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POINT LEPREAU NUCLEAR GENERATING STATION

Annual Compliance Report

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Executive Summary

This report describes the 2022 results of the environmental monitoring program for the Point Lepreau Nuclear Generating Station (PLNGS).

In 2022, 1319 samples were analyzed to monitor environmental radiation around Point Lepreau and across the province in general. There were 143 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 also well below the design and operating target for PLNGS (50 microsieverts per annum).

Source of Dose to the Representative Person	***Individual Dose (μSv·a^{-1})***
PLNGS airborne releases	1.04
PLNGS liquid releases	0.06

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 2022, as required by *Section 3.5* of CNSC *REGDOC 3.1.1, Reporting Requirements for Nuclear Power Plants*.

The REMP for 2022 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 2022 were performed in the Fredericton Health Physics Laboratory at 420 York Street, Fredericton, NB.

The basis of the REMP complies with National Standards of Canada, *CAN/CSA-N288.4-M90 (R2008) Guidelines for Radiological Monitoring of the Environment.*

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

Nuclide	*Gaseous Effluent DRL($Bq \cdot a^{-1}$)*	*Release (Bq)*	*DRL (%)**	*Liquid EffluentDRL ($Bq \cdot a^{-1}$)*	*Release(Bq)*	*DRL (%)**
H-3	2.4E+17	2.16E+14	9.18E-02	4.5E+19	4.28E+14	1.32E-03
C-14	1.2E+16	1.63E+11	1.31E-03	3.7E+14	8.87E+08	6.48E-04
Ar-41	2.6E+17	1.74E+13	6.70E-03	-----------	-----------	-----------
Mn-54	-----------	-----------	-----------	1.2E+13	1.67E+06	1.01E-04
Fe-59	-----------	-----------	-----------	3.0E+12	1.79E+06	1.77E-04
Co-60	-----------	-----------	-----------	1.0E+13	1.30E+08	1.87E-03
Kr-85m	2.3E+18	3.83E+11	1.63E-05	-----------	-----------	-----------
Kr-87	4.1E+17	1.92E+11	4.72E-05	-----------	-----------	-----------
Kr-88	1.1E+17	6.58E+11	6.03E-04	-----------	-----------	-----------
Sr-90	1.7E+12	2.19E+06	1.28E-04	5.9E+15	1.97E+05	3.35E-09
Zr-95	-----------	-----------	-----------	2.9E+14	1.11E+08	2.40E-04
Nb-95	-----------	-----------	-----------	8.1E+14	2.66E+08	2.07E-04
Mo-99	-----------	-----------	-----------	2.4E+16	1.02E+07	4.27E-08
Tc-99m	-----------	-----------	-----------	7.4E+17	1.04E+08	1.42E-08
Ru-106	-----------	-----------	-----------	9.4E+13	2.58E+07	2.76E-05
Ag-110m	-----------	-----------	-----------	4.7E+12	1.81E+06	3.02E-04
Sb-122	-----------	-----------	-----------	4.1E+14	1.06E+08	2.60E-05
Sb-124	-----------	-----------	-----------	1.3E+14	3.31E+08	4.34E-04
Sb-125	-----------	-----------	-----------	5.0E+14	9.15E+07	4.06E-05
I-131	3.9E+13	1.05E+09	2.74E-03	3.4E+13	1.73E+07	5.15E-05
Xe-131m	4.3E+19	2.13E+11	4.94E-07	-----------	-----------	-----------
Xe-133	1.2E+19	2.93E+13	2.56E-04	-----------	-----------	-----------
Xe-133m	1.3E+19	6.06E+11	4.86E-06	-----------	-----------	-----------
Cs-134	-----------	-----------	-----------	8.6E+13	4.18E+05	4.84E-07
Xe-135	1.4E+18	3.98E+12	2.74E-04	-----------	-----------	-----------
Xe-135m	8.3E+17	1.50E+11	1.80E-05	-----------	-----------	-----------
Sn-113	-----------	-----------	-----------	4.1E+12	1.02E+06	7.25E-05
Cs-137	-----------	-----------	-----------	2.1E+14	1.97E+07	1.00E-05
Xe-138	8.4E+16	3.65E+11	4.39E-04	-----------	-----------	-----------
Gd-153	-----------	-----------	-----------	4.0E+15	3.16E+05	7.99E-09
Gd-159	3.9E+16	6.30+08	1.60E-06	7.2E+15	1.79E+08	2.50E-06
Tb-160	-----------	-----------	-----------	6.2E+14	3.86E+06	6.31E-07
Ac-228	-----------	-----------	-----------	1.4E+17	2.03E+06	1.41E-09
I-132	-----------	-----------	-----------	4.4E+16	1.78E+10	4.12E-05
I-133	-----------	-----------	-----------	1.0E+15	1.46E+06	1.45E-07
Zn-65	-----------	-----------	-----------	9.7E+12	9.47E+04	9.74E-07
Cr-51	-----------	-----------	-----------	1.8E+16	1.12E+07	6.22E-08
Nb-94	-----------	-----------	-----------	3.5E+14	8.54E+05	4.69E-07
Ru-103	-----------	-----------	-----------	9.3E+13	4.31E+05	4.60E-07
Na-24	-----------	-----------	-----------	2.2E+15	1.04E+06	4.81E-08
Te-132	-----------	-----------	-----------	6.7E+13	3.12E+06	4.64E-06
Alpha	-----------	-----------	-----------	-----------	1.95E+07	-----------
Beta	-----------	2.94E+07	-----------	-----------	1.55E+08	-----------
Total			1.04E-01	Total		5.58E-03

* 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, 2022, 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 2022 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 2022 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 2022.

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

Table 3.01: Schedule of Sample Collection and Analysis

Sample Medium	*Typical Frequency*
Atmospheric Sampling	
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)
Terrestrial Sampling	
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
Marine Sampling	
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*

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

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

Table 3.02: Sample Information

Sample Medium	*Number of Samples*	*Radionuclide Measurements*
Atmospheric Sampling		
Airborne Particulates	94	gamma emitters & gross alpha/beta
Airborne Iodines	94	Iodine-131
Water Vapour	95	Tritium
Carbon Dioxide	48	Carbon-14
Ambient Gamma Measurements (TLDs)*	99*	gamma exposure
GEM Particulates	52	Strontium-89,90 & gamma emitters
Terrestrial Sampling		
Ambient Gamma Measurements (TLDs)*	99*	gamma exposure
Well Water	22	gamma emitters & tritium
Pond, Puddle and Surface Water	31	gamma emitters & tritium
Berries	7	gamma emitters
Garden Vegetables	14	gamma emitters
Vegetation	37	gamma emitters
Soil	34	gamma emitters
Monitoring Well Water (Near Plant)	34	gamma emitters & tritium
Precipitation	48	gamma emitters & tritium
Marine Sampling		
Seawater	19	gamma emitters & tritium
Clams	10	gamma emitters
Fish	1	gamma emitters
Lobster	4	gamma emitters
Periwinkles	13	gamma emitters
Aquaculture Salmon	2	gamma emitters
Scallops	0	gamma emitters
Dulse	3	gamma emitters
Other Sea Plants	3	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*

Sample Medium	*Number of Samples*	*Radionuclide Measurements*
Solid Radioactive Waste Management Facility		
Bore Hole Water	105	gamma emitters & tritium
Parshall Flume Water	156	gamma emitters & tritium
Ambient Gamma (TLDs)	184	gamma exposure
Hemlock Knoll Regional Sanitary Landfill		
Ambient Gamma (TLDs)	16	gamma exposure
Quality Assurance		
Internal	68	gamma emitters, tritium Strontium-89,90, alpha/beta, carbon-14
External	75	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

Code	*Location*
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

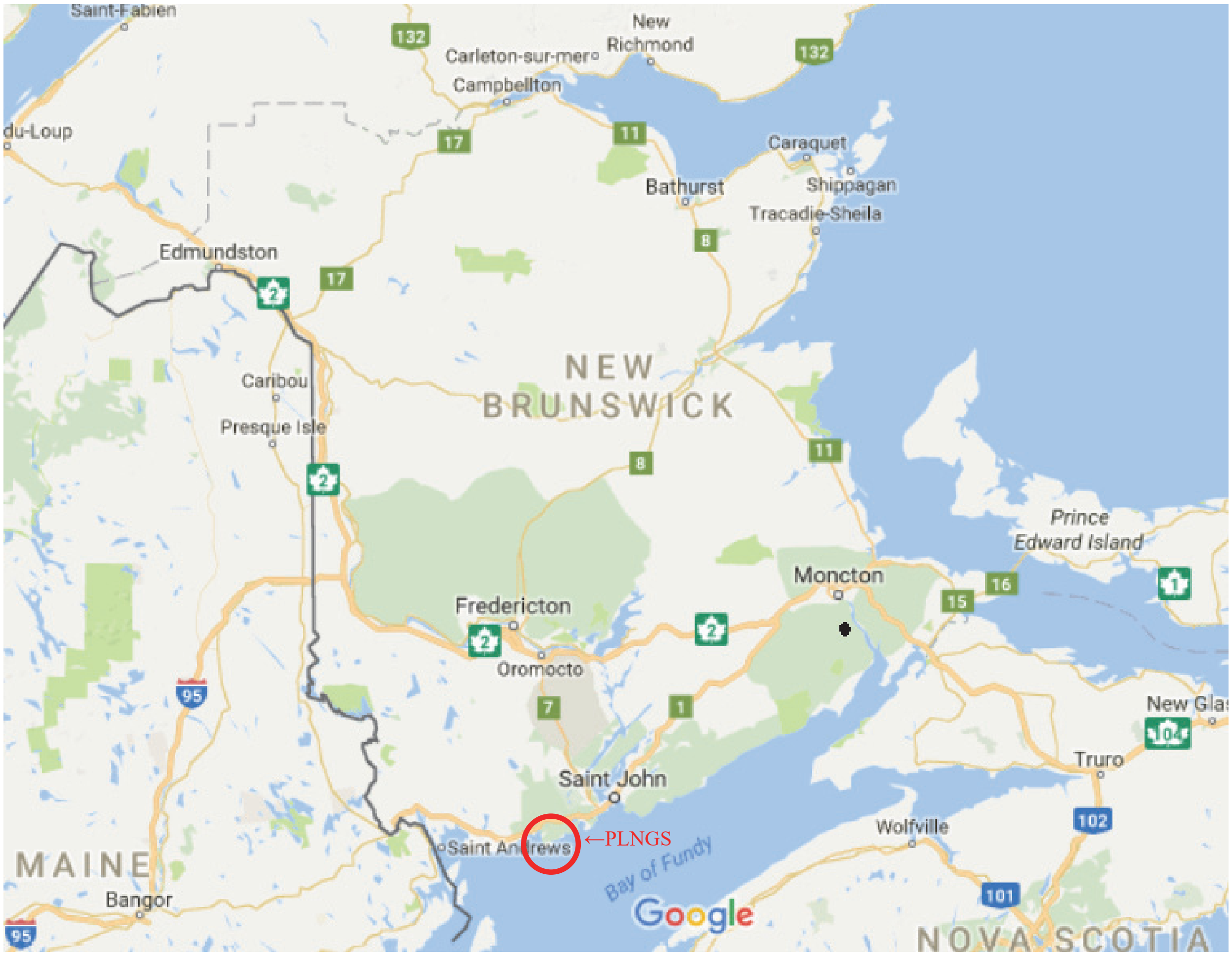


Figure 3.01: Location of PLNGS within the Province of New Brunswick (Colour)

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

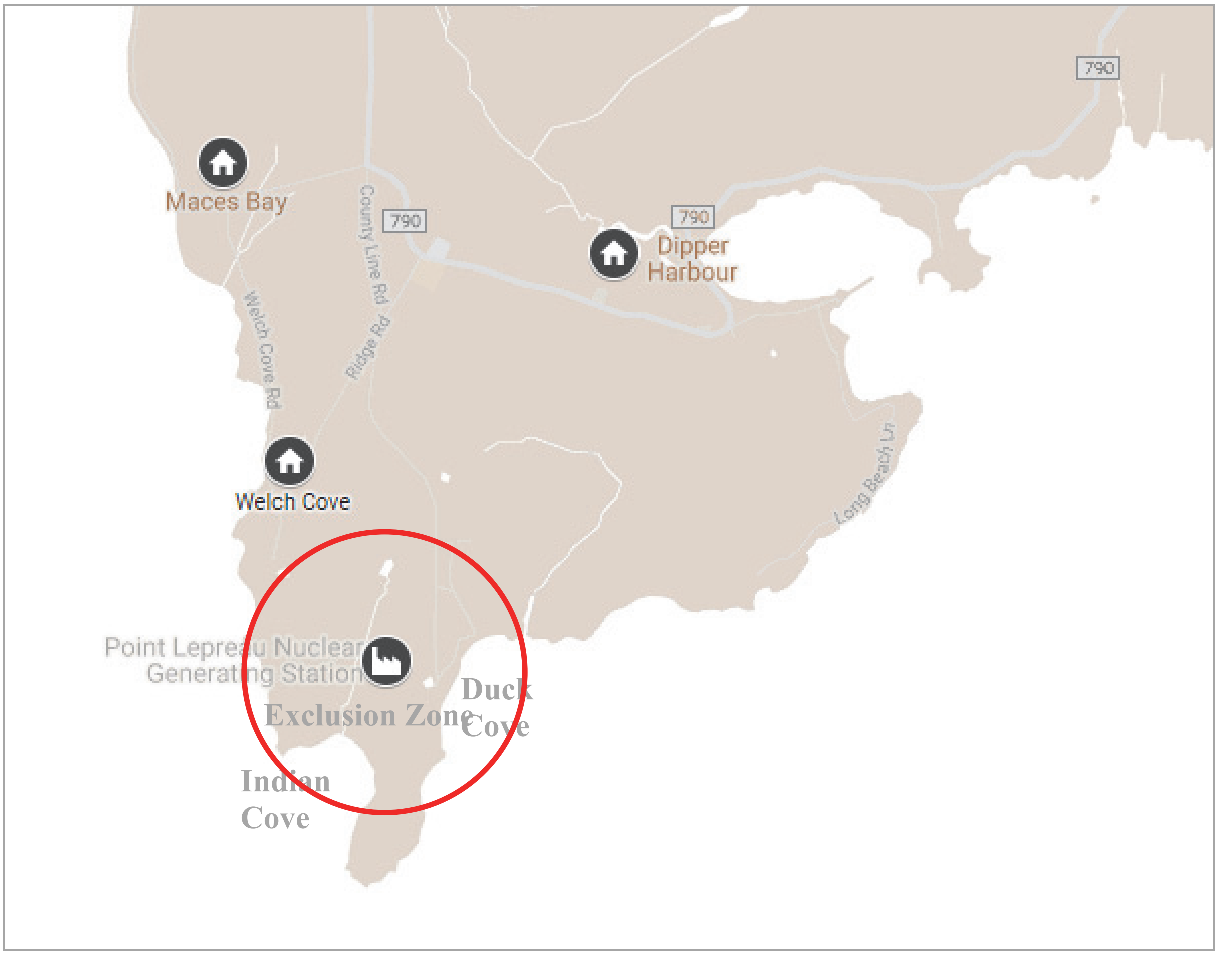


Figure 3.02: PLNGS and Immediately Surrounding Area (Colour)

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

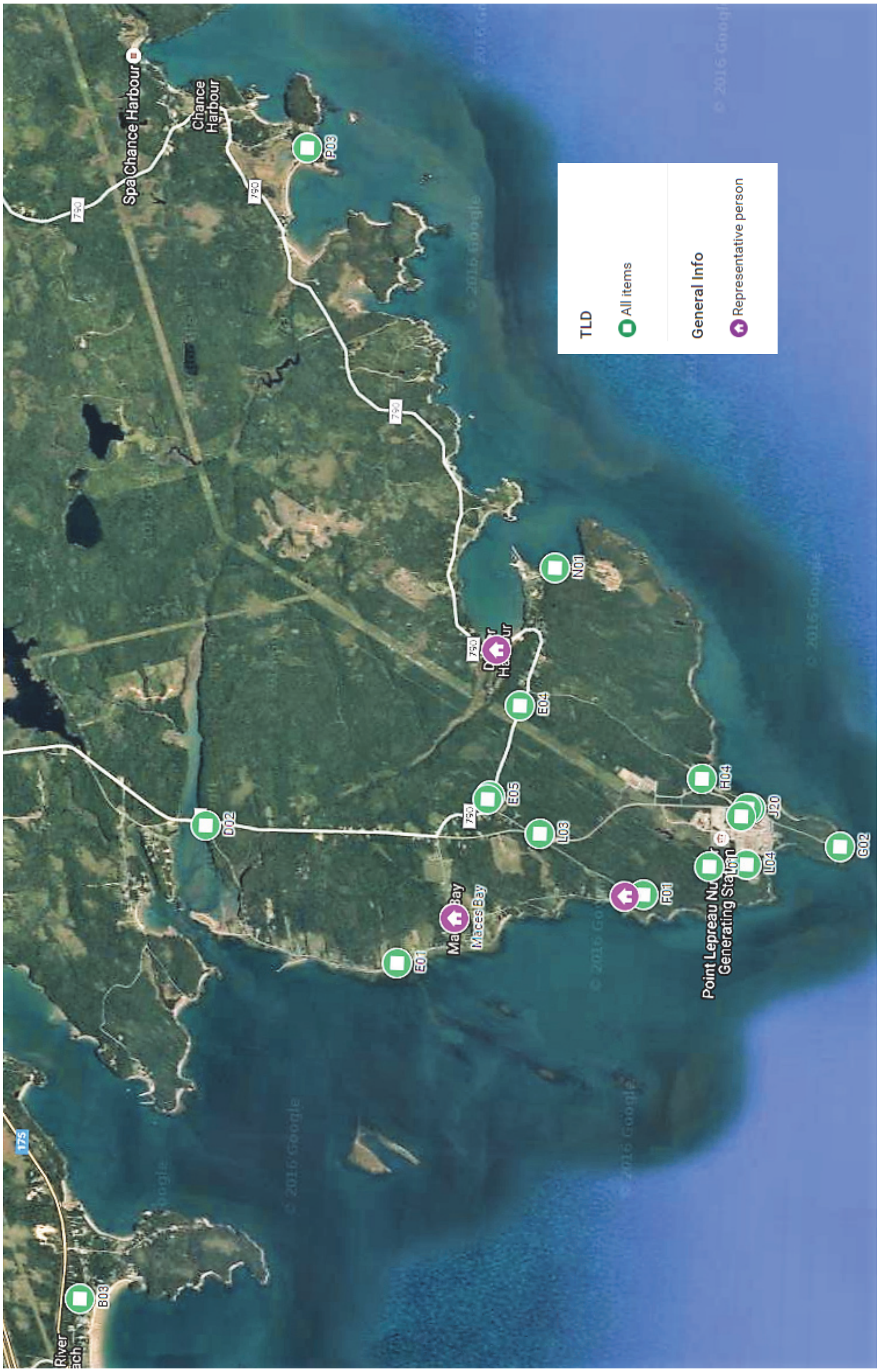


Figure 3.03: TLD Monitoring Sites at and around PLNGS (Colour)

