	1	Unknown
	Sr-89	1	Unknown
	Y-88	2	Pass/Fail limits of $\pm 10\%$ compared to all others who use $\pm 3s$ . At $\pm 3s$ this would be a pass.

## 7.2 External Quality Assurance, Continued

*Table 7.03: External Quality Assurance Frequency*

<i>Media</i>	<i>Analyses</i>	<i>Number of QA</i>	<i>External Agencies</i>
Filters	Gross Alpha/Beta	2	Eckert & Ziegler Analytics
		2	Kinectrics
	Gamma	2	Eckert & Ziegler Analytics
	Sr-89,90	2	Eckert & Ziegler Analytics
Charcoal Cartridges	Gamma	3	Eckert & Ziegler Analytics
Environmental Gamma	TLD	0	NRC
Milk	Gamma	4	Eckert & Ziegler Analytics
Water	Gross Alpha/Beta	2	Eckert & Ziegler Analytics
		1 (gross beta only)	Kinectrics
	H-3	4	Kinectrics
	C-14	4	Kinectrics
	Gamma	2	Kinectrics
		4	Eckert & Ziegler Analytics
	Sr-89,90	4 (on gamma sample)	Eckert & Ziegler Analytics
Food/Vegetation	Gamma	2	Eckert & Ziegler Analytics
Soil/Sediment	Gamma	2	Eckert & Ziegler Analytics

## 7.2 External Quality Assurance, Continued

**Table 7.04: Filter Performance (External QA)**

<i>Analysis</i>	<i>NB Power (pCi·filter<sup>-1</sup>) or (dpm·filter<sup>-1</sup>)</i>	<i>QA Agent (pCi·filter<sup>-1</sup>) or (dpm·filter<sup>-1</sup>)</i>	<i>NB Power/ QA Agent (ratio)</i>
<b>ALPHA</b>	4.05E+02	3.59E+02	1.13
	8.75E+01	8.63E+01	1.01
	3.83E+02	3.49E+02	1.10
	1.65E+02	1.87E+02	0.88
<b>BETA</b>	3.50E+02	3.60E+02	0.97
	1.72E+02	1.65E+02	1.04
	6.42E+02	6.47E+02	0.99
	1.88E+02	1.70E+02	1.11
<b>Ce-141</b>	8.18E+01	7.65E+01	1.07
	1.30E+02	1.18E+02	1.10
<b>Co-58</b>	9.18E+01	8.78E+01	1.05
<b>Co-60</b>	3.09E+02	2.44E+02	1.27
	1.70E+02	1.30E+02	1.30
<b>Cr-51</b>	1.90E+02	1.87E+02	1.02
	2.38E+02	2.02E+02	1.18
<b>Cs-134</b>	1.30E+02	1.17E+02	1.11
	2.43E+02	1.90E+02	1.28
<b>Cs-137</b>	1.60E+02	1.47E+02	1.09
	1.87E+02	1.61E+02	1.16
<b>Fe-59</b>	1.44E+02	1.10E+02	1.30
	1.87E+02	1.43E+02	1.30
<b>Mn-54</b>	1.22E+02	1.04E+02	1.17
	1.65E+02	1.31E+02	1.26
<b>Sr-89</b>	8.76E+01	9.07E+01	0.97
	8.78E+01	8.07E+01	1.09
<b>Sr-90</b>	9.45E+00	1.43E+01	0.66*
	1.39E+01	1.11E+01	1.25
<b>Zn-65</b>	1.86E+02	1.58E+02	1.18
	2.12E+02	1.69E+02	1.25

\*Outside expected range.

## 7.2 External Quality Assurance, Continued

**Table 7.05: Charcoal Cartridge Performance (External QA)**

<i>Analysis</i>	<i>NB Power (pCi-cartridge<sup>-1</sup>)</i>	<i>QA Agent (pCi-cartridge<sup>-1</sup>)</i>	<i>NB Power/QA Agent (ratio)</i>
<b>I-131</b>	7.39E+01	9.08E+01	0.81
	7.38E+01	7.86E+01	0.94
	7.80E+01	7.96E+01	0.98

\*Outside expected range.

## 7.2 External Quality Assurance, Continued

**Table 7.06: Milk Performance (External QA)**

<i>Analysis</i>	<i>NB Power (pCi·L<sup>-1</sup>)</i>	<i>QA Agent (pCi·L<sup>-1</sup>)</i>	<i>NB Power/ QA Agent (ratio)</i>
<b>Ce-141</b>	1.48E+02	1.39E+02	1.06
	1.07E+02	1.20E+02	0.89
	1.09E+02	1.04E+02	1.05
	9.66E+01	8.87E+01	1.09
<b>Co-58</b>	1.29E+02	1.31E+02	0.98
	1.30E+02	1.38E+02	0.94
	6.78E+01	6.58E+01	1.03
<b>Co-60</b>	3.02E+02	2.79E+02	1.08
	3.83E+02	3.66E+02	1.05
	2.38E+02	2.23E+02	1.07
	1.01E+02	9.29E+01	1.09
<b>Cr-51</b>	3.18E+02	3.02E+02	1.05
	2.48E+02	2.92E+02	0.85
	2.24E+02	2.05E+02	1.09
	1.43E+02	1.52E+02	0.94
<b>Cs-134</b>	2.09E+02	2.00E+02	1.05
	1.82E+02	1.83E+02	0.99
	1.25E+02	1.14E+02	1.10
	1.59E+02	1.43E+02	1.11
<b>Cs-137</b>	1.31E+02	1.40E+02	0.94
	2.21E+02	2.30E+02	0.96
	1.40E+02	1.41E+02	0.99
	1.40E+02	1.21E+02	1.16
<b>Fe-59</b>	1.24E+02	1.22E+02	1.02
	1.59E+02	1.72E+02	0.92
	8.15E+01	7.88E+01	1.03
	1.14E+02	1.08E+02	1.06

## 7.2 External Quality Assurance, Continued

**Table 7.06: Milk Performance (External QA), Continued**

<i>Analysis</i>	<i>NB Power (pCi·L<sup>-1</sup>)</i>	<i>QA Agent (pCi·L<sup>-1</sup>)</i>	<i>NB Power/ QA Agent (ratio)</i>
<b>I-131</b>	7.41E+01	8.20E+01	0.90
	4.19E+01	3.74E+01	1.12
	4.67E+01	4.00E+01	1.17
<b>Mn-54</b>	1.80E+02	1.80E+02	1.00
	1.59E+02	1.62E+02	0.98
	1.55E+02	1.46E+02	1.06
	9.69E+01	9.83E+01	0.99
<b>Zn-65</b>	3.17E+02	3.06E+02	1.04
	2.41E+02	2.48E+02	0.97
	2.08E+02	2.03E+02	1.02
	1.25E+02	1.27E+02	0.98

**Table 7.07: Water Performance (External QA)**

<i>Analysis</i>	<i>NB Power (pCi·L<sup>-1</sup>) or (uCi·kg<sup>-1</sup>)</i>	<i>QA Agent (pCi·L<sup>-1</sup>) or (uCi·kg<sup>-1</sup>)</i>	<i>NB Power/ QA Agent (ratio)</i>
<b>ALPHA</b>	1.91E+02	2.09E+02	0.91
	1.59E+02	1.43E+02	1.11
<b>BETA</b>	2.64E+02	2.73E+02	0.97
	4.30E+02	4.49E+02	0.96
	1.86E+02	1.89E+02	0.98
<b>Am-241</b>	1.68E+02	1.58E+02	1.06
	1.21E+00	1.31E+00	0.92
<b>C-14</b>	7.11E-01	7.70E-01	0.92
	4.17E-01	4.40E-01	0.95
	2.09E+01	2.20E+01	0.95
	2.14E-01	2.50E-01	0.86
<b>Cd-109</b>	1.33E+01	1.59E+01	0.85
	1.79E+01	1.74E+01	1.03
<b>Ce-139</b>	9.58E+00	1.02E+01	0.94
	6.41E-01	6.10E-01	1.05
	2.84E-01	3.60E-01	0.79*

\*Outside expected range.

## 7.2 External Quality Assurance, Continued

**Table 7.07: Water Performance (External QA), Continued**

<i>Analysis</i>	<i>NB Power (pCi·L<sup>-1</sup>) or (uCi·kg<sup>-1</sup>)</i>	<i>QA Agent (pCi·L<sup>-1</sup>) or (uCi·kg<sup>-1</sup>)</i>	<i>NB Power/ QA Agent (ratio)</i>
<b>Ce-141</b>	1.36E+02	1.36E+02	1.00
	1.03E+02	8.25E+01	1.25
	1.28E+02	1.16E+02	1.10
	8.57E+01	8.88E+01	0.97
<b>Co-57</b>	4.22E-01	4.10E-01	1.03
	2.17E-01	2.40E-01	0.90
<b>Co-58</b>	1.38E+02	1.28E+02	1.08
	9.68E+01	9.47E+01	1.02
	7.90E+01	7.36E+01	1.07
	1.38E+02	1.28E+02	1.08
<b>Co-60</b>	2.96E+02	2.74E+02	1.08
	9.41E-01	8.20E-01	1.15*
	2.69E+02	2.52E+02	1.07
	2.58E+02	2.49E+02	1.04
	5.49E-01	4.70E-01	1.17*
	1.06E+02	9.30E+01	1.14
<b>Cs-134</b>	2.09E+02	1.96E+02	1.07
	1.21E+02	1.26E+02	0.96
	1.33E+02	1.28E+02	1.04
	1.48E+02	1.43E+02	1.03
<b>Cs-137</b>	1.47E+02	1.38E+02	1.07
	5.41E-01	5.20E-01	1.04
	1.74E+02	1.58E+02	1.10
	3.10E-01	2.90E-01	1.07
	1.28E+02	1.21E+02	1.06
<b>Fe-59</b>	1.18E+02	1.19E+02	0.99
	1.03E+02	1.18E+02	0.87
	1.08E+02	1.08E+02	1.00
	1.18E+02	1.19E+02	0.99

\*Outside expected range.

## 7.2 External Quality Assurance, Continued

*Table 7.07: Water Performance (External QA), Continued*

<i>Analysis</i>	<i>NB Power (pCi·L<sup>-1</sup>) or (uCi·kg<sup>-1</sup>)</i>	<i>QA Agent (pCi·L<sup>-1</sup>) or (uCi·kg<sup>-1</sup>)</i>	<i>NB Power/ QA Agent (ratio)</i>
<b>H-3</b>	2.69E+01	2.80E+01	0.96
	1.63E+02	1.70E+02	0.96
	1.33E+01	1.26E+01	1.06
	2.49E+02	2.33E+02	1.07
<b>Hg-203</b>	1.38E+00	1.26E+00	1.10
	3.66E-01	8.00E-01	0.46*
<b>Mn-54</b>	1.76E+02	1.76E+02	1.00
	1.05E+02	1.12E+02	0.94
	1.68E+02	1.64E+02	1.02
	1.09E+02	9.84E+01	1.11
<b>Sn-113</b>	1.09E+00	1.06E+00	1.03
	4.55E-01	6.10E-01	0.75*
<b>Sr-85</b>	1.35E+00	1.30E+00	1.04
	4.12E-01	7.50E-01	0.55*
<b>Sr-89</b>	1.45E+02	9.25E+01	1.57*
	6.59E+01	8.43E+01	0.78
	6.76E+01	8.95E+01	0.76
	8.87E+01	8.74E+01	1.01
<b>Sr-90</b>	1.21E+01	1.46E+01	0.83
	1.14E+01	1.24E+01	0.92
	8.33E+00	1.16E+01	0.72
	1.27E+01	1.21E+01	1.05
<b>Y-88</b>	2.00E+00	1.80E+00	1.11*
	8.01E-01	1.02E+00	0.79*
<b>Zn-65</b>	2.95E+02	3.00E+02	0.98
	1.58E+02	1.70E+02	0.93
	2.53E+02	2.27E+02	1.11
	1.22E+02	1.27E+02	0.96

\*Outside expected range.

## 7.2 External Quality Assurance, Continued

**Table 7.08: Food/Vegetation Performance (External QA)**

<i>Analysis</i>	<i>NB Power (pCi·g<sup>-1</sup>)</i>	<i>QA Agent (pCi·g<sup>-1</sup>)</i>	<i>NB Power/ QA Agent (ratio)</i>
<b>Ce-141</b>	2.48E-01	1.92E-01	1.29
	2.95E-01	2.33E-01	1.27
<b>Co-58</b>	2.32E-01	2.20E-01	1.05
<b>Co-60</b>	6.86E-01	5.86E-01	1.17
	2.85E-01	2.44E-01	1.17
<b>Cs-134</b>	3.52E-01	2.93E-01	1.20
	4.21E-01	3.75E-01	1.12
<b>Cs-137</b>	4.25E-01	3.68E-01	1.15
	3.65E-01	3.17E-01	1.15
<b>Fe-59</b>	2.77E-01	2.75E-01	1.01
	3.08E-01	2.82E-01	1.09
<b>Mn-54</b>	2.95E-01	2.60E-01	1.13
	2.60E-01	2.58E-01	1.01
<b>Zn-65</b>	4.81E-01	3.96E-01	1.21
	3.89E-01	3.33E-01	1.17

\*Outside expected range.

## 7.2 External Quality Assurance, Continued

**Table 7.09: Soil Performance (External QA)**

<i>Analysis</i>	<i>NB Power (pCi·g<sup>-1</sup>)</i>	<i>QA Agent (pCi·g<sup>-1</sup>)</i>	<i>NB Power/QA Agent (ratio)</i>
<b>Ce-141</b>	2.46E-01	1.92E-01	1.28
	3.04E-01	2.14E-01	1.42*
<b>Co-58</b>	2.97E-01	2.20E-01	1.35*
<b>Co-60</b>	7.93E-01	5.86E-01	1.35*
	3.10E-01	2.24E-01	1.38*
<b>Cs-134</b>	3.80E-01	2.92E-01	1.30
	4.90E-01	3.46E-01	1.42*
<b>Cs-137</b>	4.89E-01	4.41E-01	1.11
	4.29E-01	3.58E-01	1.20
<b>Fe-59</b>	3.51E-01	2.75E-01	1.28
	4.50E-01	2.60E-01	1.73*
<b>Mn-54</b>	2.90E-01	2.60E-01	1.12
	3.20E-01	2.38E-01	1.34*
<b>Zn-65</b>	4.53E-01	3.96E-01	1.14
	3.52E-01	3.07E-01	1.15

\*Outside expected range.

**Table 7.10: Environmental TLD Performance (External QA)\***

<i>Analysis</i>	<i>NB Power (mR ± 2 sigma)</i>	<i>QA Agent (mR ± 2 sigma)</i>	<i>NB Power/QA Agent (ratio)</i>
<b>Gamma</b>	*	*	*

\*Test TLD data not available for 2023.

## 7.3 Internal Quality Assurance

There are three parts to Internal QA:

1. Duplicate samples – two samples collected at the same time and analyzed separately.
2. Replicate analyses – two analyses done on the same sample.
3. In house analyses – lab staff irradiate the TLDs which are subsequently analyzed.