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

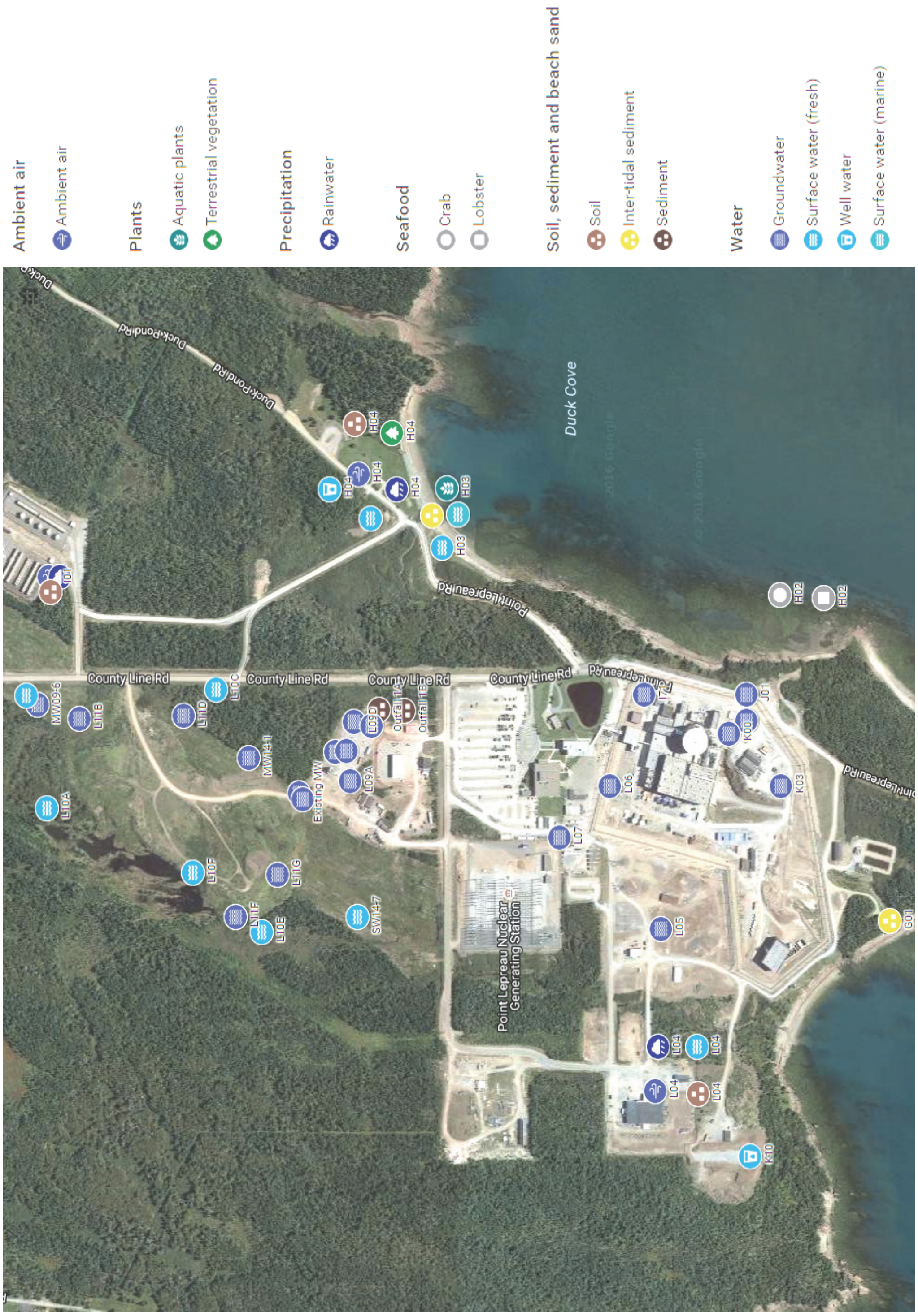


Figure 3.04: Environmental Monitoring on the PLNGS Site (Colour)

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

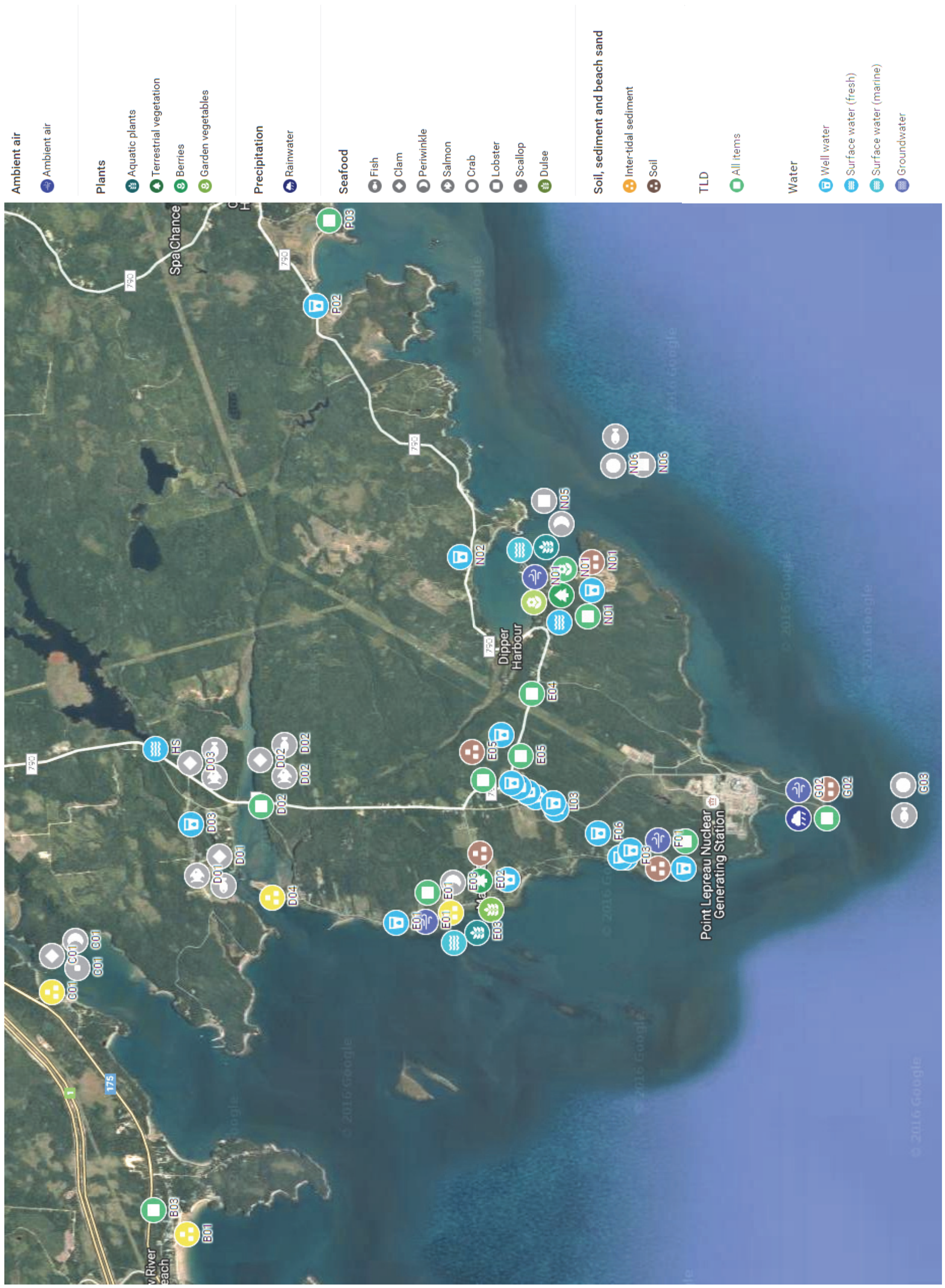


Figure 3.05: Environmental Monitoring on the Lepreau Peninsula (Colour)

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

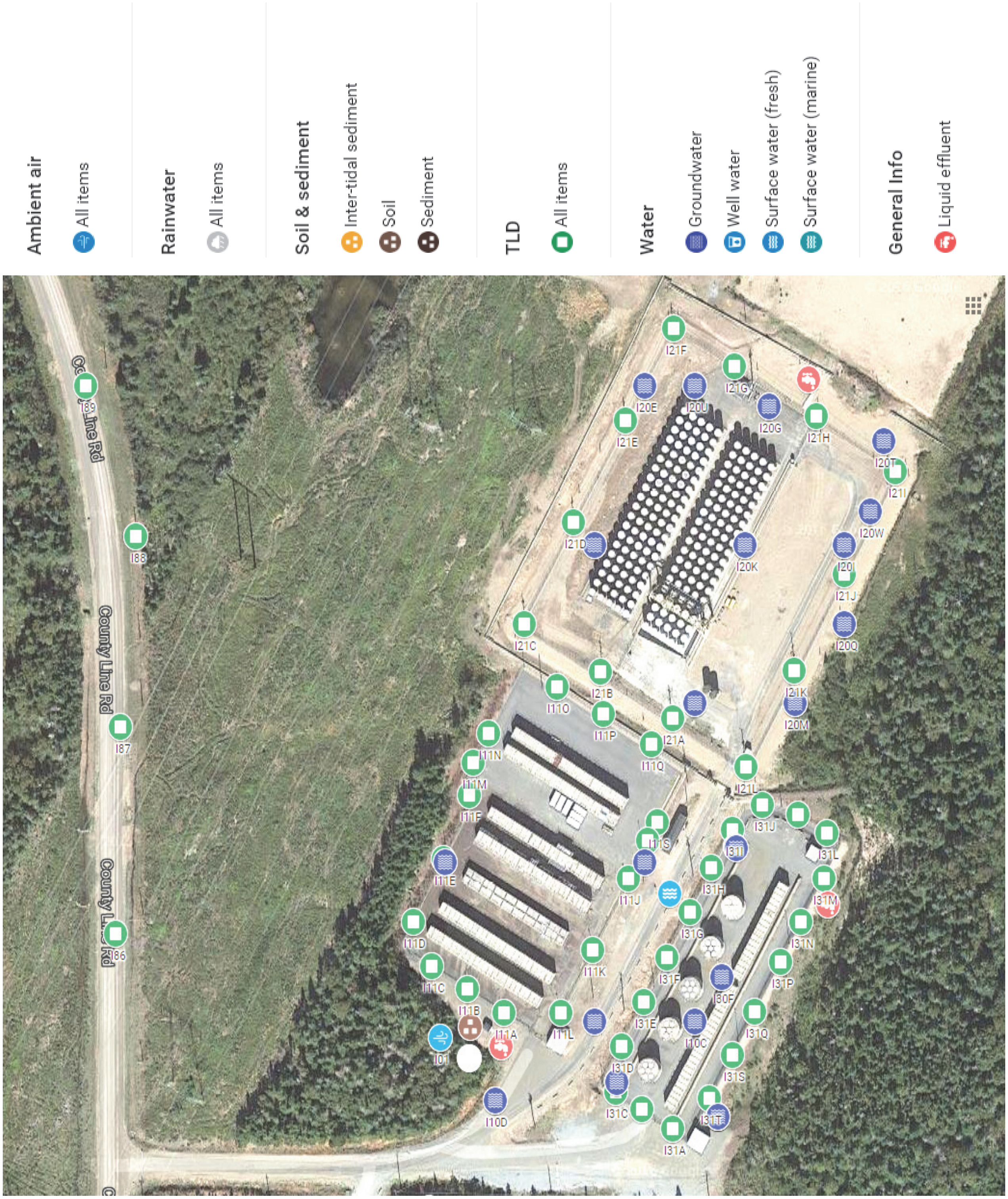


Figure 3.06: Environmental Monitoring at the Solid Radioactive Waste Management Facility (SRWMF) (Colour)

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 2022.

Most samples contained low levels of naturally occurring K-40 or cosmogenic Be-7. Some samples contained Cs-137 (soils, sediments, lichen) 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 2022, 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 ranges from less than 2E-02 $Bq \cdot m^{-3}$ (below the lower limit of detection by the method used) to approximately 4E-01 $Bq \cdot m^{-3}$ of air. The natural concentration of H-3 is up to 7E-01 $Bq \cdot L^{-1}$ in most surface waters and up to 1E-03 $Bq \cdot m^{-3}$ in air.

The natural concentration of C-14 in the atmosphere is approximately 4E-02 $Bq \cdot m^{-3}$. 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 2022.) 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 94 filters analyzed, gross alpha was detected on 88, gross beta on 93, and Be-7 on 70. 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 8.56E-05 $Bq{\cdot}m^{-3}$ of air. The reference location gross alpha in air reached 3.34E-05 $Bq{\cdot}m^{-3}$. The maximum concentration of gross beta in air in any of the indicator locations was 6.12E-04 $Bq{\cdot}m^{-3}$ of air. The reference location gross beta in air reached 3.17E-04 $Bq{\cdot}m^{-3}$.

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-two 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 2022.

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^{-3})

Analysis Type	Total Number	Indicator Locations				Reference Location			
		Mean	Minimum	Maximum	Detection Frequency	Mean	Minimum	Maximum	Detection Frequency
ALPHA	94	2.33E-05	5.35E-06	8.56E-05	77 of 82	2.22E-05	8.73E-06	3.34E-05	11 of 12
BETA	94	2.00E-04	2.05E-05	6.12E-04	81 of 82	1.61E-04	6.19E-05	3.17E-04	12 of 12
Be-7	94	1.09E-03	2.38E-04	3.18E-03	63 of 82	3.17E-04	5.55E-04	9.09E-04	7 of 12

4.1 Airborne Particulates, Continued

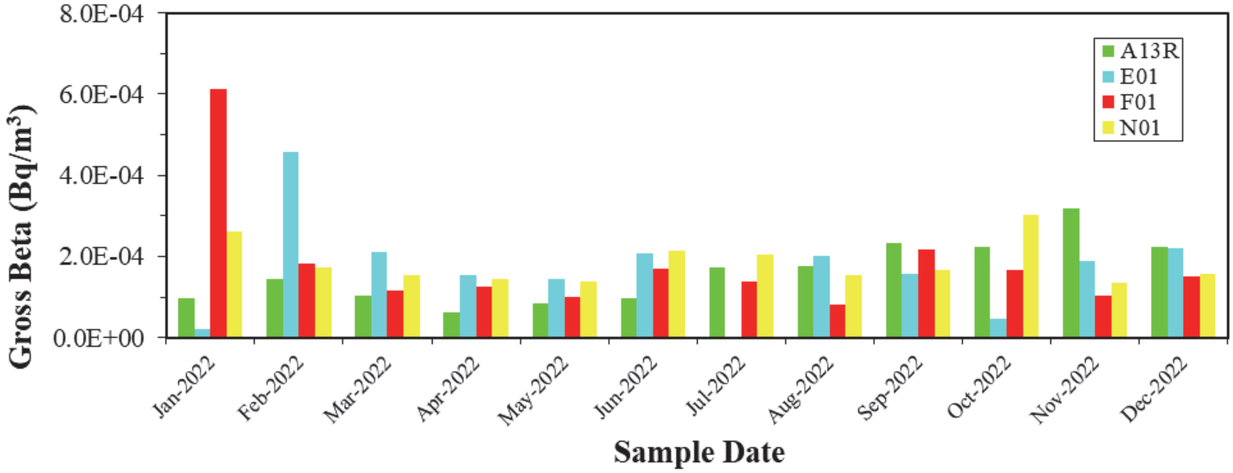


Figure 4.01: Gross Beta (Air Particulates) at Offsite Air Stations (Colour)

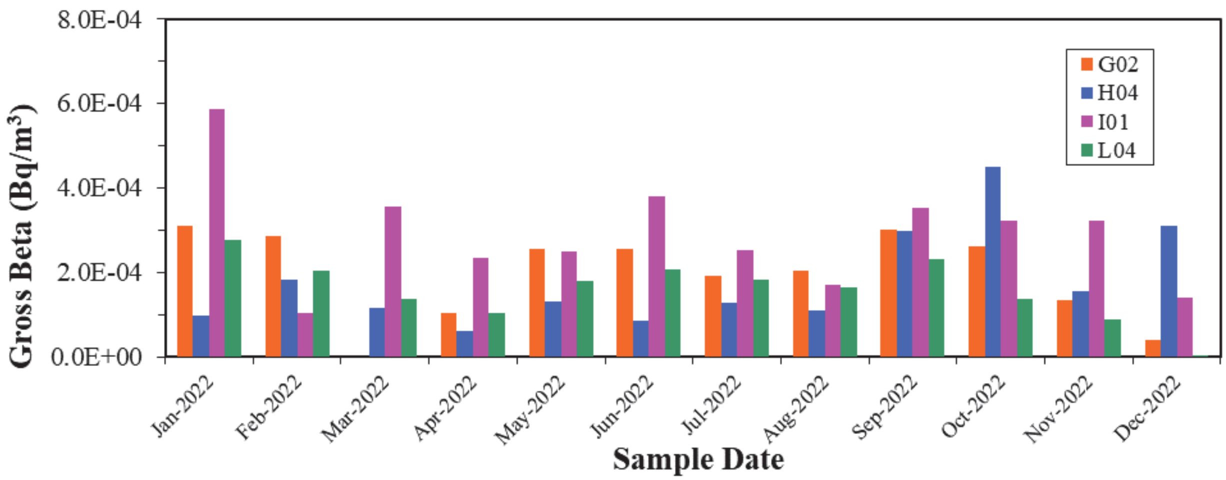


Figure 4.02: Gross Beta (Air Particulates) at Onsite Air Stations (Colour)

4.2 Airborne Iodines

No radioiodines were detected in any of the 94 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 1E-05 $Bq \cdot m^{-3}$).

4.3 Water Vapour

Tritium was detected in 80 of 83 samples collected from the air monitoring stations on the Lepreau peninsula, and in 3 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 4.02E+00 $Bq \cdot m^{-3}$ of air (this was an on-site location). Tritium has been detected occasionally at the reference location, even before PLNGS became operational. In 2022 the maximum concentration of tritium in air at the reference location was 9.49E-02 $Bq \cdot m^{-3}$ 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 2022 were 9.18E-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 for 2022 slightly lower than 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. Also contributing in 2022 were several maintenance outages.

4.3 Water Vapour, Continued

Table 4.02: Water Vapour (Bq·m^{-3})

Analysis Type	*Total Number*	*Indicator Locations*				*Reference Location*			
		Mean	*Minimum*	*Maximum*	*Detection Frequency*	*Mean*	*Minimum*	*Maximum*	*Detection Frequency*
H-3	95	5.46E-01	2.24E-02	4.02E+00	80 of 83	5.94E-02	2.41E-02	9.49E-02	3 of 12

4.3 Water Vapour, Continued

Table 4.03: Tritium (Water Vapour) at Each Air Station (Bq·m^{-3})

Location Code		***A13R***	***E01***	***F01***	***G02***	***H04***	***I01***	***L04***	***N01***
Location		***Saint Andrews***	***Maces Bay***	***Welch Cove***	***Lepreau Lighthouse***	***Duck Cove***	***SRWMF***	***Construction Stores***	***Dipper Harbour***
Distance from PLNGS		***47 km***	***4.5 km***	***1.6 km***	***1.0 km***	***0.75 km***	***1.2 km***	***0.55 km***	***3.7 km***
Collection Start Date 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.	01/01/2022	<5.20E-02	6.70E-02	4.13E-01	1.49E+00	2.49E+00	5.48E-01	4.98E-01	1.43E-01
	02/01/2022	<6.10E-02	3.22E-02	1.43E-01	2.02E+00	4.02E+00	3.88E-01	2.54E+00	1.04E-01
	03/01/2022	<3.32E-02	1.72E-01	1.31E-01	3.40E-01	2.65E+00	7.66E-01	1.90E+00	2.36E-01
	04/01/2022	5.93E-02	1.33E-01	1.67E-01	1.91E-01	1.14E+00	7.70E-01	6.60E-01	1.67E-01
	05/01/2022	<2.27E-02	2.24E-02	1.56E-01	1.01E-01	1.16E+00	7.70E-01	2.54E-01	1.90E-01
	06/01/2022	<1.68E-02	<3.54E-02	9.29E-02	5.06E-02	1.27E+00	6.71E-01	1.23E-01	1.87E-01
	07/01/2022	9.49E-02	NA	1.02E-01	1.07E-01	5.66E-01	2.25E-01	2.53E-01	9.45E-02
	08/01/2022	<3.11E-02	<4.47E-02	1.15E-01	1.16E-01	6.10E-01	7.06E-01	3.33E-01	8.16E-02
	09/01/2022	2.41E-02	2.35E-02	5.12E-02	1.36E-01	1.09E+00	2.43E-01	1.35E-01	1.09E-01
	10/01/2022	<3.97E-02	<2.85E-02	5.52E-02	1.60E-01	1.43E+00	2.81E-01	4.92E-01	5.15E-02
	11/01/2022	<2.36E-02	3.18E-02	1.38E-01	3.20E-01	4.04E-01	2.56E-01	1.36E-01	8.58E-02
	12/01/2022	<2.43E-02	9.33E-02	2.78E-01	2.00E+00	7.87E-01	4.90E-01	1.68E+00	7.42E-02

NA Not Available.

4.3 Water Vapour, Continued

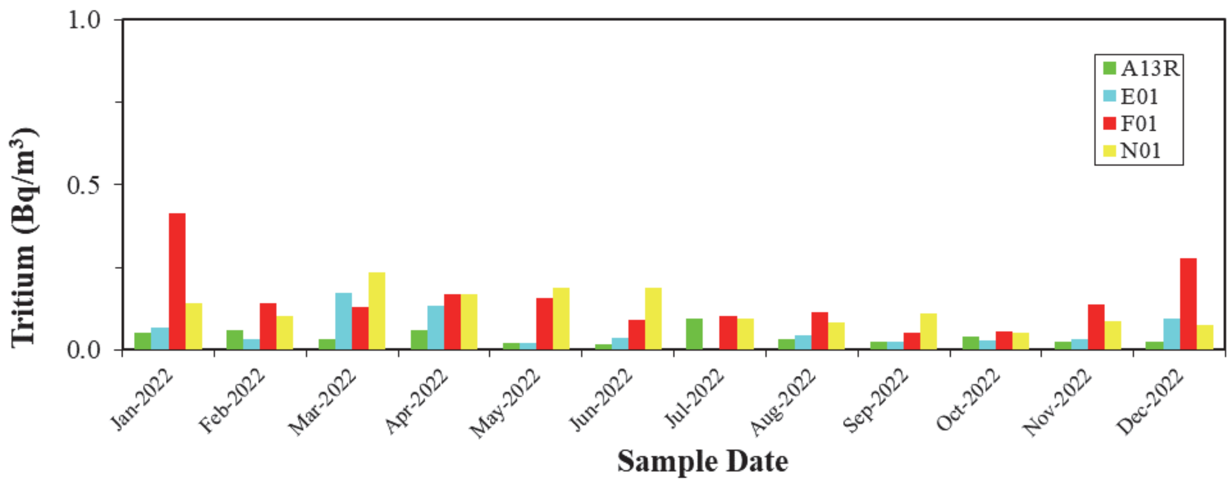


Figure 4.03: Tritium (Water Vapour) at Offsite Air Stations (Colour)

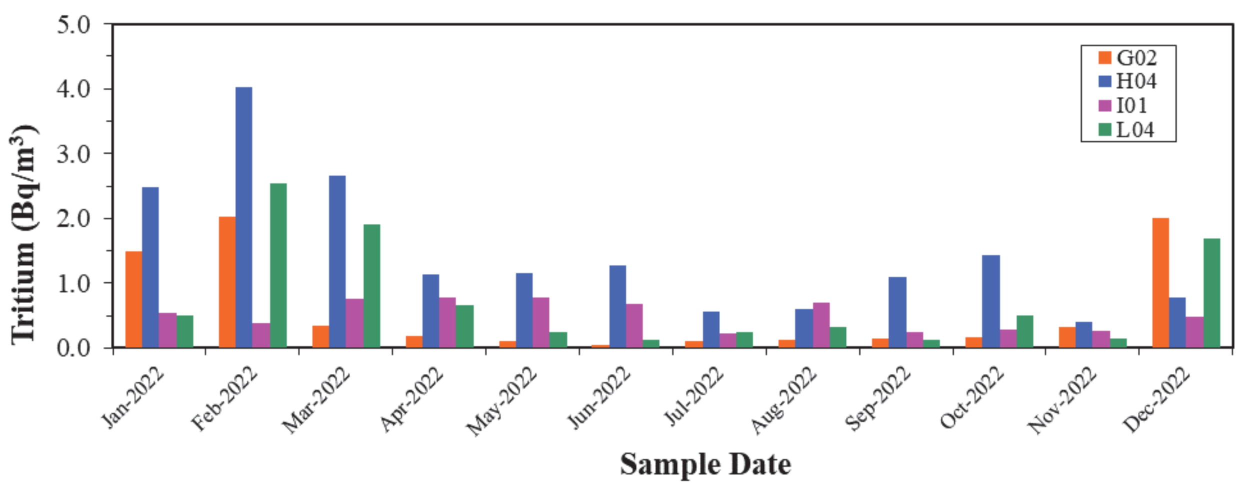
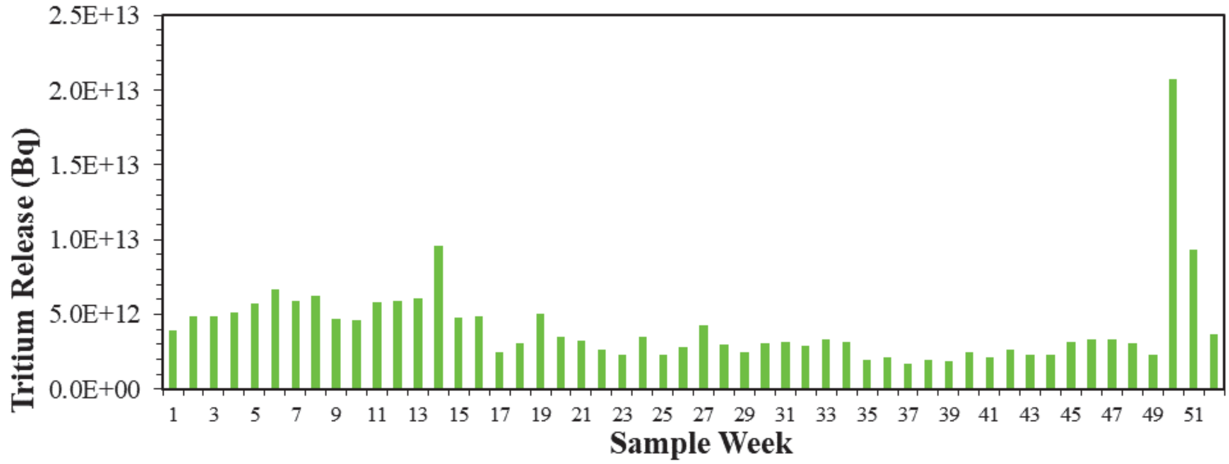


Figure 4.04: Tritium (Water Vapour) at Onsite Air Stations (Colour)

4.3 Water Vapour, Continued



NOTE
The Weekly DRL for H-3 is 4.7E+15 Bq

Figure 4.05: Gaseous H-3 Releases for 2022 (Colour)

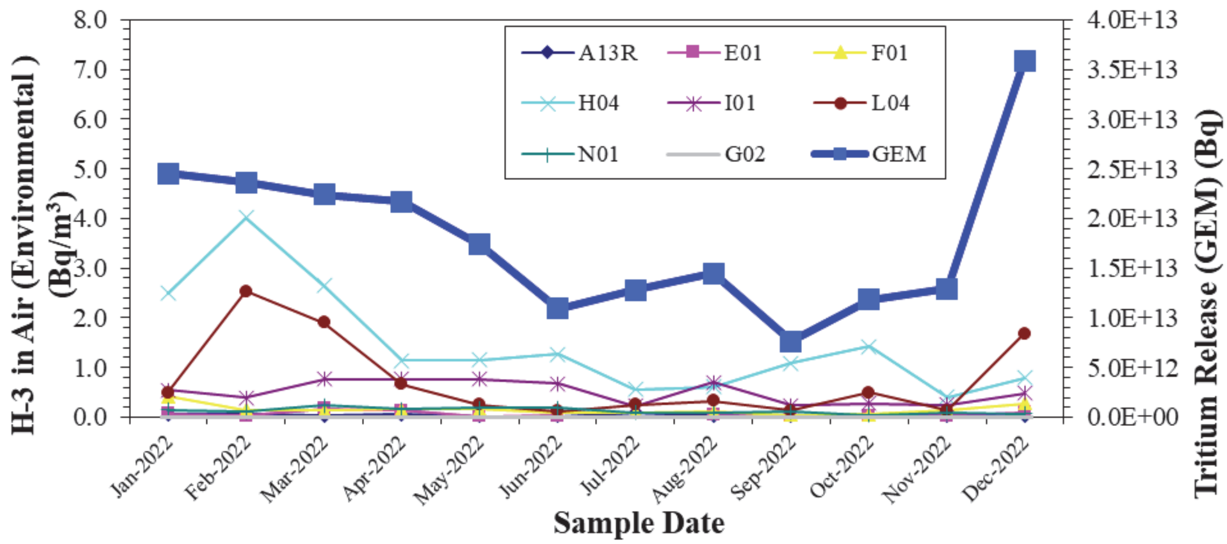


Figure 4.06: Gaseous H-3 Releases and H-3 (Water Vapour) Results (Colour)

4.4 Carbon Dioxide

Carbon-14 was detected in 22 of the 36 samples from the indicator locations and 9 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 9.30E-02 $Bq \cdot m^{-3}$. The maximum concentration of gaseous C-14 in the reference location was 9.41E-02 $Bq \cdot m^{-3}$.

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 and garden vegetables. Since the C-14 releases in 2022 were 1.3E-03% 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)

Analysis Type	*Total Number*	*Indicator Locations*				*Reference Location*			
		Mean	*Minimum*	*Maximum*	*Detection Frequency*	*Mean*	*Minimum*	*Maximum*	*Detection Frequency*
C-14	48	6.58E-02	4.26E-02	9.30E-02	22 of 36	6.19E-02	3.82E-02	9.41E-02	9 of 12

4.4 Carbon Dioxide, Continued

Table 4.05: Carbon-14 (Carbon Dioxide) at Each Monitoring Location ($Bq \cdot m^{-3}$)

Location Code		*F01*	*G02*	*H04*	*X03R*
Location		*Welch Cove*	*Lepreau Lighthouse*	*Former Information Centre Site*	*Fredericton Laboratory*
Distance from PLNGS		*1.6 km*	*1.0 km*	*0.75 km*	*100 km*
Collection Start Date 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.	01/01/2022	4.68E-02	7.25E-02	6.11E-02	9.41E-02
	02/01/2022	7.19E-02	8.66E-02	4.44E-02	3.87E-02
	03/01/2022	5.91E-02	<7.32E-02	6.44E-02	7.91E-02
	04/01/2022	<6.33E-02	5.89E-02	6.13E-02	6.75E-02
	05/01/2022	6.84E-02	4.73E-02	<7.21E-02	<3.82E-02
	06/01/2022	<6.22E-02	<6.35E-02	<7.85E-02	<7.74E-02
	07/01/2022	<6.88E-02	<8.07E-02	4.70E-02	4.00E-02
	08/01/2022	<7.74E-02	4.95E-02	<6.42E-02	<4.79E-02
	09/01/2022	<6.44E-02	<5.82E-02	<8.09E-02	4.07E-02
	10/01/2022	4.26E-02	7.69E-02	7.58E-02	9.30E-02
	11/01/2022	7.10E-02	9.30E-02	5.56E-02	4.59E-02
	12/01/2022	6.62E-02	<7.58E-02	6.37E-02	8.00E-02

N/A Sample Not Available.