Duplicate samples and replicate analyses are employed as part of the overall quality assurance program. For those media where two samples can be obtained from the same location at the same time, similar analytical results are expected. This approach demonstrates that the samples are representative of the medium in that area. Where duplicate samples are not possible, e.g., air filters, a sample is counted twice to demonstrate reproducibility in the counting system. Tracking of results is done in a spreadsheet and performance is charted. If the range of the ratio (of the two detected measurements) plus or minus the combined uncertainty (95% confidence interval) includes 1.00, then performance is acceptable. See Table 7.11 for the frequency.

There were 194 radionuclide comparisons performed. Ten of these had results outside expectations.

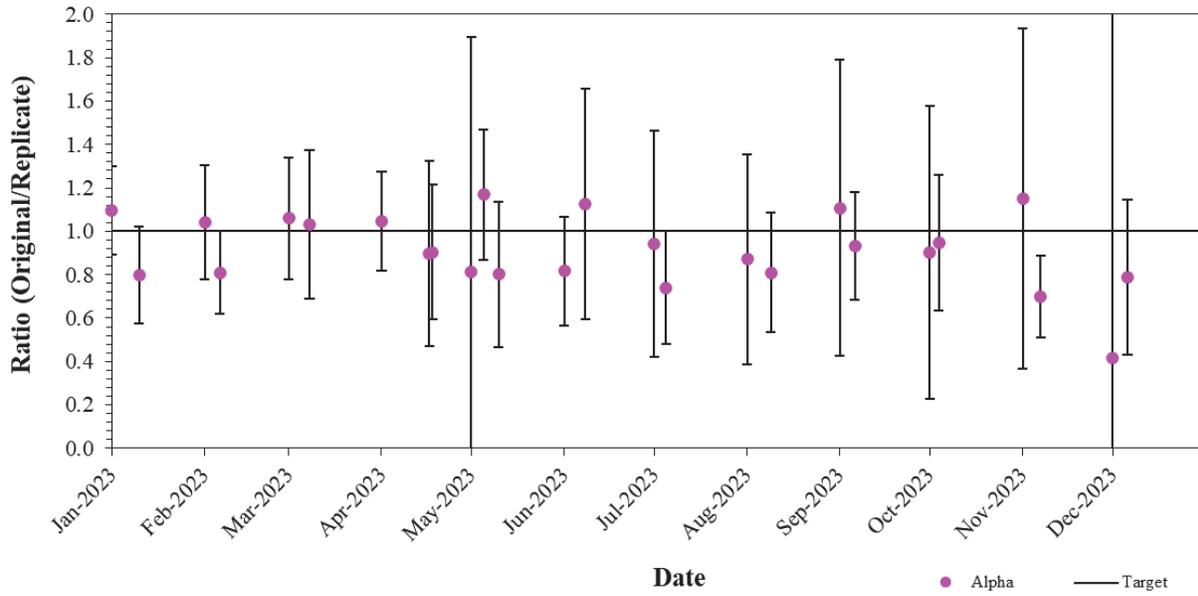
The results are presented graphically in Figures 7.01 to 7.13 (plotted against the analysis date).

### 7.3 Internal Quality Assurance, Continued

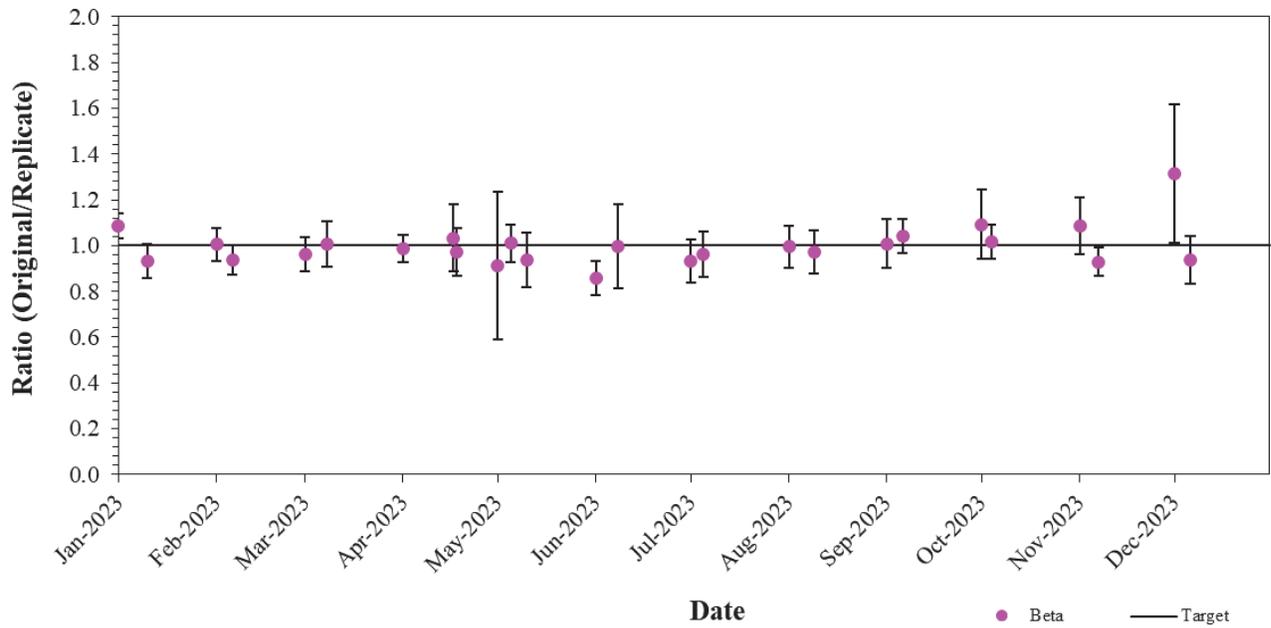
*Table 7.11: Internal Quality Assurance Frequency*

<i>Medium</i>	<i>Duplicate/Replicate</i>	<i>Number of Radionuclide Comparisons</i>	<i>Analyses</i>
Airborne Carbon Dioxide	Replicate analysis (single location)	12	LSC C-14
Airborne Iodine	Replicate count (1 composite set)	23	Gamma
Airborne Particulates	Replicate analysis	8	Gamma
		24	Alpha/Beta
Parshall Flume	Replicate analysis	11	LSC H-3
LEM Composite	Replicate analysis	44	Gamma
		28	Alpha/Beta
		14	Sr-89,90
Sediment / Soil	Duplicate sample	18	Gamma
Environmental Gamma	Duplicate sample	4	TLD
Bore Hole	Duplicate sample	1	LSC H3
Fish / Salmon / Vegetables / Vegetation	Duplicate Sample	7	Gamma

### 7.3 Internal Quality Assurance, Continued

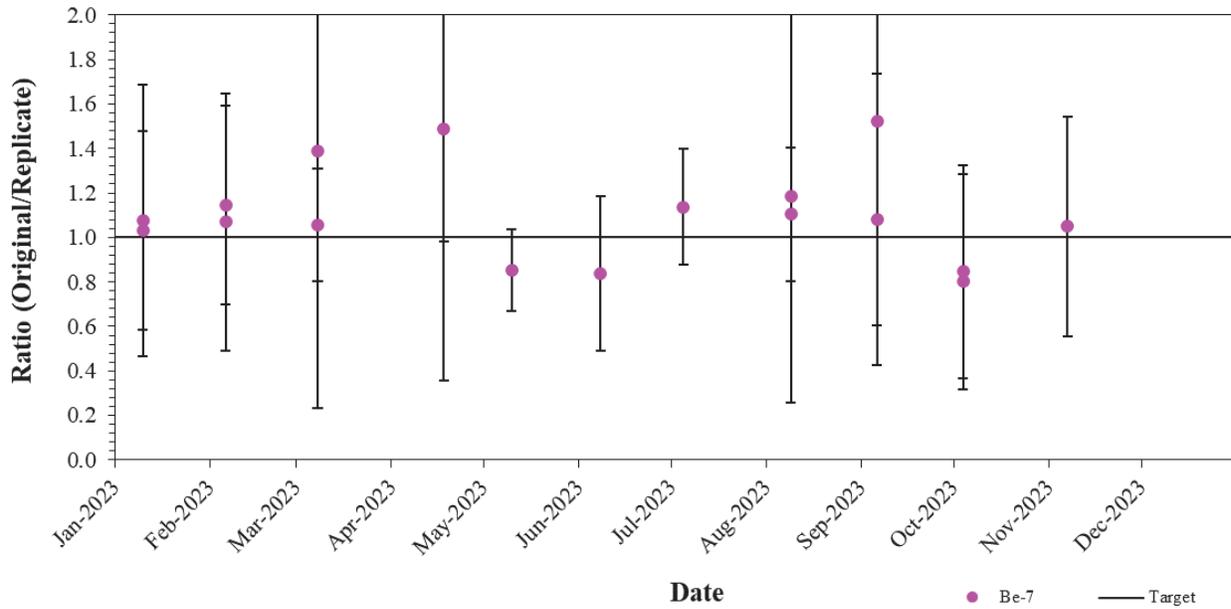


**Figure 7.01: Alpha Performance (Internal QA – duplicate/replicate) (Colour)**

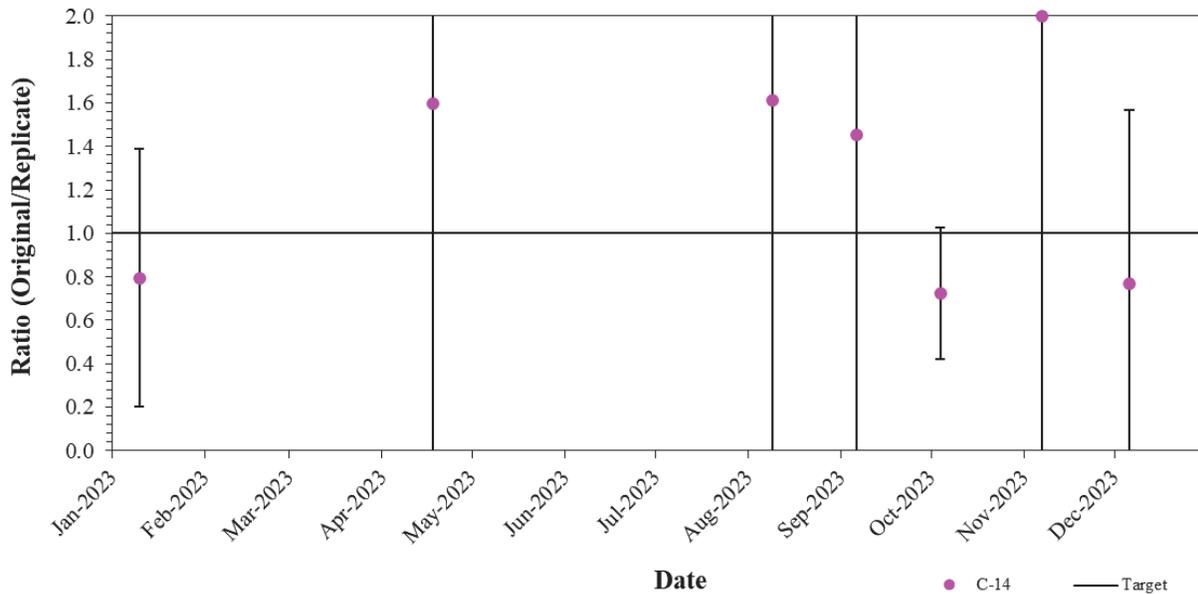


**Figure 7.02: Beta Performance (Internal QA – duplicate/replicate) (Colour)**

### 7.3 Internal Quality Assurance, Continued

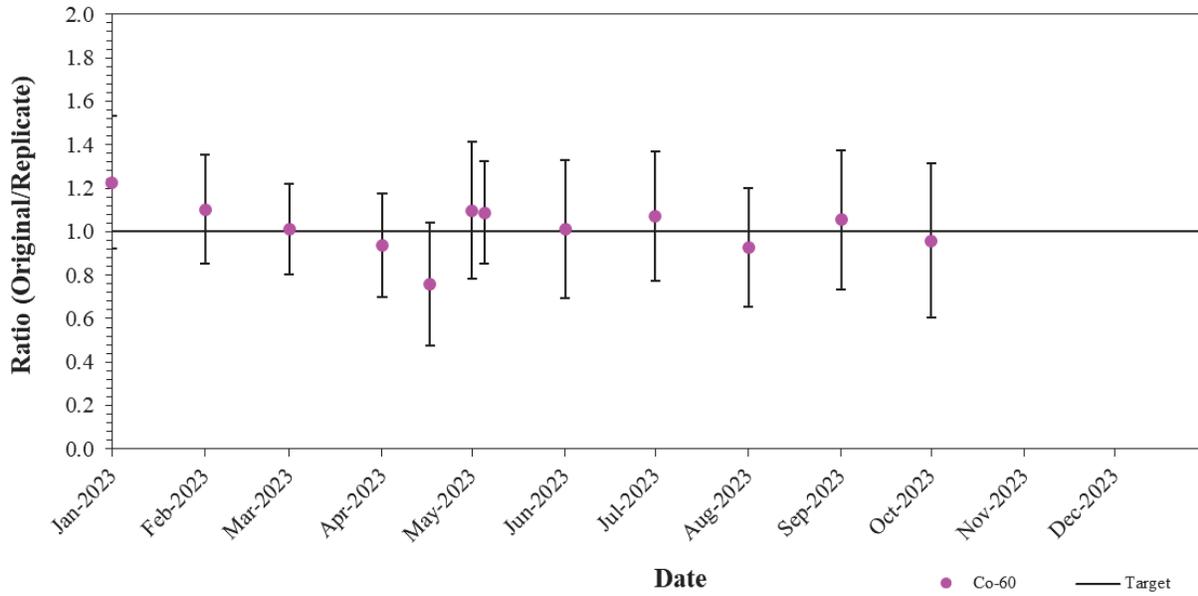


**Figure 7.03: Beryllium-7 Performance (Internal QA – duplicate/replicate) (Colour)**

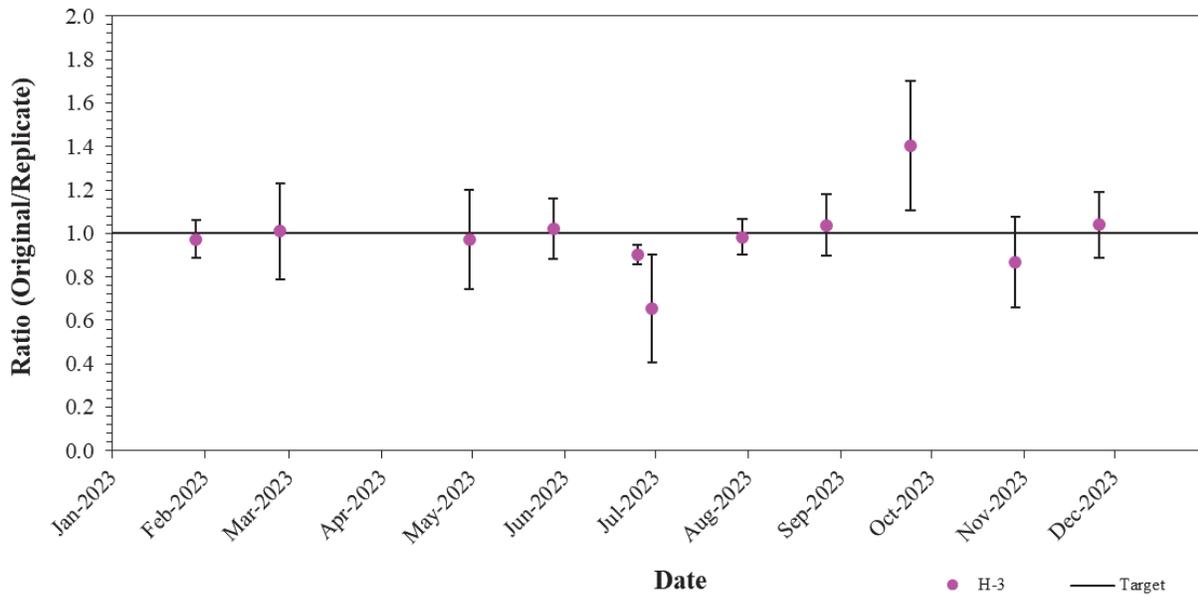


**Figure 7.04: Carbon-14 Performance (Internal QA – duplicate/replicate) (Colour)**

### 7.3 Internal Quality Assurance, Continued

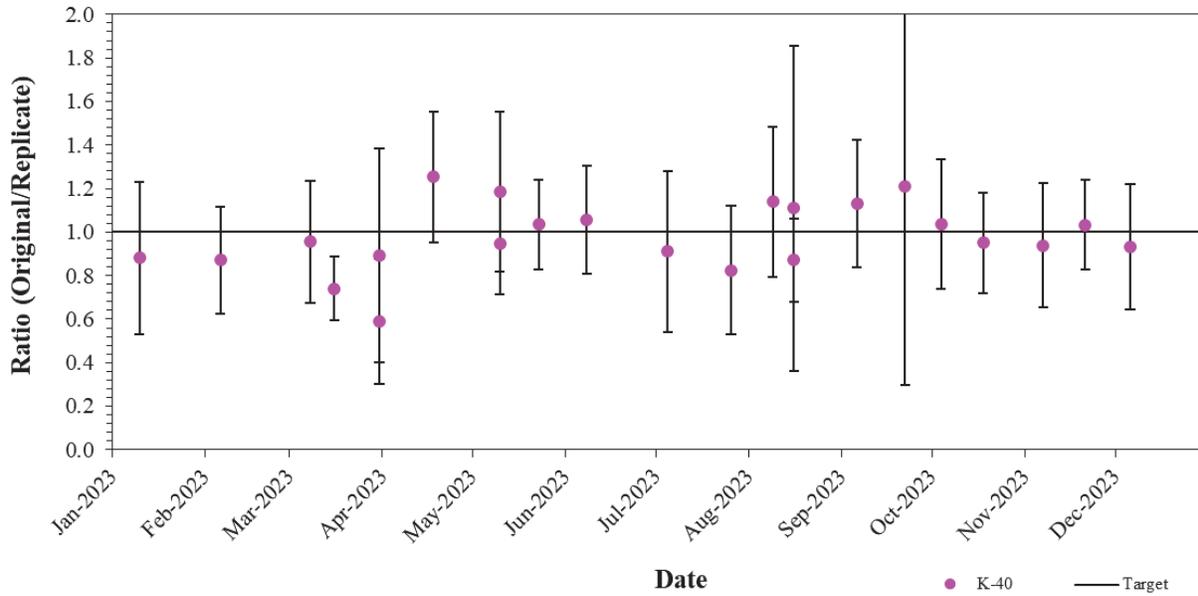


**Figure 7.05: Cobalt-60 Performance (Internal QA – duplicate/replicate) (Colour)**

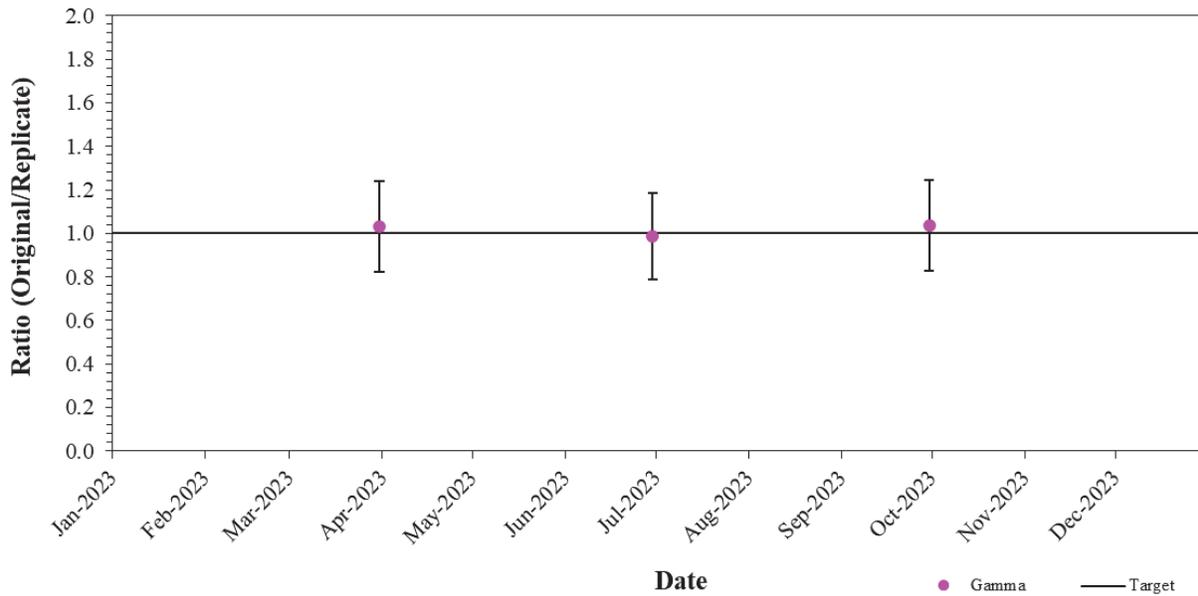


**Figure 7.06: Tritium Performance (Internal QA – duplicate/replicate) (Colour)**

### 7.3 Internal Quality Assurance, Continued

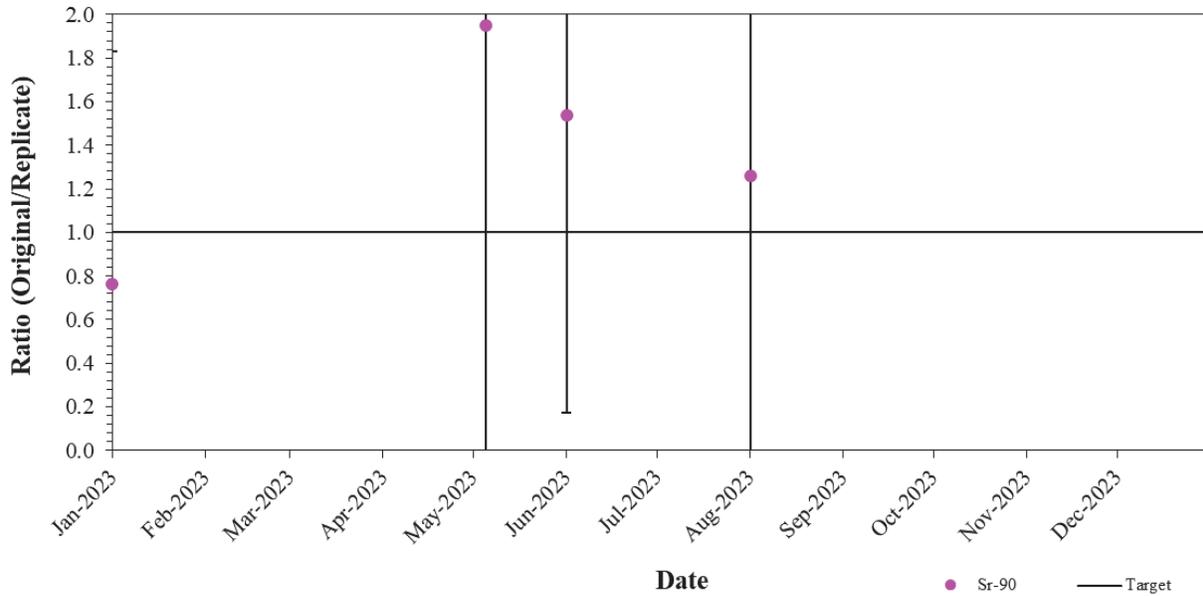


**Figure 7.07: Potassium-40 Performance (Internal QA – duplicate/replicate) (Colour)**

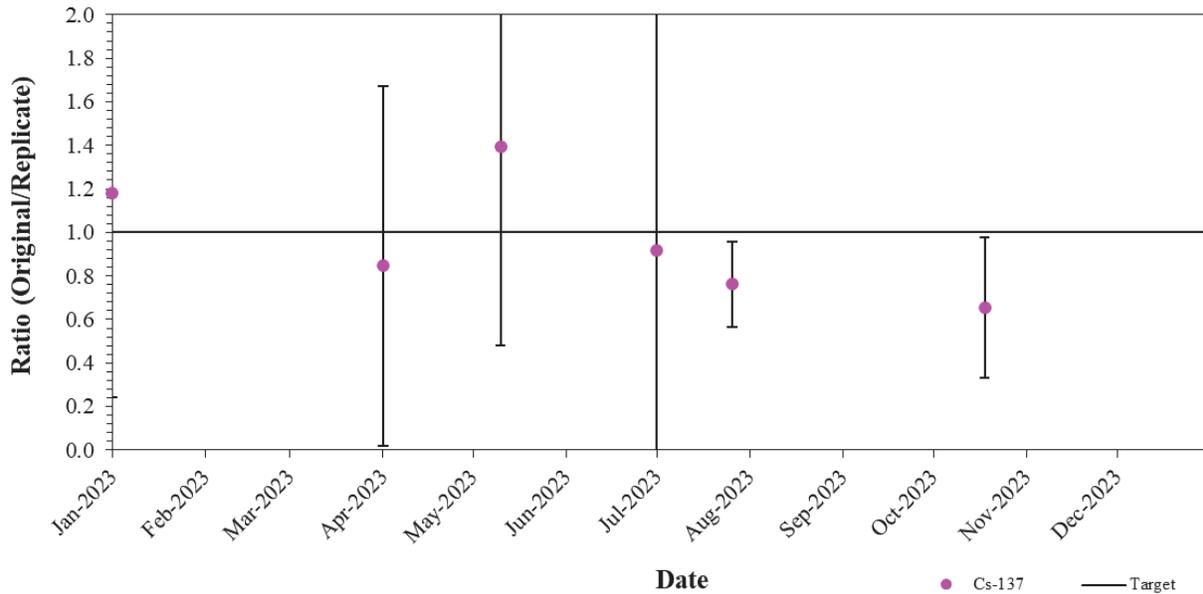


**Figure 7.08: Gamma Performance (Internal QA – duplicate/replicate) (Colour)**

### 7.3 Internal Quality Assurance, Continued

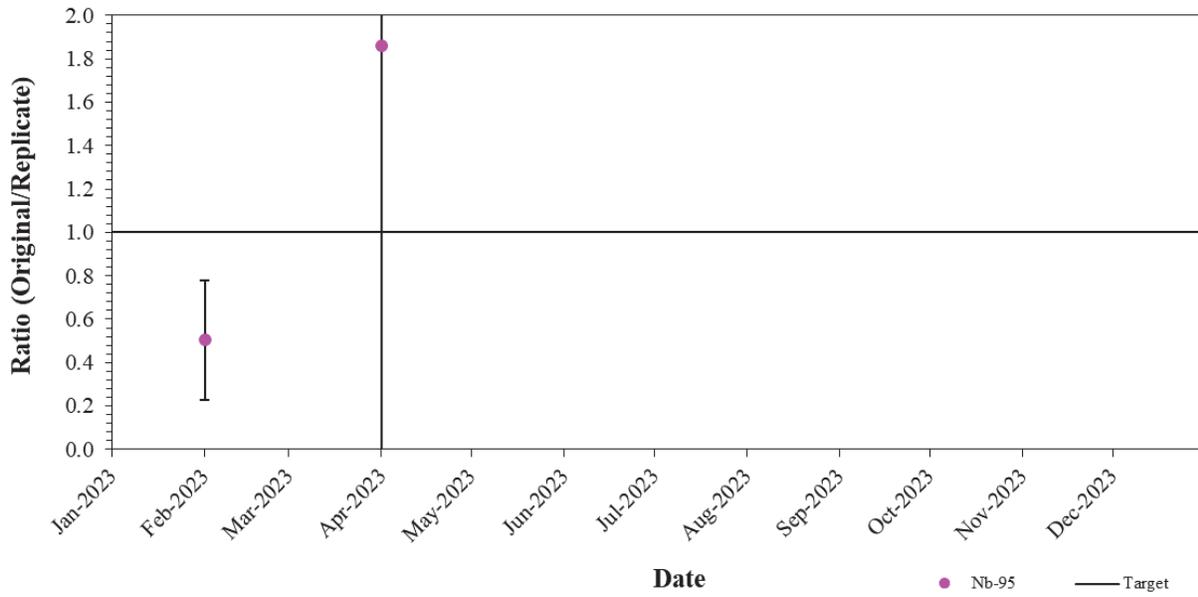


**Figure 7.09: Strontium-90 Performance (Internal QA – duplicate/replicate) (Colour)**

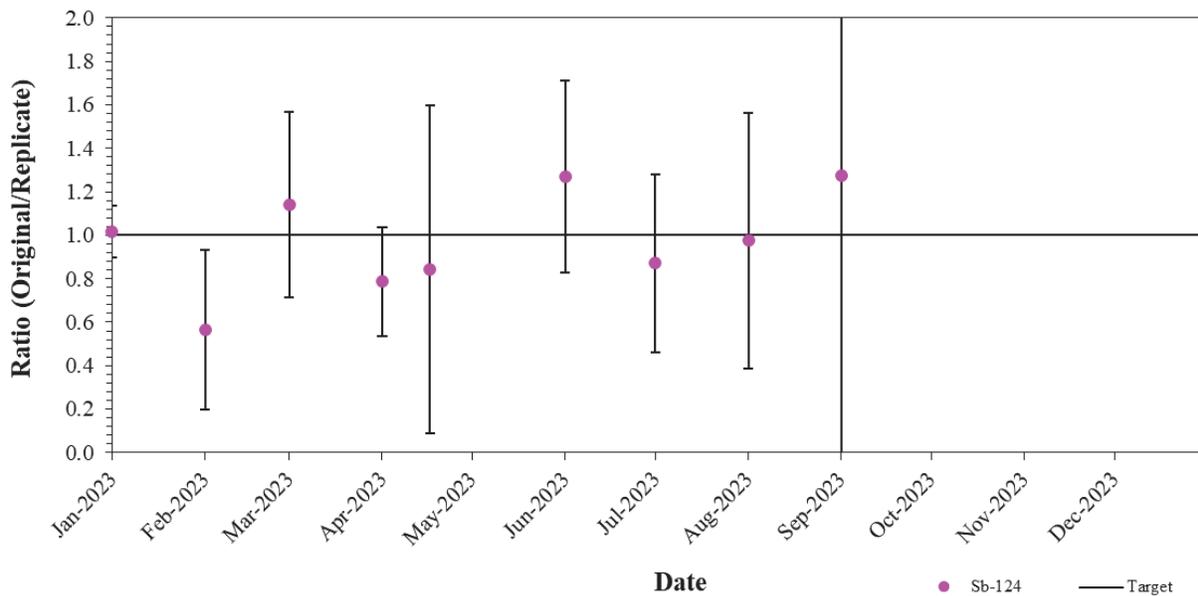


**Figure 7.10: Cs-137 Performance (Internal QA – duplicate/replicate) (Colour)**

### 7.3 Internal Quality Assurance, Continued

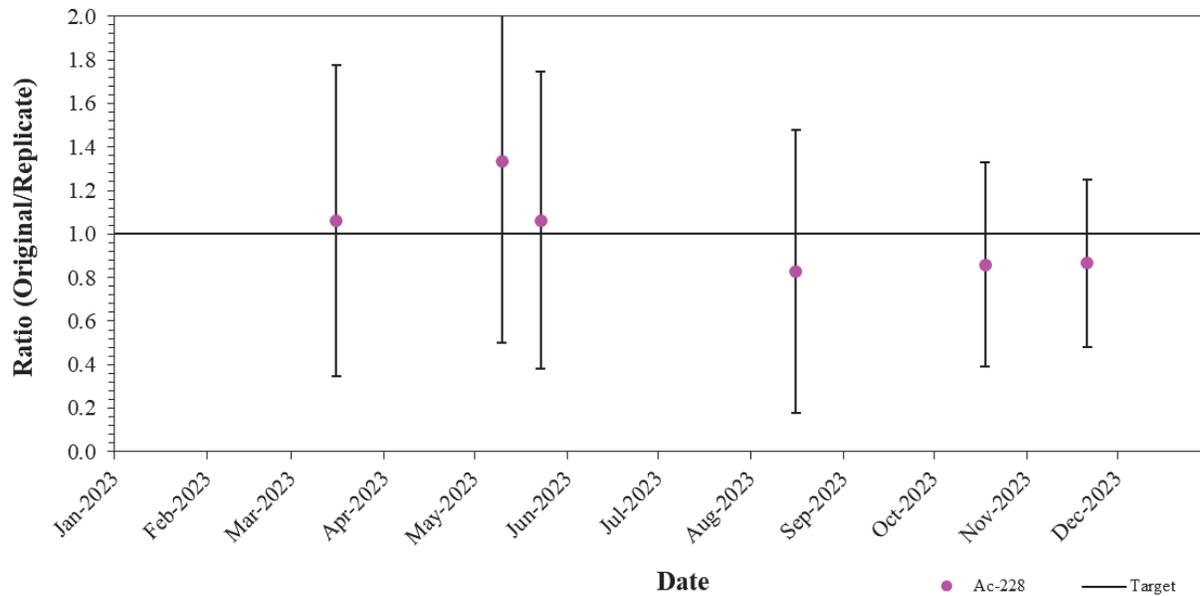


**Figure 7.11: Niobium-95 Performance (Internal QA – duplicate/replicate) (Colour)**



**Figure 7.12: Sb-124 Performance (Internal QA – duplicate/replicate) (Colour)**

### 7.3 Internal Quality Assurance, Continued



**Figure 7.13: Actinium-228 Performance (Internal QA – duplicate/replicate) (Colour)**

Samples that are spiked by laboratory personnel play a minor role in the QA program. It is more desirable to purchase QA samples from an accredited QA laboratory. The only exception is the irradiation of environmental TLDs. Lab staff irradiate the TLDs which are subsequently analyzed. Results of performance with these samples give an indication of the quality of measurements. Acceptable performance is defined as results within  $\pm 20\%$  of the expected value.

The four separate tests were successful (five TLDs for each test). The results are presented in Figure 7.14.

In addition, a stock solution of C-14 was repeatedly analyzed throughout the year. The results are shown in Figure 7.15. This practice provides an extra degree of confidence in the Environmental Program. Acceptable performance is defined as results within  $\pm 20\%$  of the expected value.

### 7.3 Internal Quality Assurance, Continued

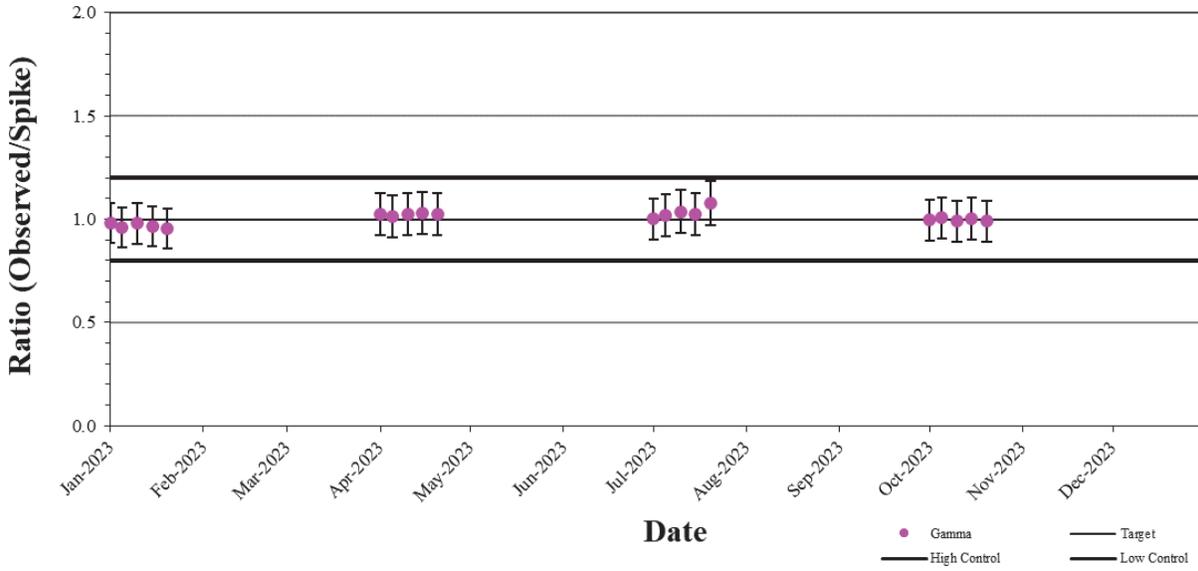


Figure 7.14: Gamma Performance (Internal QA - spikes) (Colour)

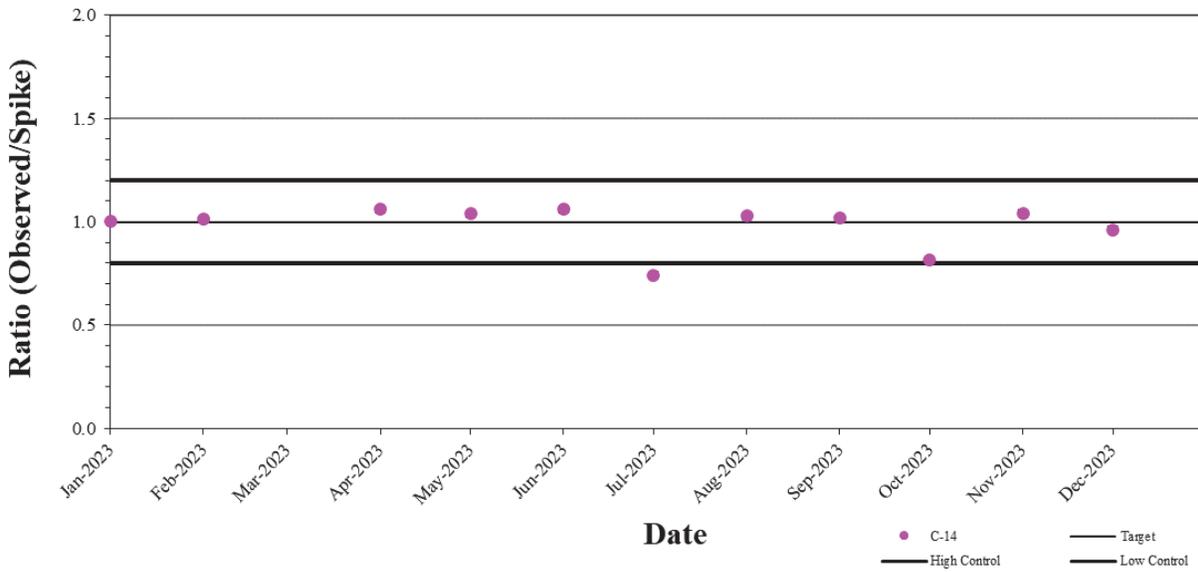


Figure 7.15: C-14 Performance (Internal QA - spikes) (Colour)

## 7.4 Program Audit

The REMP audit frequency was changed to once every five years to align with the Canadian Standards Association (CSA) standard. The Nuclear Oversight Group (NOS) at PLNGS is the principal auditor, although other groups from within NB Power, the CNSC, or other utilities may be used.

The CNSC completed a Type II Environmental Monitoring inspection which was conducted at Point Lepreau Nuclear Generating Station (PLNGS) from August 8-10, 2023. The objective of the inspection was to verify compliance with *CSA N288.4-10, Environmental monitoring program at Class I nuclear facilities and uranium mines and mills* and *REGDOC-2.9.1, version 1.2, Environmental Protection: Policies, Programs and Procedures*. Identified gaps were added to the corrective action program and have been addressed.

The station's Nuclear Oversight (NOS) team completed an evaluation of the SU-2, Provide Environmental Services station process and the Environmental Management System (ISO 14001) from June 12-16, 2023. The audit assessed compliance to *REGDOC-2.9.1 (2017)*, *ISO 14001:2015 (Sections 4 through 10)* and selected clauses from *CSA N286.12 (R2017)*. In addition, the following Significant Environmental Aspects (SEAs) were reviewed:

- SEA 1: Waterborne radioactive releases from the reactor building, service building and turbine building.
- SEA 2: Airborne radioactive releases from reactor building, serviced building and turbine building.

All findings from the audit were added to the station's corrective action program and have been addressed.

## 7.5 Annual Review

The Radiation Environmental Monitoring Program (REMP) aligns to the Canadian Standards Association (CSA) standards *N288.4-10, Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills* and *N288.5-11, Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills*. As part of this, an annual review of the program was completed on September 9, 2023. There were no actions required as a result of the annual review.