4.4 Carbon Dioxide, Continued

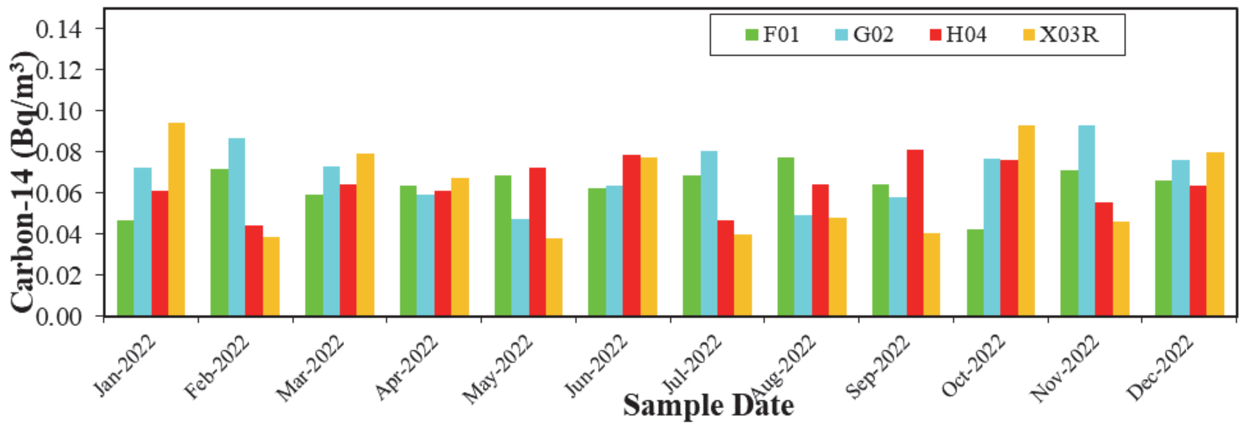
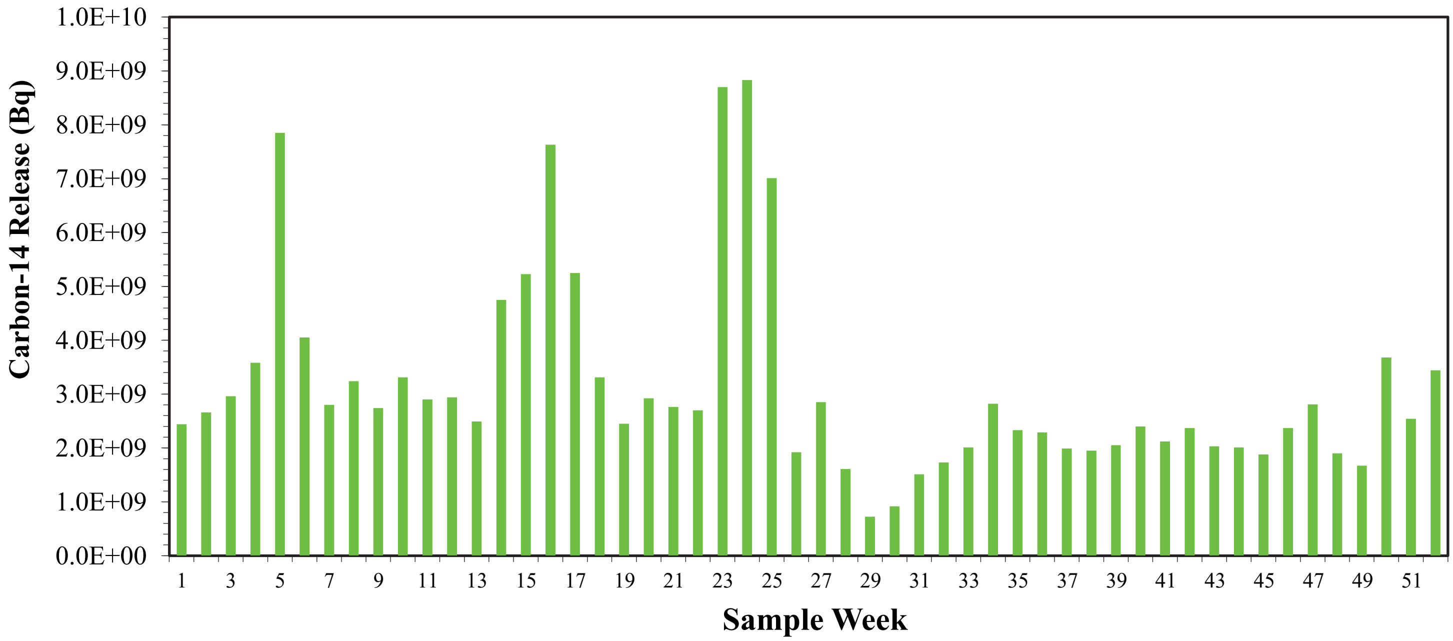


Figure 4.07: Carbon-14 (Carbon Dioxide) (Colour)



NOTE
The Weekly DRL for C-14 is 2.4E+14 Bq

Figure 4.08: Gaseous C-14 Releases for 2022 (Colour)

4.4 Carbon Dioxide, Continued

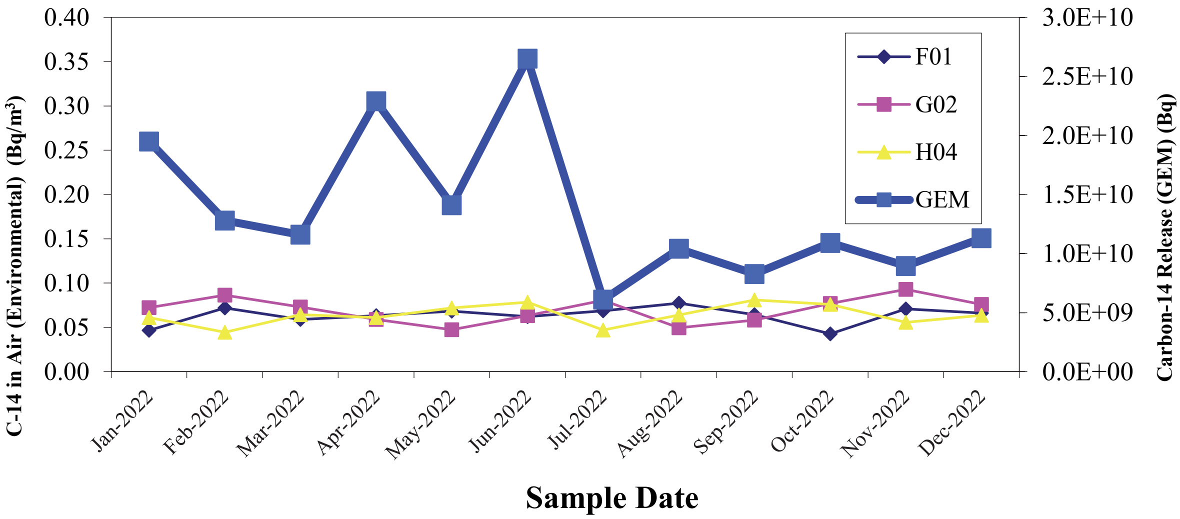


Figure 4.09: Gaseous C-14 Releases and C-14 (Carbon Dioxide) Results (Colour)

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 (985 $\mu Gy \cdot a^{-1}$) is higher than other onsite locations (700 $\mu Gy \cdot a^{-1}$). The measurements onsite, excluding the SRWMF, are not significantly different from those at offsite locations (684 $\mu Gy \cdot a^{-1}$) including the reference location (729 $\mu Gy \cdot a^{-1}$).

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 240 concrete canisters filled to the end of 2022. 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 (µGy) (+/- 10%)

Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Year
A13R	1.51E+02	2.01E+02	1.93E+02	1.84E+02	7.29E+02
B03	1.42E+02	1.50E+02	1.64E+02	1.44E+02	6.00E+02
C03	1.86E+02	2.10E+02	2.21E+02	2.10E+02	8.27E+02
D02	1.55E+02	1.77E+02	1.88E+02	1.83E+02	7.03E+02
E01	1.44E+02	1.46E+02	1.64E+02	1.69E+02	6.23E+02
E04	1.50E+02	1.69E+02	1.94E+02	2.10E+02	7.23E+02
E05	1.59E+02	1.65E+02	1.87E+02	1.95E+02	7.06E+02
E06	1.96E+02	2.39E+02	2.54E+02	2.59E+02	9.48E+02
F01	1.19E+02	1.11E+02	1.22E+02	1.35E+02	4.87E+02
G02	1.82E+02	1.79E+02	1.94E+02	2.00E+02	7.55E+02
H04	1.43E+02	1.39E+02	1.51E+02	1.62E+02	5.95E+02
H05	1.08E+02	1.11E+02	1.21E+02	1.22E+02	4.62E+02
I11A	2.15E+02	2.36E+02	2.54E+02	2.33E+02	9.38E+02
I11B	2.24E+02	2.40E+02	2.52E+02	2.64E+02	9.80E+02
I11C	2.17E+02	2.28E+02	2.48E+02	2.15E+02	9.08E+02
I11D	2.03E+02	2.37E+02	2.79E+02	2.37E+02	9.56E+02
I11E	2.17E+02	2.38E+02	2.51E+02	2.23E+02	9.29E+02
I11F	2.56E+02	3.64E+02	3.97E+02	2.92E+02	1.31E+03
I11J	2.21E+02	2.91E+02	3.62E+02	2.49E+02	1.12E+03
I11K	2.10E+02	2.25E+02	2.50E+02	2.39E+02	9.24E+02
I11L	2.00E+02	2.20E+02	2.43E+02	2.44E+02	9.07E+02
I11M	2.46E+02	2.66E+02	2.94E+02	2.40E+02	1.05E+03
I11N	2.27E+02	2.35E+02	2.69E+02	2.57E+02	9.88E+02
I11O	2.27E+02	2.43E+02	2.76E+02	2.63E+02	1.01E+03
I11P	2.49E+02	2.70E+02	2.84E+02	2.81E+02	1.08E+03
I11Q	2.36E+02	2.87E+02	2.82E+02	2.70E+02	1.07E+03
I11S	2.18E+02	2.33E+02	2.61E+02	2.43E+02	9.55E+02
I11T	2.32E+02	2.91E+02	3.03E+02	2.64E+02	1.09E+03
I21A	2.17E+02	2.25E+02	2.45E+02	2.46E+02	9.33E+02
I21B	2.58E+02	2.67E+02	2.85E+02	2.55E+02	1.07E+03
I21C	1.91E+02	2.07E+02	2.19E+02	2.13E+02	8.30E+02
I21D	2.60E+02	2.55E+02	2.74E+02	2.82E+02	1.07E+03
I21E	2.65E+02	2.49E+02	2.63E+02	2.65E+02	1.04E+03
I21F	1.95E+02	1.97E+02	2.14E+02	2.49E+02	8.55E+02
I21G	2.05E+02	2.49E+02	2.27E+02	2.32E+02	9.13E+02
I21H	2.66E+02	2.74E+02	2.97E+02	3.01E+02	1.14E+03

4.5 Ambient Gamma Measurements (TLD), Continued

Table 4.06: Ambient Gamma – TLD (µGy) **(+/- 10%),** *Continued*

Location	*1st Quarter*	*2nd Quarter*	*3rd Quarter*	*4th Quarter*	*Year*
I21I	2.27E+02	2.50E+02	2.53E+02	2.64E+02	9.94E+02
I21J	3.37E+02	3.04E+02	3.60E+02	4.70E+02	1.47E+03
I21K	1.99E+02	1.77E+02	2.34E+02	2.44E+02	8.54E+02
I21L	2.09E+02	1.72E+02	2.33E+02	2.18E+02	8.32E+02
I31A	2.01E+02	1.72E+02	2.36E+02	2.37E+02	8.46E+02
I31B	2.13E+02	1.73E+02	2.43E+02	2.36E+02	8.65E+02
I31C	2.34E+02	2.13E+02	2.58E+02	2.56E+02	9.61E+02
I31D	2.42E+02	2.02E+02	2.57E+02	2.72E+02	9.73E+02
I31E	2.27E+02	2.19E+02	2.64E+02	2.65E+02	9.75E+02
I31F	2.33E+02	2.14E+02	2.81E+02	2.90E+02	1.02E+03
I31G	2.36E+02	2.44E+02	2.71E+02	2.68E+02	1.02E+03
I31H	2.36E+02	2.48E+02	2.77E+02	2.63E+02	1.02E+03
I31I	2.27E+02	2.45E+02	2.60E+02	2.63E+02	9.95E+02
I31J	2.34E+02	2.47E+02	2.59E+02	2.59E+02	9.99E+02
I31K	2.25E+02	2.34E+02	2.55E+02	2.49E+02	9.63E+02
I31L	2.08E+02	2.17E+02	2.29E+02	2.28E+02	8.82E+02
I31M	2.07E+02	2.29E+02	2.49E+02	2.40E+02	9.25E+02
I31N	2.16E+02	2.32E+02	2.32E+02	2.32E+02	9.12E+02
I31P	2.22E+02	2.34E+02	2.44E+02	2.62E+02	9.62E+02
I31Q	2.22E+02	2.51E+02	2.53E+02	2.55E+02	9.81E+02
I31S	2.22E+02	2.44E+02	2.36E+02	2.38E+02	9.40E+02
I31T	1.99E+02	2.02E+02	2.16E+02	2.33E+02	8.50E+02
I86	1.51E+02	1.53E+02	1.71E+02	1.93E+02	6.68E+02
I87	1.47E+02	1.54E+02	1.70E+02	1.76E+02	6.47E+02
I88	1.47E+02	1.49E+02	1.60E+02	1.80E+02	6.36E+02
I89	1.53E+02	1.43E+02	1.72E+02	NA	6.42E+02*
J20	1.71E+02	1.74E+02	1.74E+02	1.89E+02	7.08E+02
J35	2.13E+02	1.93E+02	1.93E+02	2.31E+02	8.30E+02
K01	1.74E+02	1.88E+02	1.98E+02	2.17E+02	7.77E+02
L01	1.79E+02	1.83E+02	1.98E+02	1.95E+02	7.55E+02
L03	1.88E+02	2.02E+02	2.08E+02	2.25E+02	8.23E+02
L04	1.78E+02	1.96E+02	1.90E+02	2.12E+02	7.76E+02
M02	1.59E+02	1.59E+02	1.68E+02	1.80E+02	6.66E+02
N01	1.59E+02	1.69E+02	1.77E+02	1.80E+02	6.85E+02
P03	1.43E+02	1.66E+02	1.71E+02	1.67E+02	6.47E+02

NA: Data Not Available, *Estimated Total.

4.5 Ambient Gamma Measurements (TLD), Continued

Table 4.06: Ambient Gamma – TLD (µGy) **(+/- 10%),** *Continued*

Location	*1st Quarter*	*2nd Quarter*	*3rd Quarter*	*4th Quarter*	*Year*
YTL1	1.30E+02	1.42E+02	1.41E+02	1.52E+02	5.65E+02
YTL2	1.38E+02	1.34E+02	1.48E+02	1.39E+02	5.59E+02
YTL3	1.57E+02	1.97E+02	1.99E+02	2.05E+02	7.58E+02
YTL4	1.61E+02	1.85E+02	2.06E+02	1.93E+02	7.45E+02

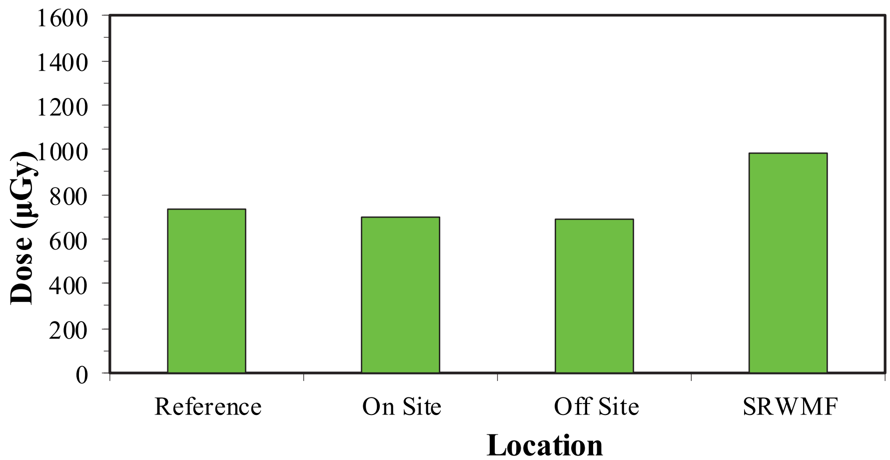


Figure 4.10: Mean Ambient Gamma (TLD) Results 2022 (Colour)

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 is sent to the Fredericton lab for analysis. Fifty-two of these GEM filters were analyzed for Sr-89,90. No significant activity was detected.

4.7 Well Water

Of the 22 samples analyzed, H-3 was detected in 15. These results are attributable to the operation of PLNGS.

Water is collected annually at six locations and semi-annually at nine locations (*Figure 3.05*). Three wells are located onsite, however, only two were available for sampling in 2022. Two offsite residential wells were unavailable for sampling in the first half of 2022. Results are consistent with previous years at these locations.

Detected H-3 concentrations ranged from 1.16E+01 to 7.04E+01 $Bq{\cdot}L^{-1}$, 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 1.38E+01 to 6.34E+02 $Bq{\cdot}L^{-1}$ in 42 of 48 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 2022.

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 2022 were 1.3E-03% 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.

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 7.0E+03 $Bq{\cdot}L^{-1}$ as the maximum acceptable average concentration for H-3 in drinking water.

4.7 Well Water, Continued

Table 4.07: Well Water (Bq·L^{-1})

Analysis Type	Total Number	Indicator Locations				Reference Location			
		Mean	Minimum	Maximum	Detection Frequency	Mean	Minimum	Maximum	Detection Frequency
H-3	22	3.13E+01	1.16E+01	7.04E+01	15 of 20	*	*	*	0 of 2

* The activity is less than or equal to the Critical Level (99% Confidence Level).

4.7 Well Water, Continued

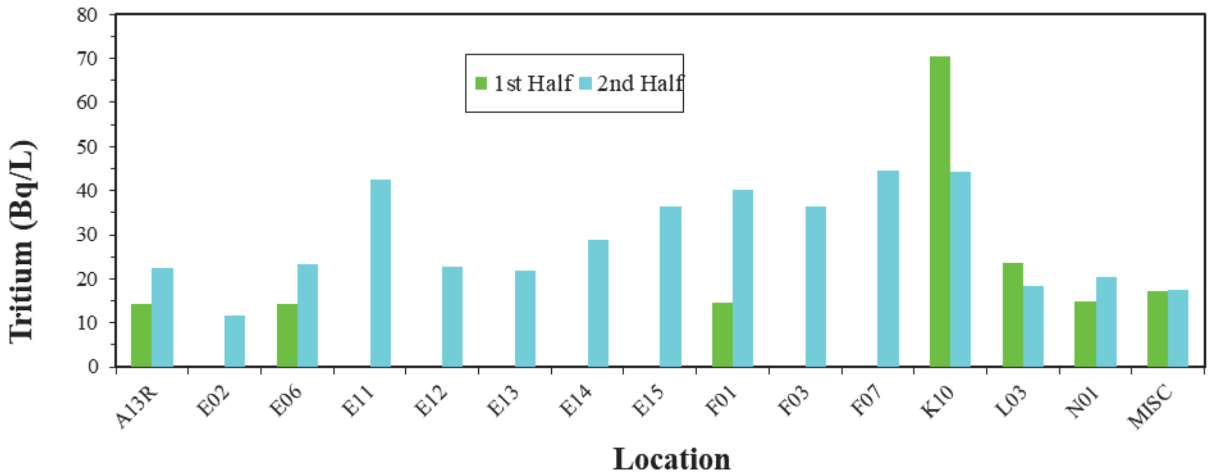


Figure 4.11: Tritium (Well Water) 2022 (Colour)

4.8 Pond/Puddle/Surface Water

Low levels of H-3 were detected in 31 of the 31 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 1.47E+01 to 5.97E+02 Bq·L^{-1}. 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 1.38E+01 to 6.34E+02 Bq·L-1 in 42 of 48 samples.

Gross alpha/beta analysis is performed if there are significant gamma emitters detected. This did not occur in 2022.