## 8.0 Non-Radiological Monitoring and Reporting

### 8.1 Ozone Depleting Substance

In Canada, the federal and provincial governments have legislation in place for the protection of the ozone layer and management of ozone-depleting substances and their halocarbon alternatives. The use and handling of these substances are regulated through the *Federal Halocarbon Regulations, 2022* (SOR 2022-110) and *New Brunswick Regulation 97-132, Ozone Depleting Substances and Other Halocarbon Regulations*. Halocarbon releases are being reported, not just Ozone Depleting Substances.

In 2023, there were no issues that required the Station to contact Environment and Climate Change Canada.

### 8.2 Domestic Waste Water Treatment (Sewage) (Approval to Operate S-3271)

The domestic wastewater is regulated by the provinces and territories in their jurisdictions, and through the Federal Wastewater System Effluent Regulations. PLNGS is governed federally and administered provincially.

At PLNGS, an electronic report via Effluent Regulation Reporting Information System (ERRIS) is completed. The electronic submission frequency is determined on the design of, and the daily discharge flow from the facility. PLNGS has a monthly sampling requirement with a quarterly reporting frequency. PLNGS electronic reporting was completed quarterly as required.

As per the *Approval to Operate*, a letter was submitted to New Brunswick Department of Environment and Local Government (NBDELG) describing any discharge to an overflow point and any environmental emergencies that occurred during the year. This was submitted in February, 2024. This letter was also submitted to the CNSC staff as per Guidance in *REGDOC-3.1.1, Section 3.5*.

The approval requires sampling (grab or composite) on a monthly basis but at least 10 days after any other samples. PLNGS collects and analyzes the effluent on a weekly basis to verify the performance of the facility.

## 8.2 Domestic Waste Water Treatment (Sewage) (Approval to Operate S-3271), Continued

The sample collection and analysis is performed by Saint John Laboratory Services Ltd. They are accredited to Canadian Association for Laboratory Accreditation Inc. (CALA).

There were no exceedances of pH or unionized ammonia at the domestic wastewater facility for 2023.

**Table 8.01: Electronic Data Submission to ERRIS (2023)**

2023	Days deposited	Volume (m3)	Average CBOD (mg/L)	Average SS (mg/L)	Unionized ammonia (mg/L)
Jan-Mar	90	11400	1.0	1.0	NA
Apr-Jun	91	9360	1.0	1.0	NA
Jul-Sept	92	13500	1.0	1.0	NA
Oct-Dec	92	10300	1.1	1.3	NA

NA – Not Applicable

## 8.3 Waste Water Compliance (Approval to Operate I-11307)

The wastewater compliance reports for PLNGS are submitted to New Brunswick Department of Environment and Local Government (NBDELG), based on the reporting Conditions of the *Approval to Operate*, as follows:

The operation of the Industrial Wastewater Treatment System at PLNGS has an *Approval to Operate (I-11307)* issued under the *New Brunswick Regulation 82-126, Water Quality Regulation*. It is valid from May 1<sup>st</sup>, 2021 to April 30<sup>th</sup>, 2026. Condition 44 states that “Within 60 days of the end of each year, The Approval Holder shall submit an Annual Environmental Report to the Department.”

Samples are collected and analyzed daily for pH, suspended solids and hydrazine. From the daily samples, a monthly composite is prepared and analyzed for heavy metals (arsenic, barium, cadmium, chromium, copper, iron, lead, mercury, nickel, vanadium and zinc) and Total Petroleum Hydrocarbons (TPH).

Hydrazine samples are collected and analyzed daily at the lagoon discharge and the ditch and reported with the Inactive Wastewater *Approval to Operate I-11307*. Hydrazine releases from system drain downs are also reported under this approval. Data showing that the hydrazine levels in the CCW remained below the 0.075 mg/L limit is provided in the reporting to NBDELG.

### 8.3 Waste Water Compliance (Approval to Operate I-11307), Continued

The daily sample analysis is performed by the Chemistry Department using procedures:

- *CAP-78200-PH01; pH Measurement by Glass Combination Electrode*
- *CLIP-78200-0074; Accumet Excel Model 25 pH/Millivolt Meter*
- *CAP-78200-SU02; Suspended Solid*
- *CAP-78200-HY01; Hydrazine by P-Dimethylaminobenzaldehyde*
- *CLIP-78200-0022; Varian Cary 50 UV/VIS Spectrometer*
- *CMP-78200-0003; Varian UV/VIS Spectrometer Model Cary*

The metals and TPH analysis are performed by Saint John Laboratory Services Ltd. They are accredited to Canadian Association for Laboratory Accreditation Inc. (CALA).

The annual report is sent to the CNSC staff as per Guidance in *REGDOC-3.1.1*.

### 8.4 Non-Radiological Air Emission

Site conventional air emissions are controlled to meet regulatory requirements, prevent pollution, reduce emissions, and to minimize environmental impacts.

PLNGS no longer requires an air quality approval to operate the Auxiliary Volcano Boiler and Diesel Generators. The fuel consumption and emissions for 2023 were tracked and calculated for possible reporting under the National Pollutant Release Inventory (NPRI) and Federal and Provincial Greenhouse Gas Emission (GHG) databases, should emissions meet reporting thresholds. In 2023, none of thresholds were met to require reporting under NPRI and GHG.

Only significant emissions are being estimated and reported, as emission estimates are well below the reporting threshold and therefore the estimation and reporting of smaller emission sources is not justified. NO<sub>x</sub> is being expressed at NO<sub>2</sub>.

## 8.4 Non-Radiological Air Emission, Continued

During the year no barrels (0 liters) of Type 2 Light Oil and 2,754 barrels (437,856 liters) of Type B Diesel Fuel were consumed at the Station. The preliminary analysis indicated the diesel fuel oil had an average energy content of 5.58 million BTUs per barrel, an average ash content of 0.0001 percent, and an average sulphur content of 0.0008 percent. Fuel analysis results are obtained from the AmSpec Services analysis results sent to the Chemistry Department at PLNGS while fuel consumption figures are provided by the NB Power Fuels Group.

During the year the annual emissions were calculated and are shown in Table 8.02. Please note the reporting threshold listed for Carbon Dioxide is for GHG reporting, while the remaining substance thresholds are for NPRI reporting. Table 8.02: Annual Emissions (2022)

**Table 8.02: Annual Emissions (2023)**

<b>Parameter</b>	<b>Tonnes</b>	<b>Reporting Threshold</b>
<b>Carbon Dioxide (CO<sub>2</sub>)</b>	<b>1290</b>	<b>10000</b>
<b>Sulphur Dioxide (SO<sub>x</sub>)</b>	<b>0.06</b>	<b>20</b>
<b>Nitrogen Dioxide (NO<sub>x</sub>)</b>	<b>3.49</b>	<b>20</b>
<b>Volatile Organic Compounds (VOC)</b>	<b>0.01</b>	<b>10</b>
<b>Carbon Monoxide (CO)</b>	<b>0.263</b>	<b>20</b>
<b>Particulate Matter (PM)</b>	<b>0.21</b>	<b>20</b>
<b>Particulate Matter (PM<sub>10</sub>)</b>	<b>0.13</b>	<b>0.5</b>
<b>Particulate Matter (PM<sub>2.5</sub>)</b>	<b>0.05</b>	<b>0.3</b>

Refer To *Section 8.7* for the hydrazine in air numbers.

## 8.5 Chlorine

There is currently no chlorine disinfection on site at the PLNGS. There is a sodium hypochlorite system utilized during maintenance of specific sections of the domestic wastewater works.

## 8.6 Ammonia

There are no significant sources of ammonia emissions to the environment as a result of PLNGS operations.

## 8.7 Hydrazine

In addition to the amount reported to the NBDELG, Hydrazine is also released through boiler blowdowns (2.8 kg) and Liquid Effluent Pumpouts (LEPA) (41.3 kg). Hydrazine is also reported to the NPRI, as per the table below:

**Table 8.03: Other NPRI Substances (2023)**

Substance	MPO Threshold (kg)	MPO (kg)	Reporting required (Y/N)	Releases to Air (kg)	Releases to Water (kg)	Releases to Land (kg)	Disposals (kg)
Sulphuric Acid	10000	0	N	NA	0	0	0.00
Ethylene Glycol	10000	615	N	NA	NA	0	
Cobalt	50	0	N	0	NA	NA	0
Hydrazine	1000	1,148	Y	81.2	51.7	0	57.41

## 8.8 Morpholine

In 2023, a total of 1419 kg of morpholine was released through the controlled pathway via the boiler blowdown process.

## 8.9 Landfill

Under the approval, (I-11675), Post Closure Monitoring of the Decommissioned Point Lepreau Waste Disposal Facility, effective January 1, 2022, Condition 21 states that "The Approval Holder shall, prior to December 1<sup>st</sup> of each year and until otherwise Approved, submit a report to the Department on the monitoring conducted within the year. The report shall contain the monitoring program information as described and scheduled by the Recommendations section of Report titled, "Former Point Lepreau Landfill Post-Construction Surface Water and Groundwater Monitoring December 2018 to September 2019 Maces Bay, New Brunswick", by Gemtec and dated November 28, 2019." These reports were submitted on November 30<sup>th</sup>, 2023.

Based on this, the NBDELG has approved final closure of the landfill in November 2023.

## 8.10 Other Non-Radiological Monitoring and Reporting through the NPRI

Each year, the NPRI substances are evaluated to determine if they require reporting based on the regulations. There are four NPRI substances that are evaluated as they are the ones that would be close to the requirement to report. If there is a significant change to a given NPRI substance, that will be re-evaluated to see if it meets the NPRI thresholds. **Refer To** Table 8.03 for the NPRI. Only hydrazine met the threshold this year.

## 8.11 Conclusion

Based on the data discussed above, the non-radiological emissions monitored under the Effluent Compliance Monitoring Program are of minimal significance. Point Lepreau Nuclear Generating Station continues to make adequate provisions for the protection of the environment and health and safety of people.

## 8.12 EMS Program Audit

The PLNGS has been successfully reregistered to the ISO 14001:2015 standard in October 2022. During the re-registration audit, the auditor identified zero (0) major non conformances, one (1) minor non-conformance (administrative in nature), and five (5) opportunities for improvement.

From September 18 to 22, 2023, a maintenance audit was conducted, and the auditor identified zero (0) major non conformances, three (3) minor non conformances (administrative in nature), and four (4) opportunities for improvement. All findings were minor in nature and are being tracked through PLNGS's internal Corrective Action Program.

An audit plan/program has been established for the Effluent and Environmental (incl. Groundwater) Monitoring Programs. The programs are audited once every 5 years, most recently in February 2022. The auditor identified zero (0) major non conformances, one (0) minor non conformance, and seven (7) opportunities for improvement. All findings were minor in nature and are being tracked through PLNGS's internal Corrective Action Program.

The most recent Corporate Compliance Audit was in February 2022 which identified zero (0) major non conformances, zero (0) minor non conformances, and zero (0) opportunities for improvement.

## 9.0 Reports and Studies

The Station is aligned to the Canadian Standards Association (CSA) standards *N288.4-10, Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills* and *N288.5-11, Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills* and *N288.7-15 Groundwater protection programs at Class I nuclear facilities and uranium mines and mills*. There were no significant changes to program requirements or documentation in 2023.

## Appendix A: Statistics, Detection Limits, and Dose at Detection Limits

### A1 Statistics

The following statistical conventions are applied in the analysis of each sample:

- Detection limits are defined following the method described by Lochamy in *NBS Special Publication 456, Measurements for the Safe Use of Radiation (US Department of Commerce, 1976)*. The lower limit of detection (LLD) at the 99% confidence level is defined as  $6.58 S_b$ , where  $S_b$  is the standard deviation of the appropriate radiation background measurement. This LLD corresponds to that amount of activity in a sample that will yield a net count greater than  $3.29 S_b$ , or the so-called critical level (CL), with 99% probability. Thus, the LLD specifies the theoretical capability of the system to detect a given amount of radioactivity, whereas the CL is used to determine whether an actual activity measurement should be considered detected. Any net measurement greater than  $3.29 S_b$  is considered detected at the 99% confidence level. This also implies a one percent probability of stating that activity is present when it is not (false positive). If activity is present at the LLD level ( $6.58 S_b$ ), there is a one percent probability of stating that activity is not present when it is (false negative).
- The CL of  $3.29 S_b$  and LLD of  $6.58 S_b$  apply in those analytical systems where the background levels are either not well defined, or where there is a relationship between the background levels and the detected signal above background, as in Ge gamma spectroscopy. Where the background readings are well defined and are independent of sample readings, as in the TLD data, the CL is  $2.33 S_b$  and the LLD is  $4.66 S_b$ .
- Unless otherwise indicated, the precision of the measurements reported here is given as  $\pm 1.96 S_a$  (95% confidence level), where  $S_a$  is the standard deviation of the activity measurement.
- The value and standard deviation are reported with two significant figures using modified scientific notation, for example 0.032 is expressed as  $3.2E-02$ .

## Appendix A: Statistics, Detection Limits, and Dose at Detection Limits, Continued

The lower limits of detection (LLD) of all radionuclides in the various sample media are shown in Tables A.01 to A.10. The Annual Dose is to the Representative Person. The LLDs are based on typical data. Decay of radionuclides is accounted for in the LLD calculations except for H-3 and C-14 (long half-lives). The major assumptions are that the sample is taken at one kilometre from the point of releases and that the level is maintained for the year. It is assumed that fish and lobster are caught at the Condenser Cooling Water (CCW) outlet and sediment, dulse, seawater and clams are collected at Dipper Harbour.

The CSA recommends, where technically feasible, that all measurements achieve LLDs less than that which would result in a dose of 5  $\mu\text{Sv}$  to the Representative Person. Most radionuclides pass this criterion. The major exceptions are noble gases. Detection of this group is through TLD measurements (20  $\mu\text{Sv}$  dose to the Representative Person at the LLD). However, the noble gas spectrometer on the GEM allows for a much smaller LLD calculation. Other exceptions are Ba-140 in soil, food, water and sediment (5 to 39  $\mu\text{Sv}$ ); Ru-106 in water, food and seafood (6 to 22  $\mu\text{Sv}$ ); Ce-144 in water and food (6 to 17  $\mu\text{Sv}$ ); La-140 in sediment and soil (12 to 15  $\mu\text{Sv}$ ); Zr-95 in sediment (5  $\mu\text{Sv}$ ); I-131 in food, water, sediment and seafood (8 to 15  $\mu\text{Sv}$ ) and 5 to 11  $\mu\text{Sv}$  in water (Co-60, Cs-134, Zn-65 and Cs-137). Effluent analyses show these radionuclides are not major components of releases. Part of the QA process identifies those LLDs or activities that do not meet this target.

### A1.01 Air

#### A1.01.01 Airborne Particulates

Typical LLDs are given for a 2400  $\text{m}^3$  sample that is counted for 5000 s. The LLDs are decay corrected to the midpoint between the start and end of sampling, except for the gross alpha/beta results which represent the long-lived activity present a few days after sample collection. Gross alpha/beta is for trending only.

#### A1.01.02 Airborne Radioiodines

A typical LLD for I-131 is approximately  $9\text{E}-05 \text{ Bq}\cdot\text{m}^{-3}$  (for a 2400  $\text{m}^3$  sample, counted for 50,000 s), which is decay corrected to the midpoint between the start and end of sampling.

## **Appendix A: Statistics, Detection Limits, and Dose at Detection Limits, Continued**

### **A1.01.03 Airborne Tritium**

The LLD is approximately  $1\text{E-}01 \text{ Bq}\cdot\text{m}^{-3}$  of air for a typical sample of 10 to 70  $\text{m}^3$  (counted for 100 min). Due to the long half-life and relatively short period of time between sampling and analysis, decay correction is not applied.

### **A1.01.04 Airborne Carbon-14**

A typical LLD is approximately  $4\text{E-}02 \text{ Bq}\cdot\text{m}^{-3}$  of air for a 30  $\text{m}^3$  sample (counted for 100 min). Due to the long half-life and relatively short period of time between sampling and analysis, decay correction is not applied.

### **A1.01.05 TLD**

The LLD is about 20  $\mu\text{Sv}$ . For typical quarterly measurements in the region of 150-200  $\mu\text{Sv}$ , measurements can be made to  $\pm 10\%$  at the 95% confidence level.

## Appendix A: Statistics, Detection Limits, and Dose at Detection Limits, Continued

*Table A.01: Annual Dose at the LLD for Air*

<i>Nuclide</i>	<i>LLD (Bq·m<sup>-3</sup>)</i>	<i>Dose at LLD (μSv)</i>	<i>Concentration That Gives 5 μSv (Bq·m<sup>-3</sup>)</i>
H-3	9.6E-02	4.8E-02	9.9E+00
C-14	4.0E-02	1.9E+00	1.0E-01
Cr-51	5.8E-04	3.2E-03	9.2E-01
Mn-54	7.8E-05	9.2E-02	4.3E-03
Fe-59	1.7E-04	6.1E-02	1.4E-02
Co-58	8.0E-05	3.5E-02	1.2E-02
Co-60	8.2E-05	1.7E+00	2.4E-04
Zn-65	1.9E-04	3.3E-01	2.9E-03
Kr-85	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Kr-85m	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Kr-87	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Kr-88	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Zr-95	1.3E-04	1.1E-01	6.2E-03
Nb-95	9.4E-05	9.9E-02	4.7E-03
Ru-103	7.4E-05	8.1E-03	4.5E-02
Ru-106	6.0E-04	1.0E+00	2.9E-03
Ag-110m	6.2E-05	2.2E-01	1.4E-03
I-131	8.4E-05	1.6E-01	2.5E-03
Xe-131m	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Xe-133	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Xe-133m	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Xe-135	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Xe-135m	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Xe-138	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Cs-134	6.4E-05	4.3E-01	7.4E-04
Cs-137	6.6E-05	1.6E+00	2.0E-04
Ba-140	4.8E-04	8.9E-02	2.7E-02
La-140	2.0E-04	2.5E-03	4.1E-01
Ce-141	7.6E-05	4.8E-03	7.9E-02
Ce-144	2.2E-04	2.7E-01	4.0E-03

## Appendix A: Statistics, Detection Limits, and Dose at Detection Limits, Continued

### A1.02 Water

The LLDs in Table A.02 apply to the midpoint between the start and end of sampling for a 3.6 L sample counted for 5000 s for gamma and a 6 mL sampled counted for 100 min for tritium. Alpha/beta results (a 100-500 mL sample counted for 100 min) represent the long-lived activity present several days after sample collection.

The LLDs are based on typical data for precipitation water. Since decay of radionuclides is accounted for in the LLD calculations, well water and other water sample types will have lower LLDs. The major assumptions are that the sample is taken at one kilometre from the point of releases, that the level is maintained for the year and the sample type is the major source of drinking water. Obviously, this is not the case but it gives a simple “worst case” that is easy to monitor and calculate.

**Table A.02: Annual Dose at the LLD for Water**

<i>Nuclide</i>	<i>LLD (Bq·L<sup>-1</sup>)</i>	<i>Dose at LLD (μSv)</i>	<i>Concentration That Gives 5 μSv (Bq·L<sup>-1</sup>)</i>
H-3	2.4E+01	3.4E-01	3.6E+02
Cr-51	5.4E+01	7.4E-02	3.7E+03
Mn-54	5.0E-01	1.7E-01	1.4E+01
Fe-59	1.3E+00	9.1E-01	7.1E+00
Co-58	5.6E-01	3.7E-01	7.5E+00
Co-60	4.6E-01	4.5E+00	5.1E-01
Zn-65	1.1E+00	2.3E+00	2.4E+00
Zr-95	9.8E-01	4.0E-01	1.2E+01
Nb-95	6.8E-01	4.0E-01	8.5E+00
Ru-103	6.4E-01	1.8E-01	1.8E+01
Ru-106	4.6E+00	1.7E+01	1.4E+00
Ag-110m	4.6E-01	6.2E-01	3.7E+00
I-131	2.4E+00	3.9E+00	3.1E+00
Cs-134	4.4E-01	4.8E+00	4.6E-01
Cs-137	5.2E-01	3.9E+00	6.6E-01
Ba-140	5.4E+00	2.7E+00	1.0E+01
La-140	2.2E+00	9.1E-01	1.2E+01
Ce-141	8.4E-01	3.4E-01	1.2E+01
Ce-144	2.4E+00	1.1E+01	1.1E+00

## Appendix A: Statistics, Detection Limits, and Dose at Detection Limits, Continued

### A1.03 Food

The LLDs in Table A.03 apply to the time of sample collection. Samples vary in size and are counted for 5000 s. The LLDs are based on typical data for garden vegetables.