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 2022 were 1.3E-03% 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.

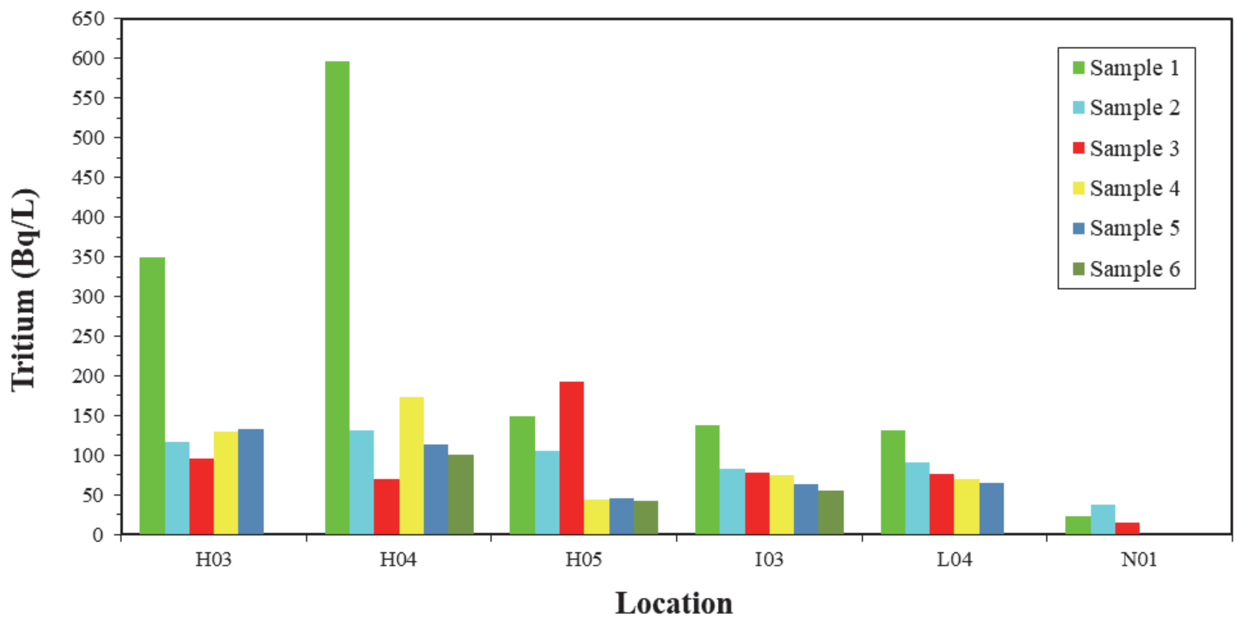


Figure 4.12: Tritium (Pond/Puddle/Surface Water) 2022 (Colour)

4.8 Pond/Puddle/Surface Water, Continued

Table 4.08: Pond/Puddle/Surface Water (Bq·L^{-1})

Analysis Type	*Total Number*	*Indicator Locations*				*Reference Location*			
		Mean	*Minimum*	*Maximum*	*Detection Frequency*	*Mean*	*Minimum*	*Maximum*	*Detection Frequency*
H-3	31	1.16E+02	1.47E+01	5.97E+02	31 of 31	*	*	*	*

*There is no reference location.

4.9 Berries

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

It is common for naturally occurring K-40 to be detected in food samples. There was no K-40 detected in any of the seven samples analyzed in 2022.

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 2022 were 9.18E-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 ($Bq \cdot kg^{-1}$)

Analysis Type	Total Number	Indicator Locations				Reference Location			
		Mean	Minimum	Maximum	Detection Frequency	Mean	Minimum	Maximum	Detection Frequency
K-40	7	*	*	*	0 of 4	*	*	*	0 of 3

* The activity is less than or equal to the Critical Level (99% Confidence Level).

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 eleven of the fourteen samples (7.2E+01 to 4.4E+02 $Bq \cdot kg^{-1}$). 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 2022 were 9.18E-02% DRL for H-3 and 1.3E-03% 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 possible 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 20 of the 37 vegetation samples (2.9E+01 to 5.6E+02 $Bq \cdot kg^{-1}$). Naturally occurring K-40 was detected in 6 of the 37 vegetation samples (6.5E+01 to 2.8E+02 $Bq \cdot kg^{-1}$).

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

4.11 Vegetation, Continued

Table 4.10: Garden Vegetables (Bq·kg^{-1})

Analysis Type	*Total Number*	*Indicator Locations*				*Reference Location*			
		Mean	*Minimum*	*Maximum*	*Detection Frequency*	*Mean*	*Minimum*	*Maximum*	*Detection Frequency*
K-40	14	1.9E+02	7.2E+01	4.4E+02	11 of 14	*	*	*	*

*There is no reference location.

4.11 Vegetation, Continued

Table 4.11: Vegetation ($Bq \cdot kg^{-1}$)

Analysis Type	Total Number	Indicator Locations				Reference Location			
		Mean	Minimum	Maximum	Detection Frequency	Mean	Minimum	Maximum	Detection Frequency
Be-7	37	2.3E+02	2.9E+01	5.6E+02	20 of 37	*	*	*	*
K-40	37	1.5E+02	6.5E+01	2.8E+02	6 of 37	*	*	*	*

* 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 and from the local elementary school.

Thirty samples contained naturally occurring K-40 (1.89E+02 to 6.93E+02 Bq·kg^{-1}), 24 samples contained naturally occurring Ac-228 (1.25E+01 to 4.04E+01 Bq·kg^{-1}) and 19 samples contained Cs-137 (2.20E+00 to 2.52+01 Bq·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 2022 are comparable to those seen before PLNGS became operational. Cs-137 was not detected in gaseous effluents in 2022.

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.

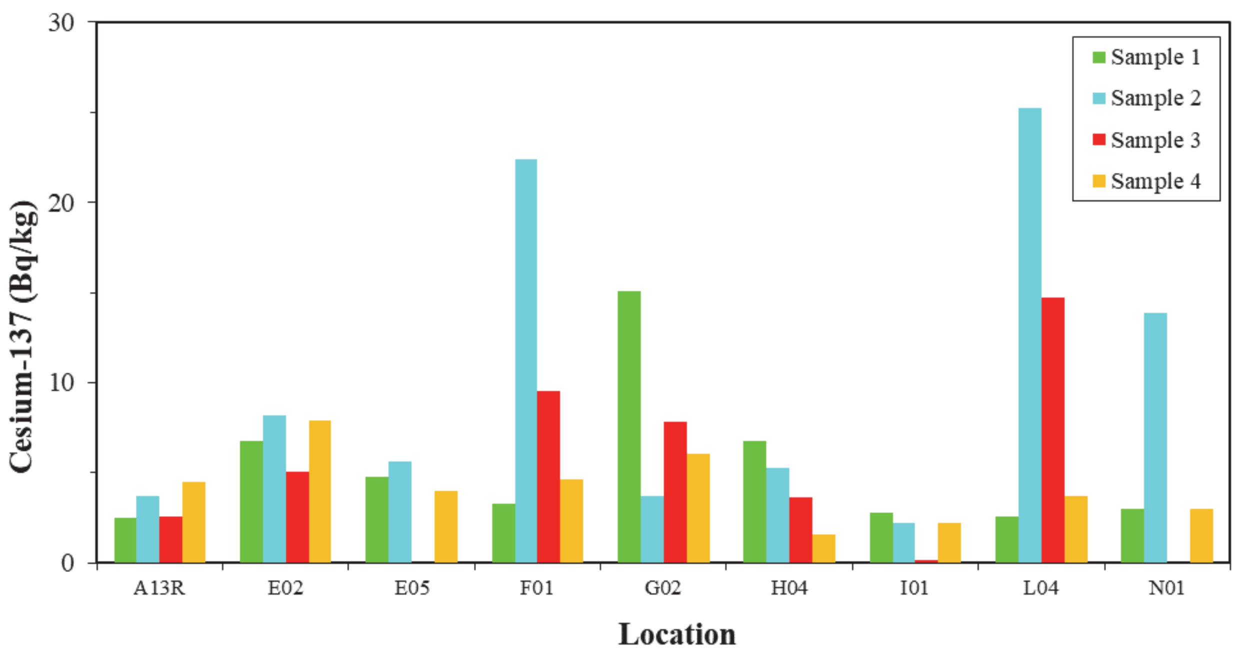


Figure 4.13: Cesium-137 (Soil) 2022 (Colour)

4.12 Soil, Continued

Table 4.12: Soil (Bq·kg^{-1})

Analysis Type	Total Number	Indicator Locations				Reference Location			
		Mean	Minimum	Maximum	Detection Frequency	Mean	Minimum	Maximum	Detection Frequency
Cs-137	34	9.15E+00	2.20E+00	2.52E+01	19 of 30	*	*	*	0 of 4
Ac-228	34	2.15E+01	1.25E+01	4.04E+01	20 of 30	2.47E+01	2.08E+01	3.08E+01	4 of 4
K-40	34	3.66E+02	1.89E+02	6.93E+02	26 of 30	4.07E+02	3.56E+02	4.87E+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.

Forty-two samples contained H-3 levels which spanned from 1.38E+01 to 6.34E+02 Bq·L^{-1}. 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 2022 were 1.3E-03% 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.

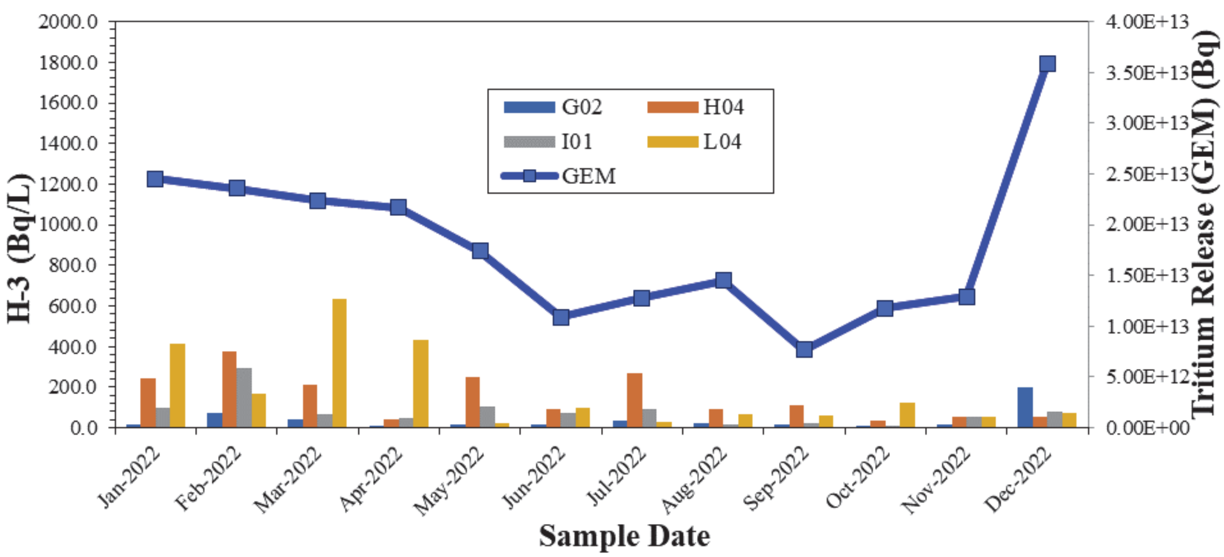


Figure 4.14: Gaseous H-3 Releases and Tritium (Precipitation) Results (Colour)

4.13 Precipitation, Continued

Table 4.13: Precipitation ($Bq \cdot L^{-1}$)

Analysis Type	*Total Number*	*Indicator Locations*				*Reference Location*			
		Mean	*Minimum*	*Maximum*	*Detection Frequency*	*Mean*	*Minimum*	*Maximum*	*Detection Frequency*
H-3	48	1.28E+02	1.38E+01	6.34E+02	42 of 48	*	*	*	*

* There is no reference location.

4.14 Monitoring Well Water, Near Plant

Fourteen monitoring wells are sampled once per year. This frequency will be increased for some or all wells if H-3 concentrations greater than 7000 $Bq \cdot L^{-1}$ 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 2022 to monitor conditions near plant during a period of expected increased releases in December 2022.

Tritium concentrations averaged 2.40E+02 $Bq \cdot L^{-1}$ ranging up to 4.91E+02 $Bq \cdot L^{-1}$. 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.

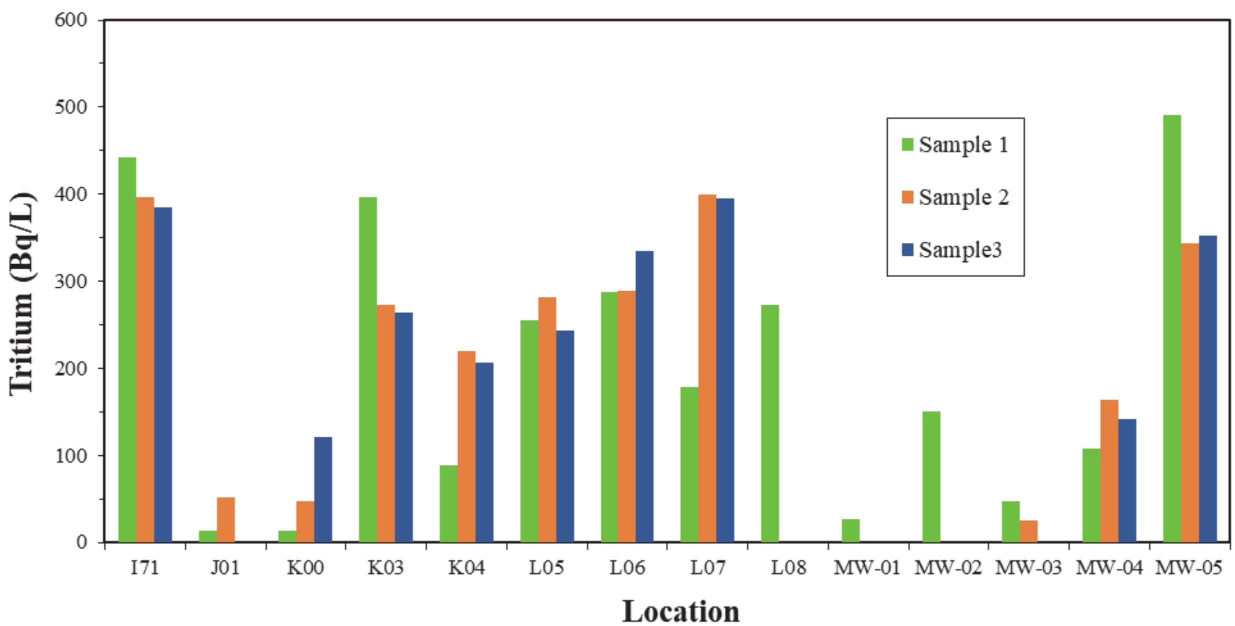


Figure 4.15: Tritium (Monitoring Well Water, Near Plant) 2022 (Colour)

4.14 Monitoring Well Water, Near Plant, Continued

Table 4.14: Monitoring Well Water, Near Plant ($Bq \cdot L^{-1}$)

Analysis Type	*Total Number*	*Indicator Locations*				*Reference Location*			
		Mean	*Minimum*	*Maximum*	*Detection Frequency*	*Mean*	*Minimum*	*Maximum*	*Detection Frequency*
H-3	34	2.40E+02	2.53E+01	4.91E+02	32 of 34	*	*	*	*

* 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 (3.4E+00 to 1.4E+01 $Bq \cdot L^{-1}$) in twelve samples. The K-40 results are not attributed to operation of PLNGS. Tritium was detected (1.3E+01 to 4.8E+01 $Bq \cdot L^{-1}$) in three of the samples. The H-3 results are attributed to PLNGS operations. Calculations suggest that the 2022 average concentration of tritium in seawater, due to releases from PLNGS in the approved liquid pathway, would be about 5E+00 $Bq \cdot L^{-1}$ at the out-fall (samples are not collected at this point, but are taken at the shoreline nearby). This calculation takes into account the total tritium released over the year, the flow rate of the condenser cooling water (about 2.5E+01 $m^3 \cdot s^{-1}$), 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 2E+00 $Bq \cdot L^{-1}$ in seawater during 2022 at the H03 location. In past years, when samples were taken soon after pump out of 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 2022 were 6.48E-04% DRL for C-14 and 3.35E-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^{-1})

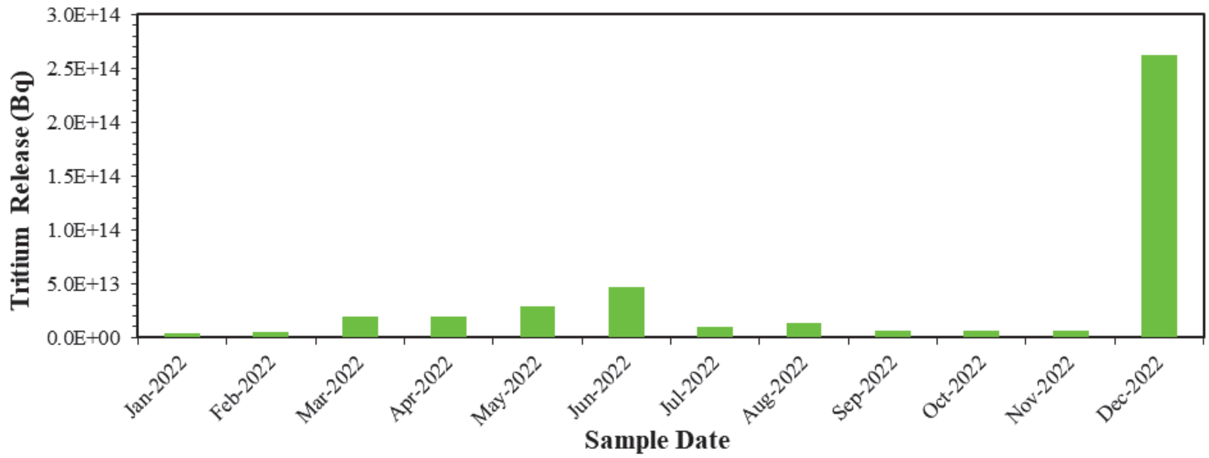
Analysis Type	Total Number	Indicator Locations				Reference Location			
		Mean	Minimum	Maximum	Detection Frequency	Mean	Minimum	Maximum	Detection Frequency
H-3	19	2.61E+01	1.28E+01	4.81E+01	3 of 14	*	*	*	0 of 5
K-40	19	9.3E+00	3.4E+00	1.4E+01	9 of 14	8.20E+00	6.36E+00	1.04E+01	3 of 5

* The activity is less than or equal to the Critical Level (99% Confidence Level).

4.16 Tritium and C-14 Analyses of Seafood

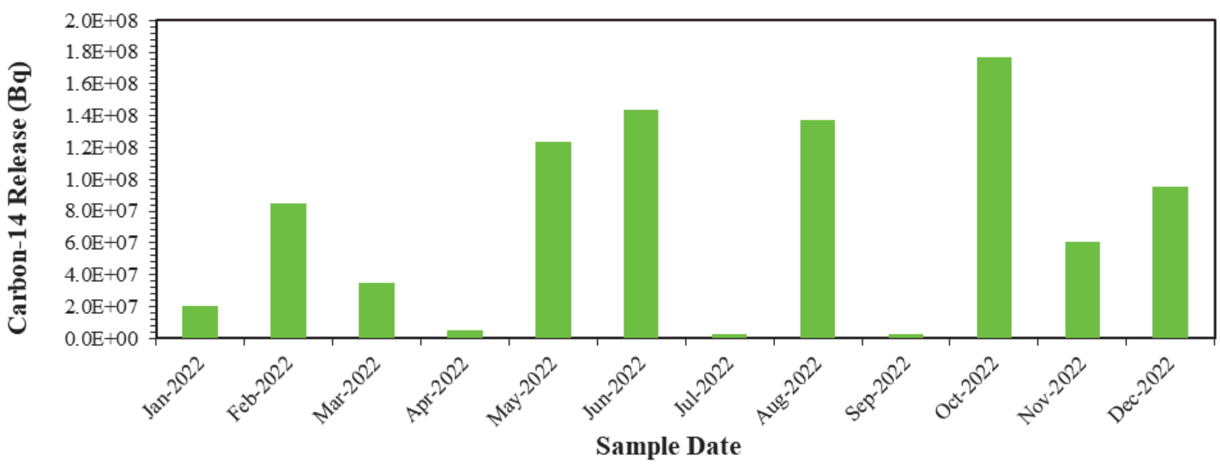
When H-3 and C-14 releases are low, the expected concentrations of these radionuclides in seafood are below the detection limit. If the monthly releases are more than one percent of the monthly DRL, a H-3 or C-14 analysis is performed on seafood. Since the releases in 2022 were 1.32E-03% DRL for H-3 and 6.48E-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 2022.

4.16 Tritium and C-14 Analyses of Seafood, Continued



NOTE
The Monthly DRL for H-3 is 3.8E+18 Bq.

Figure 4.16: Liquid H-3 Releases for 2022 (Colour)



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

Figure 4.17: Liquid C-14 Releases for 2022 (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 – Ten samples were collected (three were collected from Pocologan, two from St. Andrews, New River Beach, Dipper Harbor and one from Maces Bay). The inshore fishery often faces restrictions placed upon the harvesting of shellfish, either for conservation of stocks or because of bacterial contamination or algal blooms. The restrictions affect the availability of these sample types for analysis. Data are shown in Table 4.16.

Dulse - Three samples were collected (two from Maces Bay and one from Grand Manan). 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. One sample of haddock was collected from close to Nova Scotia. Data are shown in Table 4.18.

Lobster – Four samples were collected (two from the Lepreau area and two from the Saint Andrews area). Lobsters are typically obtained during each of the two federally regulated fishing seasons per year. Data are shown in Table 4.19. Two additional samples of tomalley from lobsters were tested; no activity was detected.

Periwinkles – Thirteen samples were collected (four from Dipper Harbor and Maces Bay, two from St. Andrews and one from Pocologan, Duck Cove and New River Beach). Data are shown in Table 4.20.

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

Scallops – One sample was collected from the Lepreau area. Data are shown in Table 4.22.

4.17 Seafood, Continued

Table 4.16: Clams, Edible, Raw Mass (Bq·kg^{-1})

Analysis Type	Total Number	Indicator Locations				Reference Location			
		Mean	Minimum	Maximum	Detection Frequency	Mean	Minimum	Maximum	Detection Frequency
K-40	10	7.8E+02	2.9E+02	1.4E+03	8 of 8	5.0E+02	2.3E+02	7.8E+02	2 of 2

Table 4.17: Dulse, Wet Mass (Bq·kg^{-1})

Analysis Type	Total Number	Indicator Locations				Reference Location			
		Mean	Minimum	Maximum	Detection Frequency	Mean	Minimum	Maximum	Detection Frequency
K-40	3	1.12E+03	2.40E+01	2.22E+03	2 of 2	2.01E+02	2.01E+02	2.01E+02	1 of 1

4.17 Seafood, Continued

Table 4.18: Fish, Raw Mass (Bq·kg^{-1})

Analysis Type	Total Number	Indicator Locations				Reference Location			
		Mean	Minimum	Maximum	Detection Frequency	Mean	Minimum	Maximum	Detection Frequency
K-40	1	*	*	*	*	1.09E+02	1.09E+02	1.09E+02	1 of 1

* No indicator sample

Table 4.19: Lobster, Edible, Cooked Mass (Bq·kg^{-1})

Analysis Type	Total Number	Indicator Locations				Reference Location			
		Mean	Minimum	Maximum	Detection Frequency	Mean	Minimum	Maximum	Detection Frequency
K-40	4	1.8E+02	1.8E+02	1.8E+02	1 of 2	9.82E+01	9.82E+01	9.82E+01	1 of 2

4.17 Seafood, Continued

Table 4.20: Periwinkles, Edible, Raw Mass (Bq·kg^{-1})

Analysis Type	Total Number	Indicator Locations				Reference Location			
		Mean	Minimum	Maximum	Detection Frequency	Mean	Minimum	Maximum	Detection Frequency
K-40	13	1.3E+02	9.0E+01	1.7E+02	2 of 9	2.64E+02	2.64E+02	2.64E+02	1 of 4

Table 4.21: Aquaculture Salmon, Raw Mass (Bq·kg^{-1})

Analysis Type	Total Number	Indicator Locations				Reference Location			
		Mean	Minimum	Maximum	Detection Frequency	Mean	Minimum	Maximum	Detection Frequency
K-40	2	1.3E+02	1.3E+02	1.3E+02	1 of 1	5.93E+01	5.93E+01	5.93E+01	1 of 1

4.17 Seafood, Continued

Table 4.22: Scallops, Wet Mass (Bq·kg^{-1})

Analysis Type	Total Number	Indicator Locations				Reference Location			
		Mean	Minimum	Maximum	Detection Frequency	Mean	Minimum	Maximum	Detection Frequency
K-40	1	1.6E+02	1.6E+02	1.6E+02	1 of 1	*	*	*	*

*There is no reference location.

Table 4.23: Sea Plants, Wet Mass (Bq·kg^{-1})

Analysis Type	Total Number	Indicator Locations				Reference Location			
		Mean	Minimum	Maximum	Detection Frequency	Mean	Minimum	Maximum	Detection Frequency
K-40	3	2.5E+02	2.2E+02	2.7E+02	3 of 3	*	*	*	*

*There is no reference location.

4.18 Other Sea Plants

Potassium-40 was detected in three of three 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, *Ascophylum*) 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 2.2E+02 to 2.7E+02 $Bq \cdot kg^{-1}$. Data are shown in Table 4.23.

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 (3.41E+02 to 9.50E+02 $Bq \cdot kg^{-1}$) from the natural potassium in feldspar, a common mineral. Three samples contained cosmogenic produced Be-7 (5.36E+01 to 5.56E+01 $Bq \cdot kg^{-1}$). Thirty-eight samples contained Ac-228 (1.19E+01 to 3.79E+01 $Bq \cdot kg^{-1}$), a radioactive progeny of naturally occurring Th-232. None of these results are attributable to the operation of PLNGS.

Occasionally, sediment samples contain Cs-137, although none was detected in 2022. Samples analyzed between 1977 and 1982, before PLNGS began operations, contained an average Cs-137 concentration of 5.0E+00 $Bq \cdot kg^{-1}$. A small additional Cs-137 component was added to this reservoir from Chernobyl in 1986. Finer grain sediments have a higher natural radioactivity content than coarse sediments.

Table 4.24 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 2022, all values were “Less Than” values.

4.19 Sediment, Continued

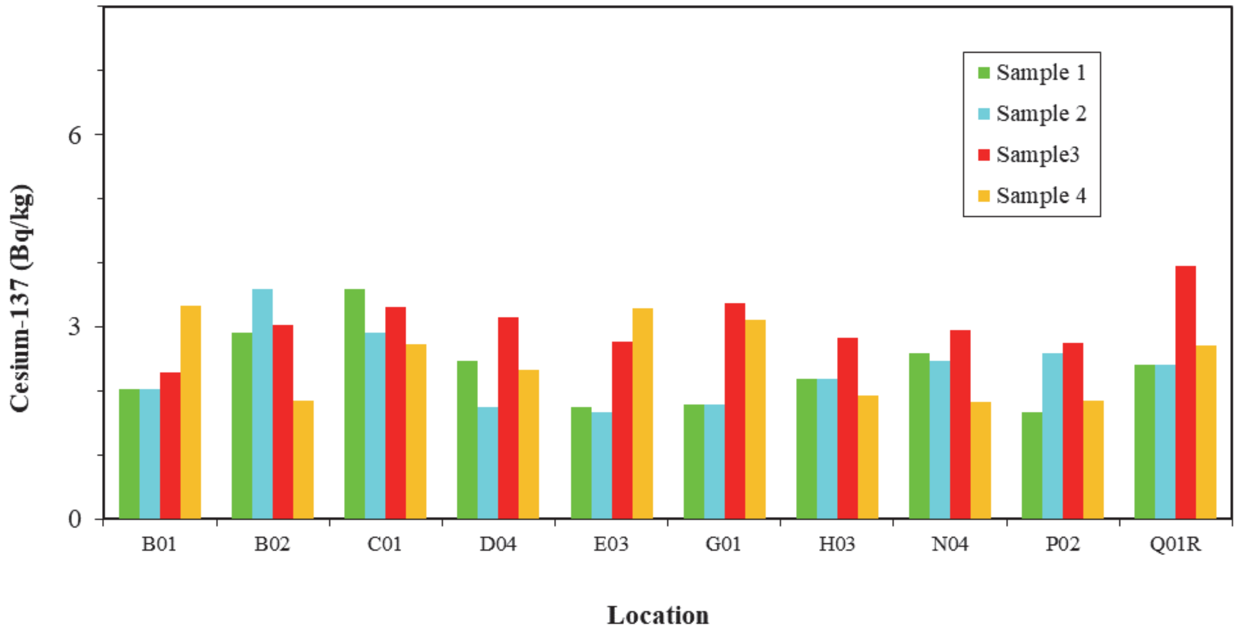


Figure 4.18: Cesium-137 (Sediment) 2022 (Colour)

4.19 Sediment, Continued

Table 4.24: Sediment ($Bq \cdot kg^{-1}$)

Analysis Type	Total Number	Indicator Locations				Reference Location			
		Mean	Minimum	Maximum	Detection Frequency	Mean	Minimum	Maximum	Detection Frequency
Be-7	40	5.49E+01	5.36E+01	5.56E+01	3 of 36	*	*	*	0 of 4
Ac-228	40	2.35E+01	1.29E+01	3.79E+01	35 of 36	1.77E+01	1.19E+01	2.32E+01	3 of 4
K-40	40	6.22E+02	3.41E+02	9.50E+02	36 of 36	6.39E+02	5.44E+02	7.55E+02	4 of 4

4.20 Ambient Gamma Measurements of Intertidal Zone

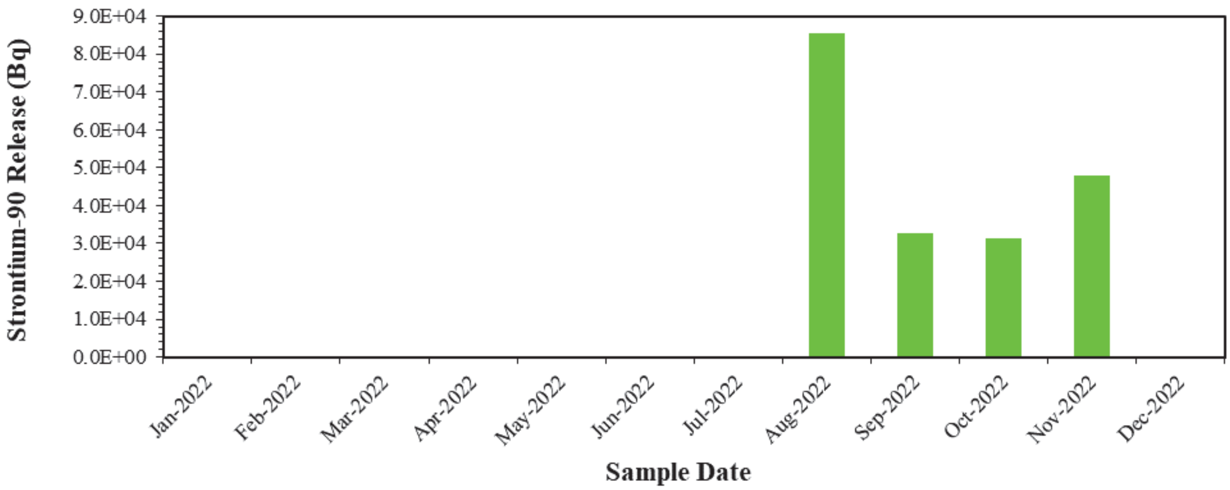
Environmental gamma survey measurements are made in the intertidal zone on beaches in the Lepreau area and at the reference location 28 km to the east-northeast (Figure 3.05). Beach surveys are performed, and grab samples of sediments are analyzed. Radiation values measured in 2022 were consistent with those measured prior to Station start-up in 1982. These values are summarized in Table 4.25.

Table 4.25: Ambient Gamma Measurements of Intertidal Zone – (μSv·h^{-1})

Location	*1st Quarter*	*2nd Quarter*	*3rd Quarter*	*4th Quarter*
B01	0.16	0.20	0.15	0.12
B02	0.14	0.17	0.17	0.20
C01	0.14	0.11	0.14	0.14
D04	0.19	0.14	0.16	0.14
E03	0.19	0.16	0.14	0.11
G01	0.13	0.10	0.13	0.16
H03	0.12	0.17	0.14	0.17
N04	0.11	0.10	0.18	0.15
P02	0.18	0.17	0.18	0.14
Q01R	0.16	0.15	0.14	0.18

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 2022 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 2022 (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 104 samples. Concentrations averaged 1.72E+02 $Bq{\cdot}L^{-1}$ (9.27E+01 to 2.39E+02 $Bq{\cdot}L^{-1}$) near the Phase 1 facility, 7.81E+01 $Bq{\cdot}L^{-1}$ (2.07E+01 to 1.75E+02 $Bq{\cdot}L^{-1}$) near the Phase 2 facility and 1.31E+02 $Bq{\cdot}L^{-1}$ (4.70E+01 to 3.04E+02 $Bq{\cdot}L^{-1}$) 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 1.38E+01 to 6.34E+02 $Bq{\cdot}L^{-1}$ in 42 of 48 samples.

Results are presented in Tables 4.26 to 4.28. 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

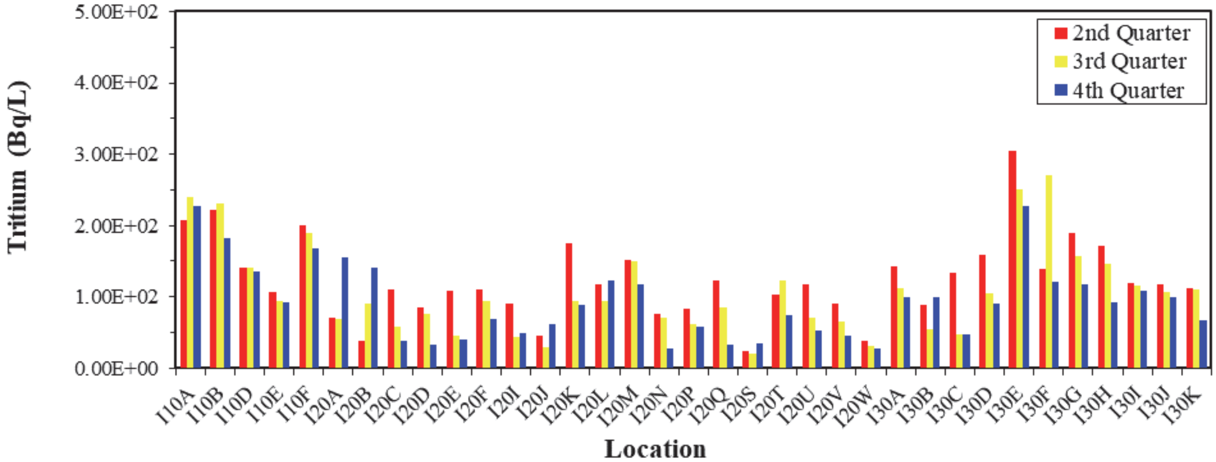


Figure 4.20: Tritium (Bore Hole Water, SRWMF) 2022 (Colour)

4.22 Bore Hole Water, SRWMF, Continued

Table 4.26: Bore Hole Water, SRWMF - Phase 1 (Bq·L^{-1})

Analysis Type	Total Number	Indicator Locations				Reference Location			
		Mean	Minimum	Maximum	Detection Frequency	Mean	Minimum	Maximum	Detection Frequency
H-3	15	1.72E+02	9.27E+01	2.39E+02	15 of 15	*	*	*	*

* There is no reference location.