*Table A.03: Annual Dose at the LLD for Food*

<i>Nuclide</i>	<i>LLD (Bq·kg<sup>-1</sup>)</i>	<i>Dose at LLD (μSv)</i>	<i>Concentration That Gives 5 μSv (Bq·kg<sup>-1</sup>)</i>
Cr-51	3.0E+01	5.9E-02	2.5E+03
Mn-54	3.4E+00	1.3E-01	1.3E+02
Fe-59	7.8E+00	8.4E-01	4.6E+01
Co-58	3.6E+00	3.0E-01	6.0E+01
Co-60	3.8E+00	3.9E+00	4.9E+00
Zn-65	9.0E+00	2.2E+00	2.1E+01
Zr-95	6.2E+00	3.3E-01	9.4E+01
Nb-95	4.0E+00	3.6E-01	5.6E+01
Ru-103	3.8E+00	1.7E-01	1.1E+02
Ru-106	3.0E+01	1.3E+01	1.1E+01
Ag-110m	3.0E+00	4.7E-01	3.2E+01
I-131	1.0E+01	6.9E+00	7.6E+00
Cs-134	3.0E+00	3.6E+00	4.2E+00
Cs-137	3.4E+00	2.9E+00	6.0E+00
Ba-140	2.4E+01	3.5E+00	3.5E+01
La-140	9.4E+00	1.2E+00	4.0E+01
Ce-141	4.2E+00	1.9E-01	1.1E+02
Ce-144	1.4E+01	4.9E+00	1.4E+01

## Appendix A: Statistics, Detection Limits, and Dose at Detection Limits, Continued

### A1.04 Soil

The LLDs in Table A.04 apply to the time of sample collection. Samples of approximately 200 g are counted for 5000 s.

**Table A.04: Annual Dose at the LLD for Soil**

<i>Nuclide</i>	<i>LLD (Bq·kg<sup>-1</sup>)</i>	<i>Dose at LLD (μSv)</i>	<i>Concentration That Gives 5 μSv (Bq·kg<sup>-1</sup>)</i>
Cr-51	4.0E+01	2.5E-01	7.9E+02
Mn-54	5.8E+00	1.2E+00	2.5E+01
Fe-59	1.2E+01	3.1E+00	1.9E+01
Co-58	5.0E+00	1.1E+00	2.2E+01
Co-60	5.8E+00	3.2E+00	9.1E+00
Zn-65	1.3E+01	1.7E+00	3.9E+01
Zr-95	1.0E+01	5.1E+00	9.9E+00
Nb-95	6.0E+00	9.9E-01	3.0E+01
Ru-103	4.8E+00	5.1E-01	4.7E+01
Ru-106	4.6E+01	1.9E+00	1.2E+02
Ag-110m	5.2E+00	2.7E+00	9.7E+00
I-131	6.8E+00	5.2E-01	6.6E+01
Cs-134	5.2E+00	1.5E+00	1.7E+01
Cs-137	5.6E+00	7.1E-01	3.9E+01
Ba-140	2.2E+01	1.1E+01	9.6E+00
La-140	7.2E+00	*	*
Ce-141	6.8E+00	1.2E-01	2.8E+02
Ce-144	2.4E+01	2.9E-01	4.2E+02
TLD	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
*Dose for Ba-140 assumes equilibrium with La-140 (contribution from both)			

## Appendix A: Statistics, Detection Limits, and Dose at Detection Limits, Continued

### A1.05 Seawater

The LLDs in Table A.05 apply to the time of sample collection for a 3.6 L sample counted for 5000 s for gamma; and a 6 mL sampled counted for 100 min for tritium. The dose is small due to the simple facts that the frigid waters of the Bay of Fundy discourage immersion and salt water is not consumable.

*Table A.05: Annual Dose at the LLD for Seawater*

<i>Nuclide</i>	<i>LLD (Bq·L<sup>-1</sup>)</i>	<i>Dose at LLD (μSv)</i>	<i>Concentration That Gives 5 μSv (Bq·L<sup>-1</sup>)</i>
H-3	2.4E+01	9.2E-11	1.3E+12
Cr-51	2.2E+00	2.6E-10	4.3E+10
Mn-54	2.8E-01	7.9E-10	1.8E+09
Fe-59	6.2E-01	2.6E-09	1.2E+09
Co-58	2.8E-01	9.1E-10	1.5E+09
Co-60	3.2E-01	2.4E-09	6.8E+08
Zn-65	6.8E-01	1.3E-09	2.6E+09
Zr-95	5.2E-01	1.2E-09	2.2E+09
Nb-95	3.0E-01	9.3E-10	1.6E+09
Ru-103	2.8E-01	4.4E-10	3.2E+09
Ru-106	2.6E+00	1.6E-09	8.3E+09
Ag-110m	2.6E-01	2.3E-09	5.7E+08
I-131	3.6E-01	2.3E-09	8.0E+08
Cs-134	2.6E-01	1.3E-09	1.0E+09
Cs-137	3.0E-01	5.2E-10	2.9E+09
Ba-140	1.2E+00	2.6E-08	2.4E+08
La-140	4.6E-01	*	*
Ce-141	4.0E-01	1.1E-10	1.8E+10
Ce-144	1.6E+00	2.7E-10	3.0E+10

\* Dose for Ba-140 assumes equilibrium with La-140 (contribution from both)

## Appendix A: Statistics, Detection Limits, and Dose at Detection Limits, Continued

### A1.06 Clams

Typical LLDs are given in Table A.06 for the edible portions of clams, decay corrected to the time of sample collection. Samples of varying size are counted for 5000 s. The major assumptions are that the sample is taken at Dipper Harbour and that the level is maintained for the year.

*Table A.06: Annual Dose at the LLD for Clams*

<i>Nuclide</i>	<i>LLD (Bq·kg<sup>-1</sup>)</i>	<i>Dose at LLD (μSv)</i>	<i>Concentration That Gives 5 μSv (Bq·kg<sup>-1</sup>)</i>
Cr-51	5.0E+01	2.0E-02	1.3E+04
Mn-54	7.0E+00	6.5E-02	5.4E+02
Fe-59	1.4E+01	3.1E-01	2.3E+02
Co-58	7.2E+00	1.3E-01	2.7E+02
Co-60	6.4E+00	1.8E+00	1.8E+01
Zn-65	1.4E+01	8.8E-01	7.8E+01
Zr-95	1.2E+01	1.5E-01	3.7E+02
Nb-95	6.6E+00	1.4E-01	2.3E+02
Ru-103	6.0E+00	5.5E-02	5.5E+02
Ru-106	5.8E+01	6.5E+00	4.5E+01
Ag-110m	5.8E+00	2.2E-01	1.3E+02
I-131	7.2E+00	9.5E-01	3.8E+01
Cs-134	6.6E+00	1.6E+00	2.1E+01
Cs-137	6.8E+00	1.5E+00	2.2E+01
Ba-140	2.4E+01	7.7E-01	1.6E+02
La-140	9.4E+00	2.2E-01	2.1E+02
Ce-141	7.4E+00	8.0E-02	4.6E+02
Ce-144	3.2E+01	2.6E+00	6.3E+01

## Appendix A: Statistics, Detection Limits, and Dose at Detection Limits, Continued

### A1.07 Fish

Typical LLDs are given in Table A.07 for the edible portions of fish, decay corrected to the time of sample collection. Samples of varying size are counted for 5000 s.

*Table A.07: Annual Dose at the LLD for Fish*

<i>Nuclide</i>	<i>LLD (Bq·kg<sup>-1</sup>)</i>	<i>Dose at LLD (μSv)</i>	<i>Concentration That Gives 5 μSv (Bq·kg<sup>-1</sup>)</i>
Cr-51	1.3E+01	1.6E-02	4.0E+03
Mn-54	1.5E+00	5.1E-02	1.5E+02
Fe-59	3.8E+00	2.8E-01	6.8E+01
Co-58	1.5E+00	9.2E-02	8.0E+01
Co-60	1.4E+00	1.3E+00	5.4E+00
Zn-65	3.0E+00	7.0E-01	2.2E+01
Zr-95	2.2E+00	1.1E-01	1.0E+02
Nb-95	1.4E+00	1.1E-01	6.6E+01
Ru-103	1.5E+00	4.9E-02	1.5E+02
Ru-106	1.1E+01	4.4E+00	1.2E+01
Ag-110m	1.2E+00	1.7E-01	3.5E+01
I-131	7.8E+00	1.3E+00	3.1E+01
Cs-134	1.0E+00	1.2E+00	4.5E+00
Cs-137	1.4E+00	1.0E+00	7.1E+00
Ba-140	1.0E+01	7.8E-01	6.4E+01
La-140	4.6E+00	2.4E-01	9.6E+01
Ce-141	1.8E+00	6.0E-02	1.5E+02
Ce-144	5.8E+00	1.6E+00	1.8E+01

## Appendix A: Statistics, Detection Limits, and Dose at Detection Limits, Continued

### A1.08 Lobster

Typical LLDs are given in Table A.08 for the edible portions of lobster, decay corrected to the time of sample collection. Samples of varying size are counted for 5000 s.

**Table A.08: Annual Dose at the LLD for Lobster**

<i>Nuclide</i>	<i>LLD (Bq·kg<sup>-1</sup>)</i>	<i>Dose at LLD (μSv)</i>	<i>Concentration That Gives 5 μSv (Bq·kg<sup>-1</sup>)</i>
Cr-51	3.0E+01	1.3E-02	1.2E+04
Mn-54	2.8E+00	2.1E-02	6.7E+02
Fe-59	9.0E+00	1.5E-01	2.9E+02
Co-58	3.2E+00	6.7E-02	2.4E+02
Co-60	3.8E+00	5.4E-01	3.5E+01
Zn-65	7.8E+00	3.4E-01	1.2E+02
Zr-95	5.4E+00	6.8E-02	4.0E+02
Nb-95	4.4E+00	9.0E-02	2.4E+02
Ru-103	4.0E+00	3.1E-02	6.4E+02
Ru-106	3.0E+01	2.4E+00	6.3E+01
Ag-110m	3.4E+00	8.8E-02	1.9E+02
I-131	1.7E+01	3.3E+00	2.6E+01
Cs-134	2.8E+00	6.4E-01	2.2E+01
Cs-137	3.4E+00	4.5E-01	3.8E+01
Ba-140	3.4E+01	1.2E+00	1.4E+02
La-140	1.2E+01	4.2E-01	1.4E+02
Ce-141	4.4E+00	4.3E-02	5.1E+02
Ce-144	1.3E+01	8.7E-01	7.4E+01

## Appendix A: Statistics, Detection Limits, and Dose at Detection Limits, Continued

### A1.09 Dulse

Typical LLDs are given in Table A.09 for dulse, decay corrected to the time of sample collection. Samples of varying size are counted for 5000 s. The major assumptions are that the sample is taken at Dipper Harbour and that the level is maintained for the year. There were no samples available to be collected in 2021.

**Table A.09: Annual Dose at the LLD for Dulse**

<i>Nuclide</i>	<i>LLD (Bq·kg<sup>-1</sup>)</i>	<i>Dose at LLD (μSv)</i>	<i>Concentration That Gives 5 μSv (Bq·kg<sup>-1</sup>)</i>
Cr-51	2.0E+01	2.4E-03	4.2E+04
Mn-54	3.4E+00	7.4E-03	2.3E+03
Fe-59	8.0E+00	4.4E-02	9.0E+02
Co-58	3.4E+00	1.5E-02	1.1E+03
Co-60	3.4E+00	2.1E-01	7.9E+01
Zn-65	8.2E+00	1.1E-01	3.9E+02
Zr-95	6.6E+00	1.6E-02	2.1E+03
Nb-95	3.6E+00	1.9E-02	9.5E+02
Ru-103	2.8E+00	7.1E-03	2.0E+03
Ru-106	2.6E+01	6.7E-01	2.0E+02
Ag-110m	3.0E+00	2.3E-02	6.4E+02
I-131	5.4E+00	3.0E-01	9.1E+01
Cs-134	2.8E+00	1.9E-01	7.3E+01
Cs-137	3.2E+00	1.3E-01	1.2E+02
Ba-140	1.6E+01	1.6E-01	4.9E+02
La-140	5.4E+00	2.8E-02	9.7E+02
Ce-141	3.4E+00	8.8E-03	1.9E+03
Ce-144	1.4E+01	2.4E-01	2.9E+02

## Appendix A: Statistics, Detection Limits, and Dose at Detection Limits, Continued

### A1.10 Sediment

The LLDs in Table A.10 apply to the time of sample collection. Samples weighing approximately 200 g are counted for 5000 s. The major assumptions are that the sample is taken at Dipper Harbour and that the level is maintained for the year.

**Table A.10: Annual Dose at the LLD for Sediment**

<i>Nuclide</i>	<i>LLD (Bq·kg<sup>-1</sup>)</i>	<i>Dose at LLD (μSv)</i>	<i>Concentration That Gives 5 μSv (Bq·kg<sup>-1</sup>)</i>
Cr-51	1.7E+01	2.1E-01	4.2E+02
Mn-54	2.8E+00	7.9E-01	1.8E+01
Fe-59	6.2E+00	2.3E+00	1.3E+01
Co-58	2.6E+00	8.4E-01	1.5E+01
Co-60	2.8E+00	2.3E+00	6.1E+00
Zn-65	6.8E+00	1.3E+00	2.7E+01
Zr-95	4.8E+00	3.9E+00	6.1E+00
Nb-95	3.0E+00	7.2E-01	2.1E+01
Ru-103	2.4E+00	3.9E-01	3.1E+01
Ru-106	2.0E+01	1.5E+00	6.6E+01
Ag-110m	2.2E+00	2.1E+00	5.3E+00
I-131	3.4E+00	4.7E-01	3.6E+01
Cs-134	2.0E+00	1.2E+00	8.7E+00
Cs-137	2.8E+00	6.2E-01	2.3E+01
Ba-140	1.2E+01	1.0E+01	5.8E+00
La-140	3.8E+00	*	*
Ce-141	3.0E+00	8.9E-02	1.7E+02
Ce-144	1.1E+01	2.1E-01	2.7E+02
gamma meter	0.01 μSv·h <sup>-1</sup>	3.0E+00	1.7E-02
* Dose for Ba-140 assumes equilibrium with La-140 (contribution from both)			

## Appendix B: Sample Collection and Analytical Techniques

### B1 Analytical Techniques

All environmental samples are analyzed at the Health Physics Fredericton Laboratory. The following pages provide a general summary of the analytical techniques used in the laboratory. Sample collection, preparation and analysis are briefly described, but can be found in detail in the laboratory procedures.

The major analytical techniques and the instruments used in routine environmental analyses are summarized in the Table B.01.

**Table B.01: Summary of Analytical Techniques**

Analytical Technique	Instrumentation
Gamma Spectroscopy	Canberra 24% efficient* intrinsic, Ge detector in an Applied Physical Technology 10 cm graded lead cave; Canberra S-100 MCA
Liquid Scintillation (tritium and C-14)	PerkinElmer Tri-Carb 2910TR Liquid Scintillation Counter
Gross Alpha/Beta (Wet Chemical Analysis for Sr-89 and Sr-90)	Protean WPC 9550 Counting System
Gamma Surveys	RadEye G-10 gamma survey meter (range 50 nSv·h <sup>-1</sup> to 0.1 Sv·h <sup>-1</sup> for 50 keV to 3 MeV photons).
Thermoluminescent Dosimetry	Panasonic UD-7900U and UD-716AGL TLD Readers and UD-804A1 (CaSO <sub>4</sub> ) dosimeters

\*relative to a 3x3 inch sodium iodide detector

In gamma spectroscopy analysis, all statistically significant peaks in the spectrum are identified either by reference to a database library of about 150 radionuclides, or by manual reference to compilations of all known radionuclides. In addition, approximately 20 selected radionuclides are specifically searched for in every sample with the exception of Air Iodine samples in which only I-131 is selected. The selected radionuclides include those that are produced in PLNGS, and which would be readily detectable because of their abundance (high fission yield) and high branching ratios for gamma releases. Naturally occurring gamma emitters, with the exception of Be-7, K-40 and Ac-228, are not included in this report. These excepted radionuclides are sometimes useful as general indicators of the consistency of the analytical techniques.

## Appendix B: Sample Collection and Analytical Techniques, Continued

The peak search and analysis program APEX GAMMA is used to process spectra. The library of radionuclides uses data of the Oak Ridge Laboratory. There are three categories of radionuclides evaluated:

1. selected nuclides of key fission and activation products
2. all other identified radionuclides, including natural radionuclides
3. detected energy peaks for which no identification can be readily made.

The three categories cover all possible eventualities in a spectral analysis and ensure that no significant radionuclides or photon energies will be overlooked.

The usefulness of gross alpha/beta analysis lies primarily in showing trends and determining whether more detailed analyses should be done. The reported alpha and beta values are assessed with respect to Am-241 and Sr-Y-90 calibration sources, respectively.

Wet chemical analysis for Sr-89,90 on GEM and LEM samples follows a method developed by Eichrom Industries Inc.<sup>(20)</sup> using a strontium specific chromatography resin. This method is similar to test method 05811-95 issued by the American Society of Tests and Materials (ASTM).

Liquid samples, other than milk, are acidified upon receipt to keep radionuclides from plating out on the container walls. Perishable samples are refrigerated or frozen.

### B2 Sample Collection and Analysis

#### B2.01 Airborne Particulates

Airborne particulates are collected on a 47 mm diameter Gelman Type A glass fibre filter, through which air is drawn at about  $60 \text{ L} \cdot \text{min}^{-1}$  for a 28 day continuous sample. The volume of air sampled (approximately  $2400 \text{ m}^3$ ) is measured with an in-line integrating dry gas meter. Every month the filters are replaced and the used ones are returned to the laboratory for analysis. Sampling is, therefore, continuous throughout the year.

Air particulate filters are analyzed by gamma spectroscopy as soon as possible after collection to ensure the detection of any short lived gamma emitters that may be present, and to minimize any decay corrections. Samples are counted for 5000 s on the Ge detector.

## Appendix B: Sample Collection and Analytical Techniques, Continued

### B2.01 Airborne Particulates, Continued

Approximately three days after the end of the sample collection interval, each filter is counted on one of the alpha beta counters for 100 minutes for the simultaneous determination of gross alpha and gross beta activities. Counting is delayed to allow for the decay of the short-lived radon progeny that would otherwise complicate the analysis.

If alpha/beta levels are detected at twice the normal level, further investigation is initiated by longer gamma counts or radiostrontium determinations.

If levels of Sr-89,90, indicating one percent of the weekly DRL, are detected in the chemical analysis of GEM filters, then the air monitoring station particulate filters are also to be analyzed for these radionuclides.

### B2.02 Airborne Radioiodines

Airborne radioiodines are collected in an activated charcoal cartridge placed downstream of the particulate filter. The cartridges are from F&J Specialty Products (TE3C 20x40 mesh TEDA). Approximately 2400 m<sup>3</sup> of air is sampled continuously over 28 days at a flow rate of about 60 L·min<sup>-1</sup>. The volume of air sampled is measured with an in-line integrating dry gas meter.

Iodine-131 is the major nuclide of interest on the charcoal cartridges. The cartridges are counted in groups of four for 50,000 s on the gamma spectrometer. Counts are performed as soon as possible after collection because of the relatively short-half life of I-131 (8 days). If radioiodines, believed to have originated from PLNGS, are detected, then the cartridges are re-analyzed individually. Fission product radioiodines other than I-131, with much shorter half-lives (minutes to hours), decay before they reach the sample location or during the time the sample is being collected. If an elevated release of radioiodines were noted from the Station in this interval, the samples would be changed and analyzed earlier to minimize errors from decay corrections.

### B2.03 Airborne Tritium

Air is passed through a molecular sieve container (Advanced Specialty Gas Equipment type 13X sieve material) to extract water vapour from the sampled air. Sample volume is measured with a mass flow controller (MFC) (Alicat Scientific Inc. MC-1SLPM-0).

Sampling is continuous at each location throughout the year. Since the amount of water absorbed by the molecular sieve from a given volume of air depends upon absolute humidity, flow rates are adjusted with a MFC to avoid saturation of the sieve material and to ensure adequate sample collection.

For tritium analysis by liquid scintillation counting, 6 mL of water taken from the molecular sieve condensate is counted for 100 minutes.

## **Appendix B: Sample Collection and Analytical Techniques,** Continued

### **B2.04 Airborne Carbon-14**

An aquarium pump bubbles air through 2N NaOH (1 L), into which carbon dioxide and its C-14 component is absorbed. Carbon dioxide is regenerated from the resulting sodium carbonate by acidification of the 2N NaOH solution and then analyzed for the determination of C-14 activity. The carbon dioxide is passed through a silica gel trap to remove moisture and tritium and then absorbed into the chemical Carbo-sorb<sup>®</sup> E until saturation is reached. After the addition of the scintillation cocktail Permafluor<sup>®</sup> E<sup>+</sup>, the sample is analyzed for 100 minutes by liquid scintillation counting.

### **B2.05 Environmental Gamma Radiation (TLD)**

The environmental TLD is composed of three elements of calcium sulphate with lead filtration of 700 mg·cm<sup>-2</sup>. The badge is sealed in plastic, placed in a screw cap plastic container and suspended approximately 1 m above the ground for a period of three months. This arrangement measures the ambient gamma dose, whether it is from activity in the air, from the ground or cosmic in origin.

Readout is by a Panasonic Automatic Reader. For typical quarterly measurements in the region of 150-200 µSv, measurements can be made to ±10% at the 95% confidence level.

### **B2.06 Soil**

Soil samples are collected in undisturbed locations away from nearby buildings or trees. Level areas with some vegetation are preferred. A representative sample (approximately 1.6 kg) of the top 25 mm of a 20 cm by 20 cm area of soil is placed in a disposable plastic bag.

The soil is air dried overnight. If excessive moisture is present, the sample is dried on a disposable aluminum tray (at 100 °C). Composed organic matter and stones are removed. Approximately 0.25 kg of dry soil is counted by gamma spectroscopy for 5000 s.

### **B2.07 Food**

Garden produce and berries, which are either collected or purchased, require no special preparation. The edible portion is put in a calibrated container and weighed. The sample is counted by gamma spectroscopy for 5000 s.

## Appendix B: Sample Collection and Analytical Techniques, Continued

### B2.08 Water

A 4 L sample of well water, pond water, lake water or surface runoff is collected in a clean polyethylene container.

A portion is removed for tritium analysis, and the remainder is acidified (15 mL of 70% nitric acid per 4 L sample). Of this, 3.6 L is measured into a Marinelli beaker for gamma spectroscopy. After gamma analysis, well water samples (125-500 mL, depending upon the historical content of dissolved solids) are evaporated until dry on stainless steel planchets for gross alpha/beta analysis (if required). For tritium analysis, a 6 mL aliquot is analyzed by liquid scintillation counting. For gamma spectroscopy, the sample is counted for 5000 s. For tritium and gross alpha/beta analyses, samples are counted for 100 min. A level twice the normal level for alpha/beta will initiate further investigation by longer gamma counts and/or Sr-89,90 analyses.

Measurements of gross alpha and beta, if required, are made approximately two weeks after sample collection. This delay avoids analytical interference from radon progeny, which decay with a half-life of about 3.8 days. Naturally occurring radon and radon progeny are present in well waters everywhere and are known to reach elevated concentrations in many New Brunswick locations.

### B2.09 Vegetation

The only vegetation types routinely collected and analyzed are tree lichen (Spanish moss) and various ground mosses such as Cladonia and Lycopodium. They concentrate a wide range of radionuclides, both natural and anthropogenic. This makes vegetation a sensitive indicator of radionuclides in the environment even though they are not identified in the pathway to humans. The same methodology outlined below is used for samples of significance to First Nations. In some cases when the mass of a singular sample is very small, composite samples are prepared (i.e. samples are counted together). In the unlikely event that non-naturally occurring radionuclides are detected in the composite samples, individual counts would be completed.

About 25 g or more of each of the samples is collected and air-dried before analysis. No special preparation is required. The sample is placed in a calibrated container, weighed and counted by gamma spectroscopy for 5000 s.

## **Appendix B: Sample Collection and Analytical Techniques,** Continued

### **B2.10 Precipitation**

Various forms of precipitation are collected continuously throughout the year.

A portion is removed for tritium analysis and the remainder is acidified (15 mL of 70% nitric acid per 4 L sample). For gamma spectroscopy, 3.6 L is measured into a Marinelli beaker and counted for 5000 s. For tritium analysis by liquid scintillation techniques, 6 mL is counted for 100 min.

### **B2.11 Sediment and Beach Surveys**

Beach sediment samples are collected near the low tide mark, with preference being given to the top 10 mm of the fine sediment characteristic of tidal mud flats. A disposable plastic bag is used to collect about 1 kg of sample. In addition, direct gamma radiation dose rate measurements are made at each sediment site using a RadEye G-10 gamma survey meter. The meter is held for one minute at a point one metre above the intertidal surface. After the sediment sample has been collected, this is repeated.

The sample is transferred to a disposable aluminum tray for drying at 80 °C. Dried, caked samples are broken into their original free granular form with a porcelain mortar and pestle and sieved through a 0.5 mm mesh to collect the fines for analysis (a 1 mm sieve is used for coarse sediments). Approximately 0.25 kg of dried sediment is counted by gamma spectroscopy for 5000 s.

### **B2.12 Seafood**

The inshore fishery throughout the Maritimes has declined since the program was started in 1982. Some of it has been closed to any kind of harvesting. However, species of local seafood are collected when available from local fishermen. Sampling focuses on fish, lobsters, aquaculture salmon and clams. Some of the areas where clam harvesting is prohibited are sampled with the permission of the Department of Fisheries and Ocean. Other seafood species are more mobile and can sometimes be found throughout the area: crab, periwinkles, scallops, herring, mackerel, dogfish, cod, haddock, sea urchin, mussels, and flounder. The severe restrictions placed on the inshore fishery as well as the depletion of stocks make many of these samples unavailable for periods of time sometimes spanning years. However, whenever they are available an effort is made to collect as many samples as possible. Approximately 0.5 kg of fresh seafood is collected per sample.

Approximately 0.25 kg of each sample is prepared for gamma spectroscopy. Lobsters are cooked first, and the edible meat is removed for analysis. Clams, periwinkles, and crab are analyzed whole, with a yield factor applied to account for the mass of the inedible shell. The edible portion of fish is usually analyzed, although sometimes the whole fish is analyzed. Samples are counted for 5000 s.

## Appendix B: Sample Collection and Analytical Techniques, Continued

### B2.13 Aquatic Plants

Dulse (*Rhododymenia palmata*), an edible seaweed which is commercially harvested in the area, is collected monthly when available. Other species of seaweed concentrate a wide range of radionuclides, both natural and man-made. This makes them sensitive indicators of radionuclides in the environment even though they are not identified in the pathway to humans.

When available, a portion of the seaweed or dulse is put in a calibrated container and weighed. This is counted by gamma spectroscopy for 5000 s.

### B2.14 Seawater

A 4 L sample is collected in a clean polyethylene container.

A portion is removed for tritium analysis and the remainder is acidified (15 mL of 70% nitric acid per 4 L sample). For gamma spectroscopy, 3.6 L is measured into a Marinelli beaker and counted for 5000 s. For tritium analysis by liquid scintillation techniques, 6 mL is counted for 100 min.

If levels of Sr-89,90, indicating one percent of the monthly DRL, are detected in the chemical analysis of the LEM composite, then the seawater is also to be analyzed for these radionuclides.

### B2.15 Miscellaneous

This category encompasses all of those samples collected that do not fall within the other categories. It is a mechanism by which the lab can track and evaluate media for potential inclusion in the program. It gives the program flexibility and freedom and encourages the scientific curiosity of laboratory staff. A few of the media types started out this way.

### B2.16 Bore Holes

A 4 L sample of water is pumped out of the bore hole into a clean polyethylene container.

A portion is removed for tritium analysis and the remainder is acidified (15 mL of 70% nitric acid per 4 L sample). For gamma spectroscopy, 3.6 L is measured into a Marinelli beaker and counted for 5000 s. For tritium analysis by liquid scintillation techniques, 6 mL is counted for 100 min.

## **Appendix B: Sample Collection and Analytical Techniques,** Continued

### **B2.17 Parshall Flume**

PLNGS staff collect a 4 L sample of water from the Parshall flume systems.

A portion is removed for tritium analysis, and the remainder is acidified (15 mL of 70% nitric acid per 4 L sample). Of this, 3.6 L is measured into a Marinelli beaker for gamma spectroscopy. For tritium analysis, a 6 mL sample of water is counted for 100 min by liquid scintillation techniques. For gamma spectroscopy, the sample is counted for 5000 s.

### **B2.18 Hemlock Knoll Regional Sanitary Landfill**

In December 1999, PLNGS began disposing of its non-active waste at the public landfill facility. A monitoring program was established prior to the first shipment. In the past, water from the leachate, bore holes and various holding ponds has been analyzed. Currently there are dosimeters placed at key locations.

Although some extra precautions are observed due to the potential biohazard of some of these samples, they would be analyzed according to established procedures previously described.