Table 4.27: Bore Hole Water, SRWMF - Phase 2 (Bq·L^{-1})

Analysis Type	Total Number	Indicator Locations				Reference Location			
		Mean	Minimum	Maximum	Detection Frequency	Mean	Minimum	Maximum	Detection Frequency
H-3	57	7.81E+01	2.07E+01	1.75E+02	56 of 57	*	*	*	*

* There is no reference location.

4.22 Bore Hole Water, SRWMF, Continued

Table 4.28: Bore Hole Water, SRWMF - Phase 3 (Bq·L^{-1})

Analysis Type	Total Number	Indicator Locations				Reference Location			
		Mean	Minimum	Maximum	Detection Frequency	Mean	Minimum	Maximum	Detection Frequency
H-3	33	1.31E+02	4.70E+01	3.04E+02	33 of 33	*	*	*	*

* There is no reference location.

4.23 SRWMF Parshall Flume Water

Of the 156 samples analyzed, H-3 was detected in 137 samples. These results are attributable to the releases from PLNGS (primarily) and 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:

- 2.05E+02 Bq·L^{-1} at Phase 1
- 9.31E+01 Bq·L^{-1} at Phase 2
- 1.88E+02 Bq·L^{-1} at Phase 3.

Tables 4.29 to 4.31 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.

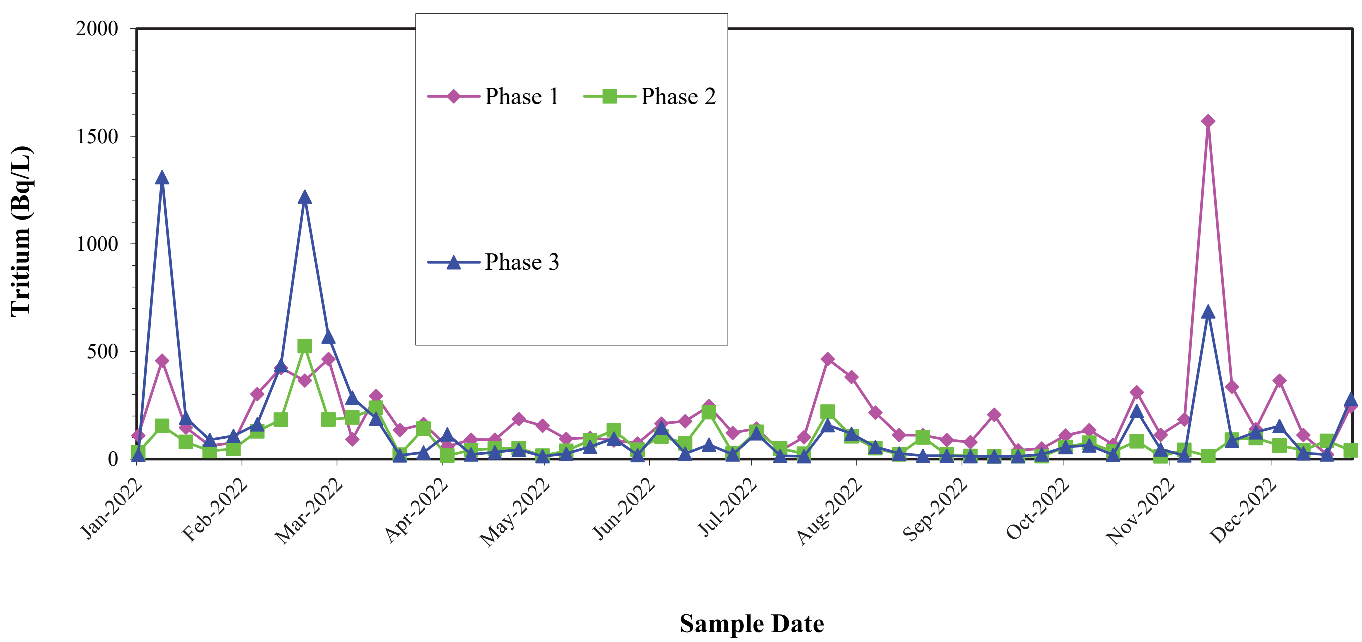


Figure 4.21: Tritium (Parshall Flume Water, SRWMF) 2022 (Colour)

4.23 SRWMF Parshall Flume Water, Continued

Table 4.29: Parshall Flume Water, SRWMF - Phase 1 (Bq·L^{-1})

Analysis Type	*Total Number*	*Indicator Locations*				*Reference Location*			
		Mean	*Minimum*	*Maximum*	*Detection Frequency*	*Mean*	*Minimum*	*Maximum*	*Detection Frequency*
H-3	52	2.05E+02	3.89E+01	1.57E+03	51 of 52	*	*	*	*

* There is no reference location.

Table 4.30: Parshall Flume Water, SRWMF - Phase 2 (Bq·L^{-1})

Analysis Type	*Total Number*	*Indicator Locations*				*Reference Location*			
		Mean	*Minimum*	*Maximum*	*Detection Frequency*	*Mean*	*Minimum*	*Maximum*	*Detection Frequency*
H-3	52	9.31E+01	1.31E+01	5.25E+02	46 of 52	*	*	*	*

* There is no reference location.

4.23 SRWMF Parshall Flume Water, Continued

Table 4.31: Parshall Flume Water, SRWMF - Phase 3 ($Bq \cdot L^{-1}$)

Analysis Type	Total Number	Indicator Locations				Reference Location			
		Mean	Minimum	Maximum	Detection Frequency	Mean	Minimum	Maximum	Detection Frequency
H-3	52	1.88E+02	1.31E+01	1.31E+03	40 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 2022 were collected at ten minutes intervals and are presented in Table 4.32. Wind Rose data for 2022 are presented in Figure 4.22.

4.25 Meteorological Data, Continued

Table 4.32: Meteorological Data for Point Lepreau (2022)

	Temperature (Degrees Celsius) 10 Metre Tower Data					Wind Direction* (Relative %) 42 Metre Tower Data							
		Mean Daily		Extreme		% Observations from							
Month	***Avg***	***Max***	***Min***	***Max***	***Min***	***N***	***NE***	***E***	***SE***	***S***	***SW***	***W***	***NW***
January	-5.7	-0.1	-12.1	9.0	-22.5	30	7	3	3	7	6	10	33
February	-2.9	1.0	-7.0	9.9	-18.0	16	8	4	1	23	13	9	25
March	1.1	4.6	-2.0	10.8	-16.5	5	3	13	5	14	12	18	29
April	5.1	8.8	1.7	14.4	-3.2	16	6	13	4	14	11	10	26
May	9.7	13.5	5.6	19.5	-0.6	10	14	17	7	16	16	10	11
June	13.2	16.8	9.5	20.9	3.1	10	5	13	12	23	14	10	12
July	16.5	21.1	12.8	25.7	9.2	4	1	4	6	26	23	18	18
August	17.6	21.1	14.9	25.8	12.2	13	8	9	10	23	14	13	9
September	14.5	18.1	11.2	22.6	4.2	14	7	10	6	15	10	13	26
October	11.6	15.2	7.6	20.3	-1.2	14	9	18	5	10	20	12	13
November	5.7	9.5	1.7	17.3	-7.3	12	4	3	3	8	22	17	31
December	0.9	4.0	-2.3	11.9	-11.7	25	12	5	5	10	8	14	20
Average for 2022	7.4	Max 11.2	Min 3.5	Extreme Max 25.8	Extreme Min -22.5	14	7	9	6	16	14	13	21

*Each compass direction covers ±22.5 degrees.

4.25 Meteorological Data, Continued

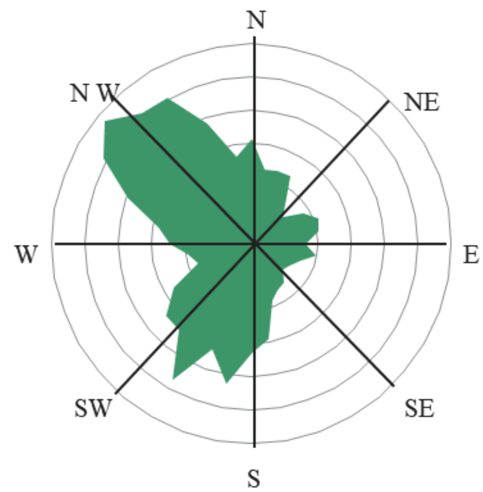


Figure 4.22: Wind Rose for Point Lepreau (2022) (Colour)

5.0 Trends (REMP)

The following trends were observed in the historical data:

- Gaseous tritium releases in 2022 were slightly less than the previous year, and remain below historic levels.
- Tritium continues to be detected 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).
- 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 2022 was slightly less than the previous year, and 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.

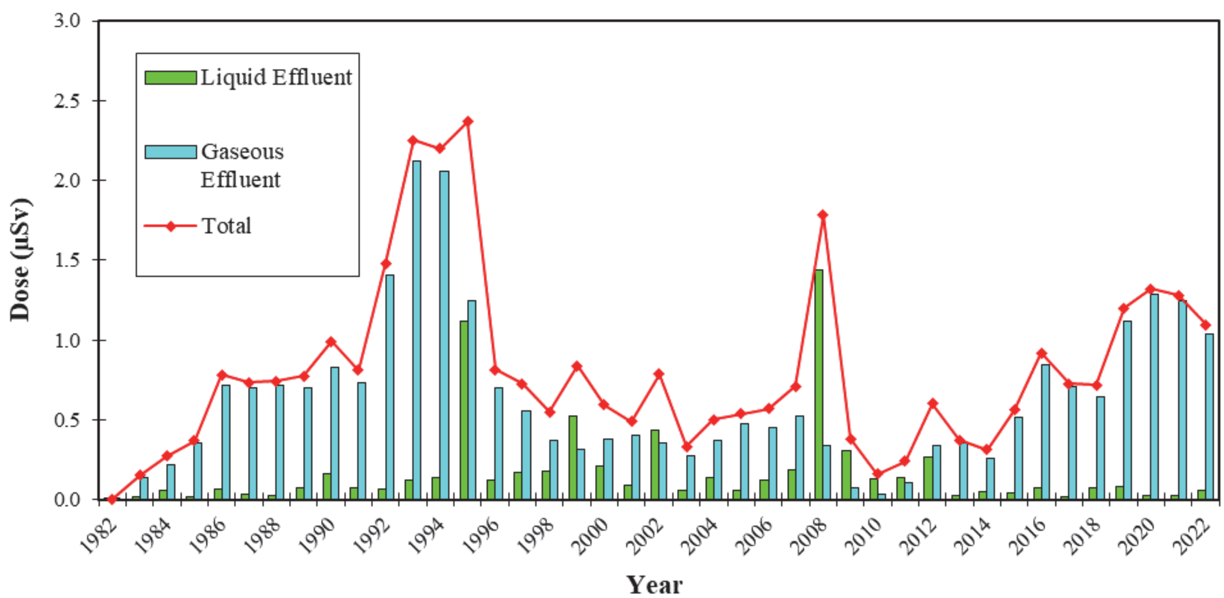


Figure 5.01: Dose from Airborne and Liquid Pathways (Colour)

5.2 Tritium (Water Vapour)

Station 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 increasing dilution with distance from the release stack.

Airborne tritium releases for 2022 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. Also contributing in 2022 were unplanned maintenance outages.

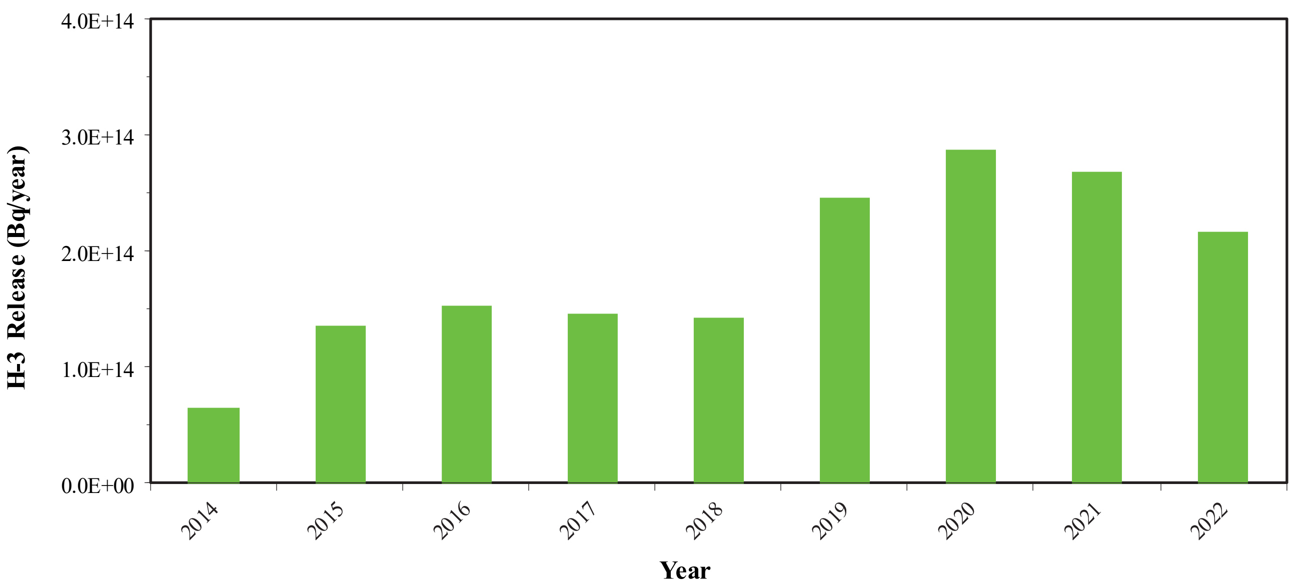


Figure 5.02: Airborne H-3 Releases (Colour)

NOTE

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

5.2 Tritium (Water Vapour), Continued

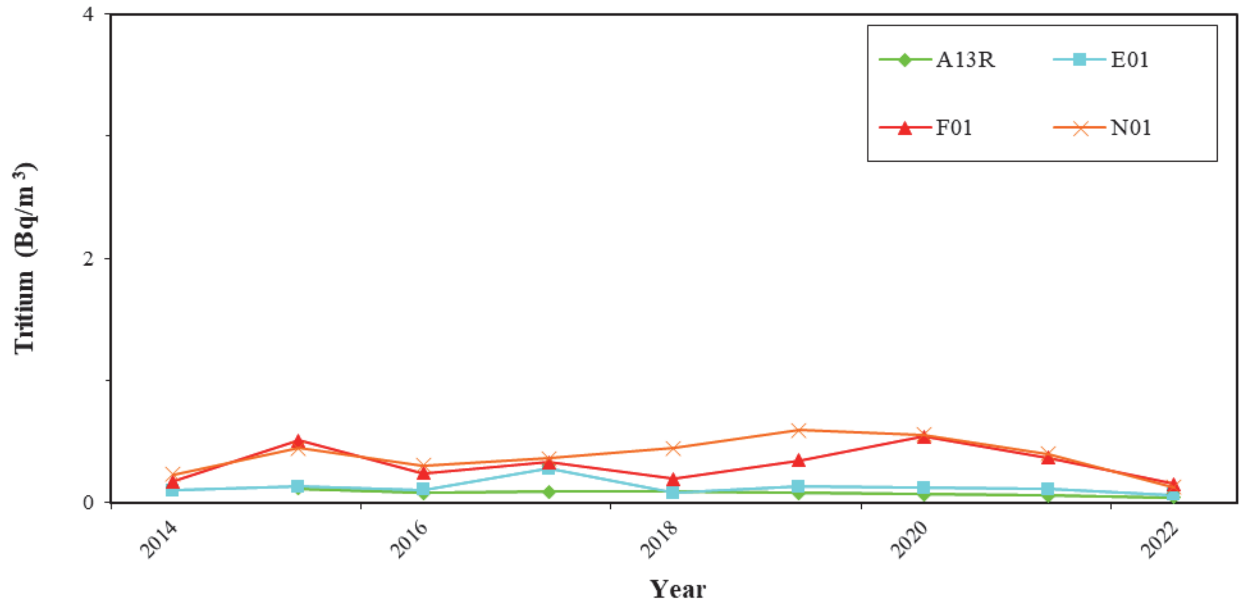


Figure 5.03: Tritium (Water Vapour) at Offsite Air Stations (Colour)

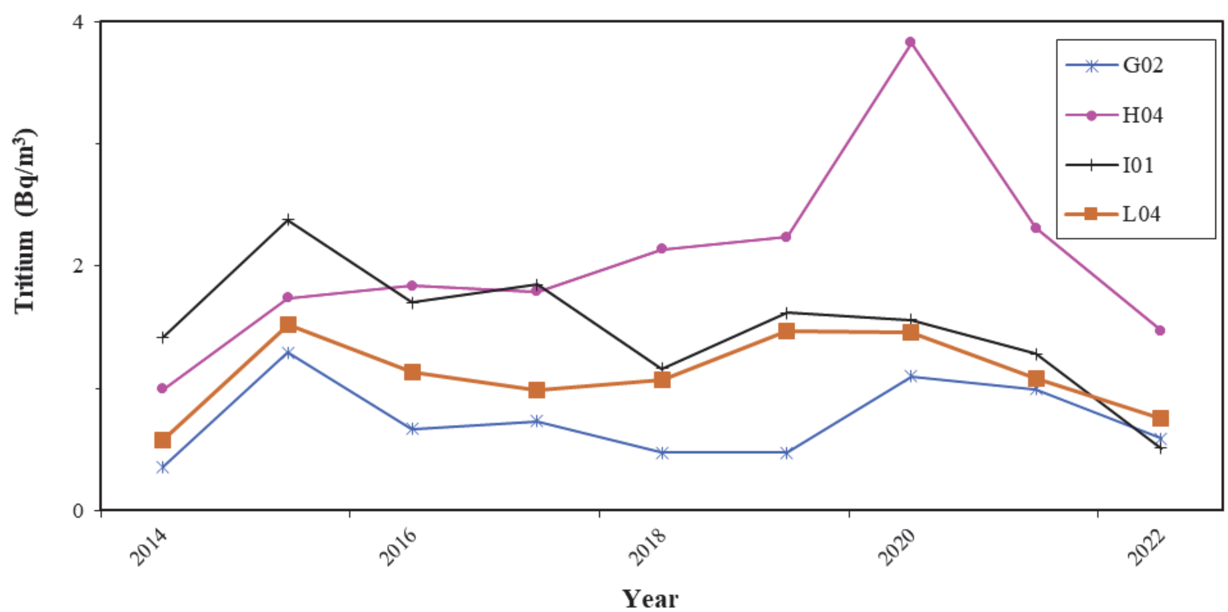


Figure 5.04: Tritium (Water Vapour) at Onsite Air Stations (Colour)

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.