## Appendix C: Location Codes

<b>A08</b>	Back Bay
<b>A10R</b>	Grand Manan
<b>A12</b>	St. Andrews

**Appendix C: Location Codes**, Continued

<b>A13R</b>	St. Andrews environmental monitoring station
<b>ANA</b>	Eckert & Ziegler Analytics (QA)
<b>B01</b>	New River Beach - inter-tidal zone
<b>B02</b>	Pocologan
<b>B03</b>	New River Beach - park
<b>B10</b>	Pennfield
<b>BB</b>	PLNGS – Boiler Blow-down
<b>BD</b>	Belledune GS
<b>C01</b>	Lepreau Harbour – intertidal zone
<b>C03</b>	Lepreau
<b>CC</b>	Coleson Cove GS
<b>CCW</b>	PLNGS – Condenser Cooling Water Duct
<b>COG</b>	Kinectrics (CANDU Owners Group)
<b>D01</b>	Little Lepreau Basin - inter-tidal zone (remnants of clam shack)
<b>D02</b>	Little Lepreau
<b>D04</b>	Little Lepreau Basin – inter-tidal zone (remnants of boat wreck)
<b>E01</b>	Maces Bay –GPS Reading–L 45° 06.306 N, Lo 66° 28.651 W
<b>E02</b>	Maces Bay – Fundy Senior Citizens Centre
<b>E03</b>	Maces Bay – inter-tidal zone
<b>E04</b>	Maces Bay Cemetery

<b>E05</b>	Fundy Shores Elementary School – outside (Thompson/Trynor’s Field)
<b>E06</b>	Fundy Shores Elementary School – inside
<b>E11</b>	28 Ridge Rd., Dipper Harbour
<b>E12</b>	22 Ridge Rd., Dipper Harbour
<b>E13</b>	16 Ridge Rd., Dipper Harbour
<b>E14</b>	10 Ridge Rd., Dipper Harbour
<b>E15</b>	4 Ridge Rd., Dipper Harbour
<b>F01</b>	Welch Cove–GPS Reading–L 45° 04.782N, Lo 66° 27.986 W
<b>F03</b>	190 Welch Cove Rd., Maces Bay
<b>F07</b>	68 Ridge Rd., Maces Bay
<b>G01</b>	Indian Cove – inter-tidal zone
<b>G02</b>	Point Lepreau – lighthouse
<b>G03</b>	offshore – within 2 km of Point Lepreau lighthouse
<b>GEM</b>	PLNGS – Gaseous Effluent Monitor
<b>H03</b>	Duck Cove - inter-tidal zone
<b>H04</b>	PLNGS – across the road from old site of Information Centre building
<b>H05</b>	PLNGS - start of nature trail near old site of Information Centre trailers
<b>I01</b>	PLNGS SRWMF Phase 1
<b>I02</b>	PLNGS SRWMF Phase 2
<b>I03</b>	PLNGS SRWMF Phase 2 – general site area

**Appendix C: Location Codes**, Continued

<b>I04</b>	SRWMF Phase 3
<b>I10A</b>	PLNGS SRWMF Phase 1 Bore Hole A (BHA)
<b>I10B</b>	PLNGS SRWMF Phase 1 Bore Hole B (BHB)
<b>I10C</b>	PLNGS SRWMF Phase 1 Bore Hole C (BHC)
<b>I10D</b>	PLNGS SRWMF Phase 1 at I01 Barn (Shallow Bore Hole)
<b>I10E</b>	PLNGS SRWMF Phase 1 at I01 Barn (Deep Bore Hole)
<b>I10F</b>	PLNGS SRWMF Phase 1 Bore Hole southeast from C structure
<b>I10G</b>	FUTURE BORE HOLE
<b>I10H</b>	FUTURE BORE HOLE
<b>I10I</b>	FUTURE BORE HOLE
<b>I11A</b>	PLNGS SRWMF Phase 1 - south fence (east side)
<b>I11B</b>	PLNGS SRWMF Phase 1 - south fence (centre)
<b>I11C</b>	PLNGS SRWMF Phase 1 - south fence (west side)
<b>I11D</b>	PLNGS SRWMF Phase 1 - west fence (south side)
<b>I11E</b>	PLNGS SRWMF Phase 1- west fence (centre)
<b>I11F</b>	PLNGS SRWMF Phase 1 - west fence (north side)
<b>I11G</b>	PLNGS SRWMF Phase 1 - north fence (west side)
<b>I11H</b>	PLNGS SRWMF Phase 1 - north fence (centre)
<b>I11I</b>	PLNGS SRWMF Phase 1 - north fence (east side)
<b>I11J</b>	PLNGS SRWMF Phase 1 - east fence (north side)

<b>I11K</b>	PLNGS SRWMF Phase 1 - east fence (centre)
<b>I11L</b>	PLNGS SRWMF Phase 1 - east fence (south side)
<b>I11M</b>	SRWMF Phase 1 ext, Fence W-N
<b>I11N</b>	SRWMF Phase 1 ext, Fence W-NN
<b>I11O</b>	SRWMF Phase 1 ext, Fence N-W
<b>I11P</b>	SRWMF Phase 1 ext, Fence N-C
<b>I11Q</b>	SRWMF Phase 1 ext, Fence N-E
<b>I11S</b>	SRWMF Phase 1 ext, Fence E-NN
<b>I11T</b>	SRWMF Phase 1 ext, Fence E-N
<b>I1A1</b>	PLNGS SRWMF Phase 1 – Cell 1A1
<b>I1A2</b>	PLNGS SRWMF Phase 1 – Cell 1A2
<b>I20A</b>	PLNGS SRWMF Phase 2 – well #4 (shallow) BH4
<b>I20B</b>	PLNGS SRWMF Phase 2 – well #4 (deep) BH4
<b>I20C</b>	PLNGS SRWMF Phase 2 - well #7 (shallow) BH7
<b>I20D</b>	PLNGS SRWMF Phase 2 - well #7 (deep) BH7
<b>I20E</b>	PLNGS SRWMF Phase 2 – well #6 (shallow) BH6
<b>I20F</b>	PLNGS SRWMF Phase 2 - well #6 (deep) BH6
<b>I20G</b>	PLNGS SRWMF Phase 2 – well #5 (shallow) BH5
<b>I20H</b>	PLNGS SRWMF Phase 2 – well #5 (deep) BH5
<b>I20I</b>	PLNGS SRWMF Phase 2 – well #2 (shallow) BH2

**Appendix C: Location Codes**, Continued

<b>I20J</b>	PLNGS SRWMF Phase 2 - well #2 (deep) BH2
<b>I20K</b>	PLNGS SRWMF Phase 2 - well #3 (shallow) BH3
<b>I20L</b>	PLNGS SRWMF Phase 2 – well #3 (deep) BH3
<b>I20M</b>	PLNGS SRWMF Phase 2 – well #1 (shallow) BH1
<b>I20N</b>	PLNGS SRWMF Phase 2 – well #1 (deep) BH1
<b>I20P</b>	PLNGS SRWMF Phase 2 – north from bore hole 1
<b>I20Q</b>	PLNGS SRWMF Phase 2 – south from bore hole 2 (shallow)
<b>I20S</b>	PLNGS SRWMF Phase 2 – south from bore hole 2 (deep)
<b>I20T</b>	PLNGS SRWMF Phase 2 – north from bore hole 2
<b>I20U</b>	PLNGS SRWMF Phase 2 – well #8 shallow (BH8)
<b>I20V</b>	PLNGS SRWMF Phase 2 – well #8 deep (BH8)
<b>I20W</b>	SRWMF Phase 2, Middle NE Shallow
<b>I21A</b>	PLNGS SRWMF Phase 2 – Periphery – south fence (east side)
<b>I21B</b>	PLNGS SRWMF Phase 2 - Periphery – south fence (centre)
<b>I21C</b>	PLNGS SRWMF Phase 2 - Periphery – south fence (west side)
<b>I21D</b>	PLNGS SRWMF Phase 2 - Periphery – west fence (south side)
<b>I21E</b>	PLNGS SRWMF Phase 2- Periphery - west fence (centre)
<b>I21F</b>	PLNGS SRWMF Phase 2 - Periphery - west fence (north side)
<b>I21G</b>	PLNGS SRWMF Phase 2 – Periphery – north fence (west side)
<b>I21H</b>	PLNGS SRWMF Phase 2 - Periphery – north fence (centre)

<b>I21I</b>	PLNGS SRWMF Phase 2 - Periphery – north fence (east side)
<b>I21J</b>	PLNGS SRWMF Phase 2 – Periphery – east fence (north side)
<b>I21K</b>	PLNGS SRWMF Phase 2 – Periphery – east fence (centre)
<b>I21L</b>	PLNGS SRWMF Phase 2 - Periphery – east fence (south side)
<b>I30A</b>	SRWMF Phase 3, Well 1
<b>I30B</b>	SRWMF Phase 3, Well 2 Shallow
<b>I30C</b>	SRWMF Phase 3, Well 2 Deep
<b>I30D</b>	SRWMF Phase 3, Well 3
<b>I30E</b>	SRWMF Phase 3, Well 4
<b>I30F</b>	SRWMF Phase 3, Well 5 Shallow
<b>I30G</b>	SRWMF Phase 3, Well 5 Deep
<b>I30H</b>	SRWMF Phase 3, Well 6
<b>I30I</b>	SRWMF Phase 3, Well 7
<b>I30J</b>	SRWMF Phase 3, Well 8 Shallow
<b>I30K</b>	SRWMF Phase 3, Well 8 Deep
<b>I31A</b>	SRWMF Phase 3, Fence S-E
<b>I31B</b>	SRWMF Phase 3, Fence S–C
<b>I31C</b>	SRWMF Phase 3, Fence S-W
<b>I31D</b>	SRWMF Phase 3, Fence W-SS
<b>I31E</b>	SRWMF Phase 3, Fence W-S

**Appendix C: Location Codes**, Continued

<b>I31F</b>	SRWMF Phase 3, Fence W-SC	<b>J20</b>	PLNGS – south 19° east, 115 m from the stack (on fence)
<b>I31G</b>	SRWMF Phase 3, Fence W-NC	<b>J35</b>	PLNGS – south 34° east, 135 m from the stack (on sign)
<b>I31H</b>	SRWMF Phase 3, Fence W-N	<b>K00</b>	PLNGS - Near Plant Monitoring Well MW01-3 south from RB
<b>I31I</b>	SRWMF Phase 3, Fence W-NN	<b>K01</b>	PLNGS – 95 m west of south gate leading to the lighthouse
<b>I31J</b>	SRWMF Phase 3, Fence N-W	<b>K02</b>	PLNGS Cooling Water Pump-house – east fence near surge shaft
<b>I31K</b>	SRWMF Phase 3, Fence N-E	<b>K03</b>	PLNGS - Near Plant Monitoring Well MW01-4 SSW from RB
<b>I31L</b>	SRWMF Phase 3, Fence N-C	<b>K04</b>	PLNGS - Near Plant Monitoring Well MW01-5, WSW from RB
<b>I31M</b>	SRWMF Phase 3, Fence E-NN	<b>K10</b>	Firing Range
<b>I31N</b>	SRWMF Phase 3, Fence E-N	<b>L01</b>	PLNGS – site of old cement plant
<b>I31P</b>	SRWMF Phase 3, Fence E-NC	<b>L03</b>	PLNGS – outer security building (main gate)
<b>I31Q</b>	SRWMF Phase 3, Fence E-WC	<b>L04</b>	PLNGS – construction stores
<b>I31S</b>	SRWMF Phase 3, Fence E-W	<b>L05</b>	PLNGS - Near Plant Monitoring Well MW01-6, WNW from RB
<b>I31T</b>	SRWMF Phase 3, Fence E-WW	<b>L06</b>	PLNGS - Near Plant Monitoring Well MW01-7, paved staff parking
<b>I71</b>	PLNGS - Near Plant Monitoring Well MW01-10, northeast from RB	<b>L07</b>	PLNGS - Near Plant Monitoring Well MW01-8, construction parking
<b>I86</b>	PLNGS – 2 <sup>nd</sup> pole from SRWMF driveway heading toward outer gate	<b>L08</b>	PLNGS - Near Plant Monitoring Well MW01-9, N beyond fire
<b>I87</b>	PLNGS – 3 <sup>rd</sup> pole from SRWMF driveway heading toward outer gate	<b>LAB</b>	Fredericton – Health Physics Laboratory
<b>I88</b>	PLNGS – 4 <sup>th</sup> pole from SRWMF driveway heading toward outer gate	<b>LEM</b>	PLNGS – Liquid Effluent Monitor
<b>I89</b>	PLNGS – 5 <sup>th</sup> pole from SRWMF driveway heading toward outer gate	<b>M02</b>	PLNGS – Administration Building (2 <sup>nd</sup> floor)
<b>J00</b>	PLNGS – south, 180 m from the stack (on fence)	<b>MISC</b>	Miscellaneous locations
<b>J01</b>	PLNGS - Near Plant Monitoring Well MW01-1, near surge shaft	<b>N01</b>	Dipper Harbour – GPS Reading – L 45° 05.399 N, Lo 66° 25.154 W

**Appendix C: Location Codes**, Continued

<b>N02</b>	Dipper Harbour – GPS Reading – L 45° 06.106 N, Lo 66° 24.949 W
<b>N03</b>	Dipper Harbour – GPS Reading – L 45° 05.551 N, Lo 66° 25.449 W
<b>N04</b>	Dipper Harbour – intertidal zone
<b>N05</b>	Dipper Harbour – beach behind restaurant
<b>N06</b>	Dipper Harbour – offshore
<b>P02</b>	Little Dipper Harbour
<b>Q01R</b>	Lorneville
<b>X03R</b>	Fredericton - Chestnut Complex lab
<b>Y</b>	Hemlock Knoll Regional Sanitary Landfill
<b>MW-01</b>	Near Front Gate
<b>MW-02</b>	Duck Cove Field
<b>MW-03</b>	Indian Cove
<b>MW-04</b>	Construction Stores
<b>MW-05</b>	Duck Cove Road (outside site boundary)

## Appendix D: Abbreviations

<b><i>CCW</i></b>	Condenser Cooling Water
<b><i>CL</i></b>	Critical Level
<b><i>CNSC</i></b>	Canadian Nuclear Safety Commission
<b><i>COG</i></b>	CANDU Owners Group
<b><i>CSA</i></b>	Canadian Standards Association
<b><i>DRL</i></b>	Derived Release Limit
<b><i>FWHM</i></b>	Full Width Half Maxima
<b><i>GEM</i></b>	Gaseous Effluent Monitor
<b><i>IAEA</i></b>	International Atomic Energy Agency
<b><i>ISO</i></b>	International Organization for Standardization
<b><i>LEM</i></b>	Liquid Effluent Monitor
<b><i>LLD</i></b>	Lower Limit of Detection
<b><i>LSC</i></b>	Liquid Scintillation Counter
<b><i>MFC</i></b>	Mass Flow Controller
<b><i>NBEMO</i></b>	New Brunswick Emergency Measures Organization
<b><i>NIST</i></b>	National Institute of Standards and Technology
<b><i>NRC</i></b>	National Research Council
<b><i>NTS</i></b>	Nuclear Technology Services
<b><i>REMP</i></b>	Radiation Environmental Monitoring Program
<b><i>PICA</i></b>	Problem Identification and Corrective Action
<b><i>PLNGS</i></b>	Point Lepreau Nuclear Generating Station
<b><i>QA</i></b>	Quality Assurance
<b><i>QC</i></b>	Quality Control
<b><i>REPD</i></b>	Radiation and Environmental Protection Division
<b><i>RPB</i></b>	Radiation Protection Bureau
<b><i>SEA</i></b>	Significant Environmental Aspect
<b><i>SRWMF</i></b>	Solid Radioactive Waste Management Facility
<b><i>TLD</i></b>	Thermoluminescent Dosimeter
<b><i>USDOE</i></b>	United States Department of Energy

## Appendix E: Sampling Species of Cultural Importance to First Nations

Goldenrod  
Yarrow  
Burdock Root  
Bladder Wrack  
Balsam Fir  
Saint John's Wort  
Blueberries  
Old Man's Beard  
Viper's Bugloss  
Mullein  
Milk Thistle  
Heal All  
Sarsaparilla  
Red Clover  
Plantain  
Horsetail  
Labrador Tea  
Cattail Head  
Cattail Root  
Red Osier Dogwood  
Pineapple Weed (wild chamomile)  
Pearly Everlasting  
Wild Strawberry  
Cinnamon Fern  
Cedar  
Juniper  
Sphagnum Moss  
Sweet Grass  
Mountain Ash  
Spruce Boughs  
Cloudberry Leaf  
Beach Pea  
Bull Thistle  
Wild Snapdragon  
White Meadowsweet