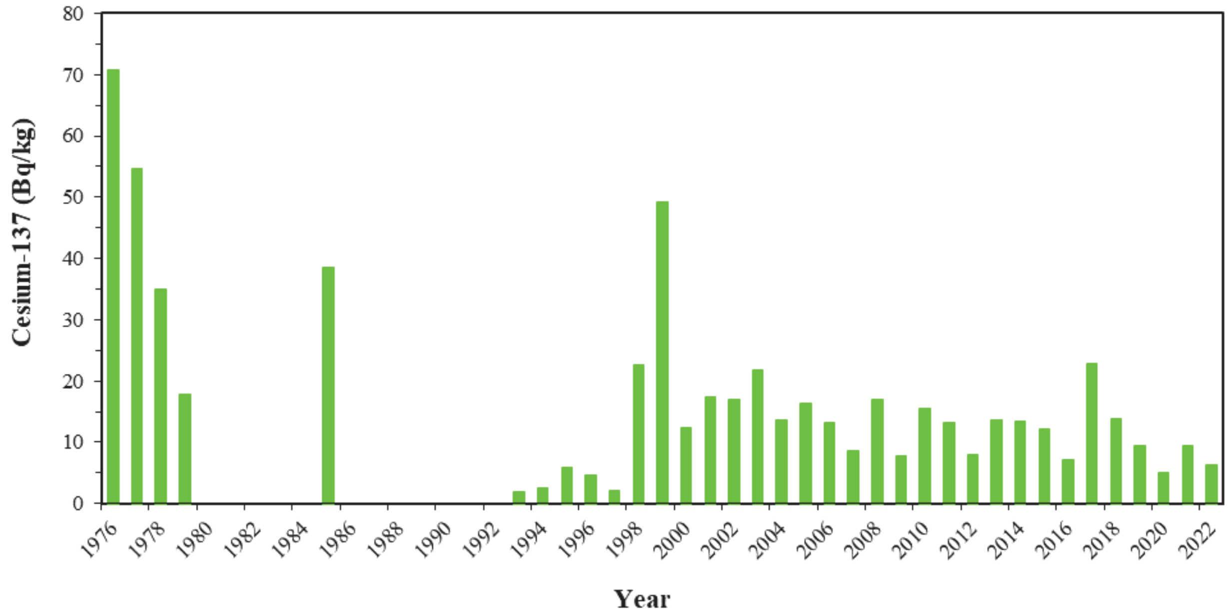


Figure 5.05: Cesium-137 (Soil) (Colour)

5.4 Tritium (Monitoring Well Water, Near Plant)

The concentration of H-3 in the monitoring wells is shown in Figure 5.06.

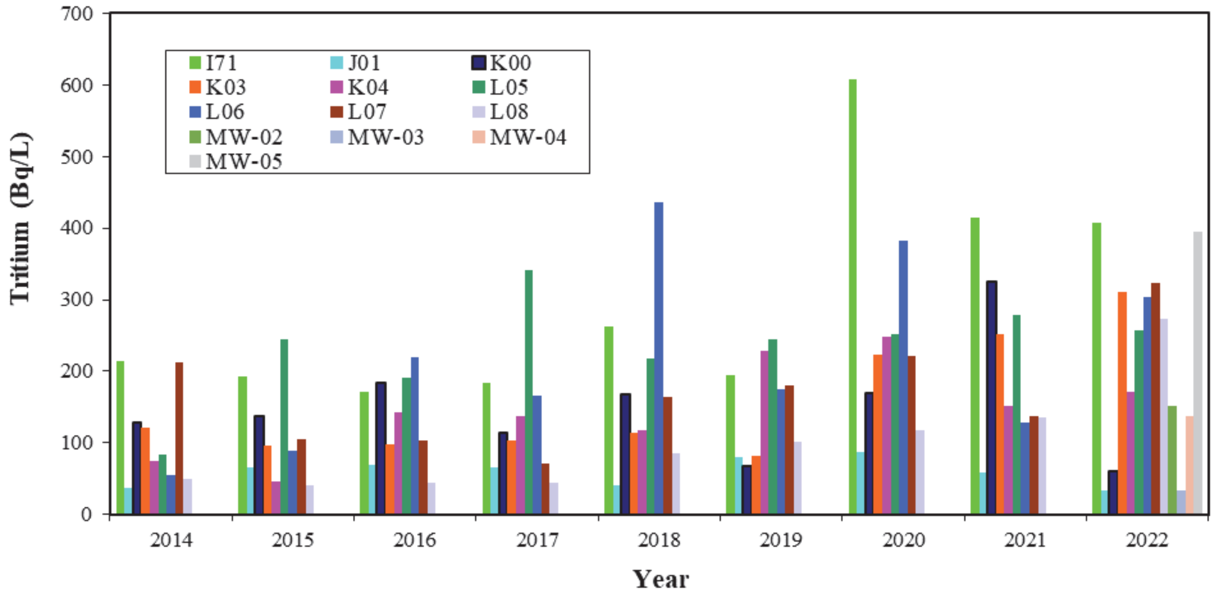


Figure 5.06: Tritium (Monitoring Well Water, Near Plant) (Colour)

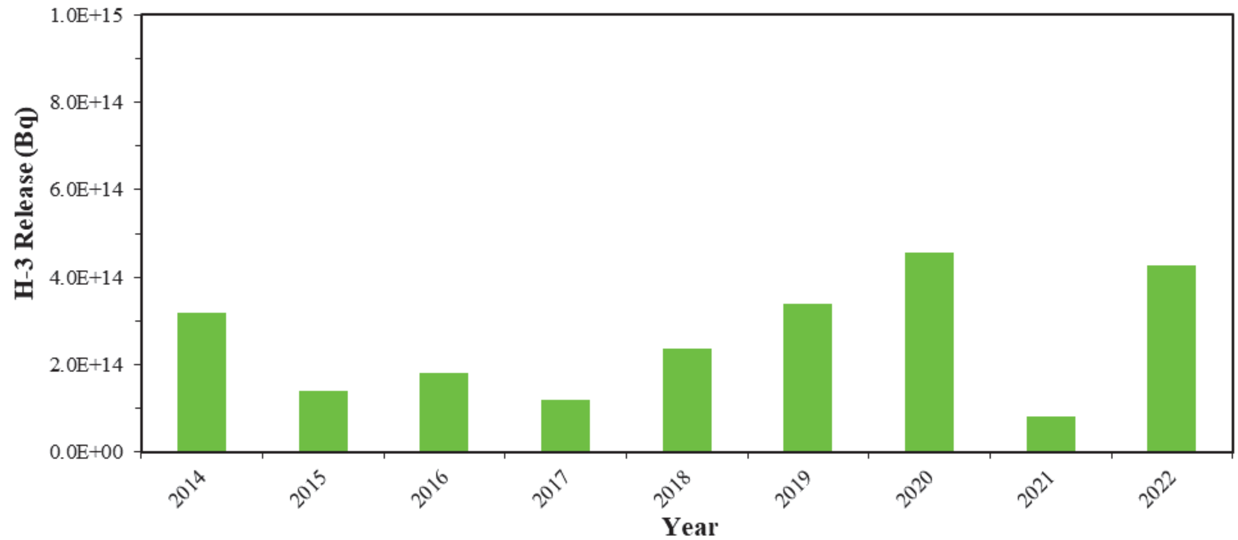
5.5 Tritium and C-14 (Seawater)

Tritium releases to seawater for 2022 were increased in comparison to the previous year. Tritium releases are related to operational activities at the Station, in particular maintenance and outages. An unplanned maintenance outage in December 2022 included a controlled, planned release of tritiated liquid effluent.

The value plotted for each year in Figure 5.07 is the mean of all values for that year. “Less Than” values are plotted for non-detected values.

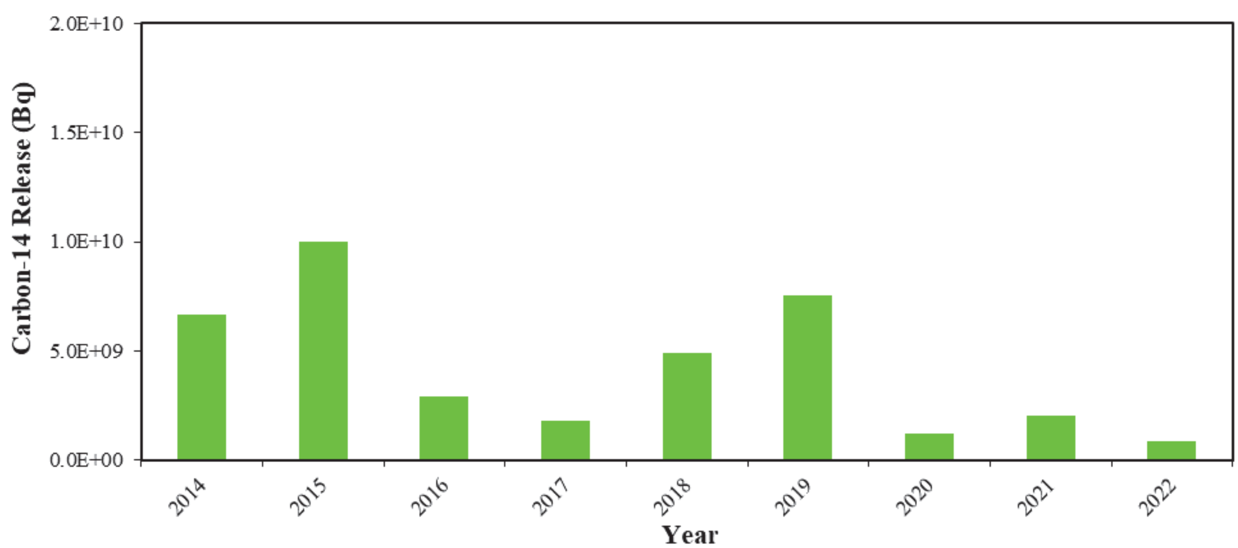
Carbon-14 releases to seawater are also related to Station operational activities. Releases of C-14 in liquid effluents in 2022 were lower than the previous year. The maintenance outages in 2022 did not include significant work related to spent resin transfers or open moderator system work. The expected 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)

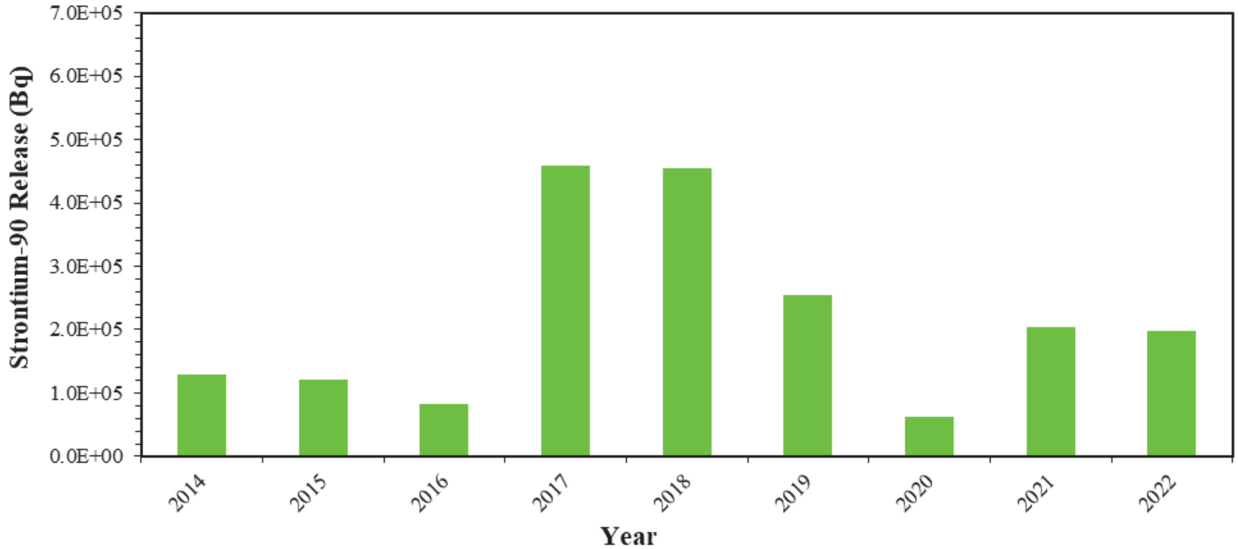


NOTE
The current annual DRL for C-14 is 3.7E+14 Bq/year.

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 H-3 values at Phase 2 and Phase 3 are typically less than those at Phase 1. The Phase 1 results are due to H-3 vapour escaping from the structures and condensing onto surfaces (Figure 5.10).

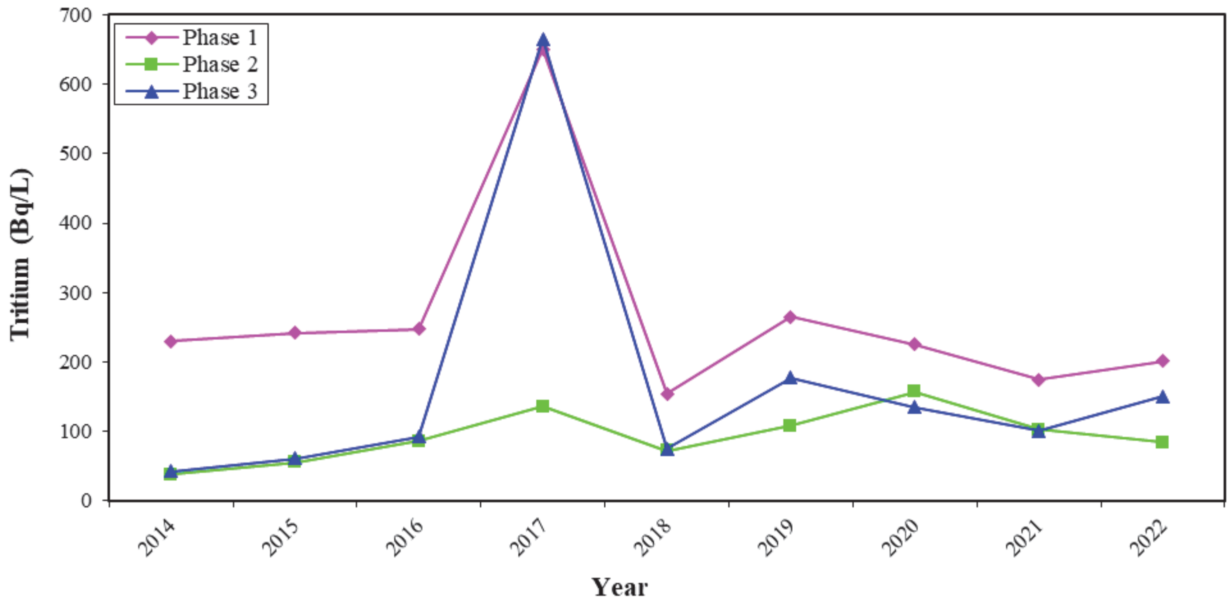


Figure 5.10: Tritium (Parshall Flume Water) (Colour)

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 µSv. In 2022 (Table 6.01), the liquid releases were 5.58E-03% DRL, which corresponds to 0.06 µSv to the Representative Person. Airborne releases for 2022 were 1.04E-01% DRL, which corresponds to a public dose of 1.04 µSv. 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 88.0% of the dose from airborne releases; and 23.7% of the dose from liquid releases in 2022. The other major contributor to dose from airborne releases was Argon-41 (6.4%). The other major contributors to dose from liquid releases were C-14 (11.6%) and Co-60 (33.5%).

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 1.10 µSv. This radiation dose may be compared with the individual natural radiation dose in Canada of approximately 2000 to 3000 µSv per annum. (TLDs show only the external, penetrating component, amounting to about 500 to 1000 µSv.) 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 µSv.

Table 6.01: Annual Dose (2022)

Source of Dose to the Representative Person	*Dose to the Representative Person (µSv.a^{-1})*
PLNGS airborne releases	1.04
PLNGS liquid releases	0.06

6.0 Dose Estimation, Continued

Table 6.02: Contribution of Radionuclides to Dose in Each Pathway (2022)

Radionuclide	*Contribution to Dose (%) (from Airborne Releases)*	*Contribution to Dose (%) (from Liquid Releases)*
H-3	88.0	23.7
C-14	1.3	11.6
Mn-54	----	1.8
Ar-41	6.4	----
Co-60	----	33.5
Fe-59	----	3.2
I-131	2.6	----
Zr-95	----	4.3
Nb-95	----	3.7
Ag-110m	----	5.4
Sb-124	----	7.8
Sn-113	----	1.3
All others	1.7	3.7
TOTAL	***100***	***100***

NOTE

Only radionuclides contributing 1% or more are itemized.

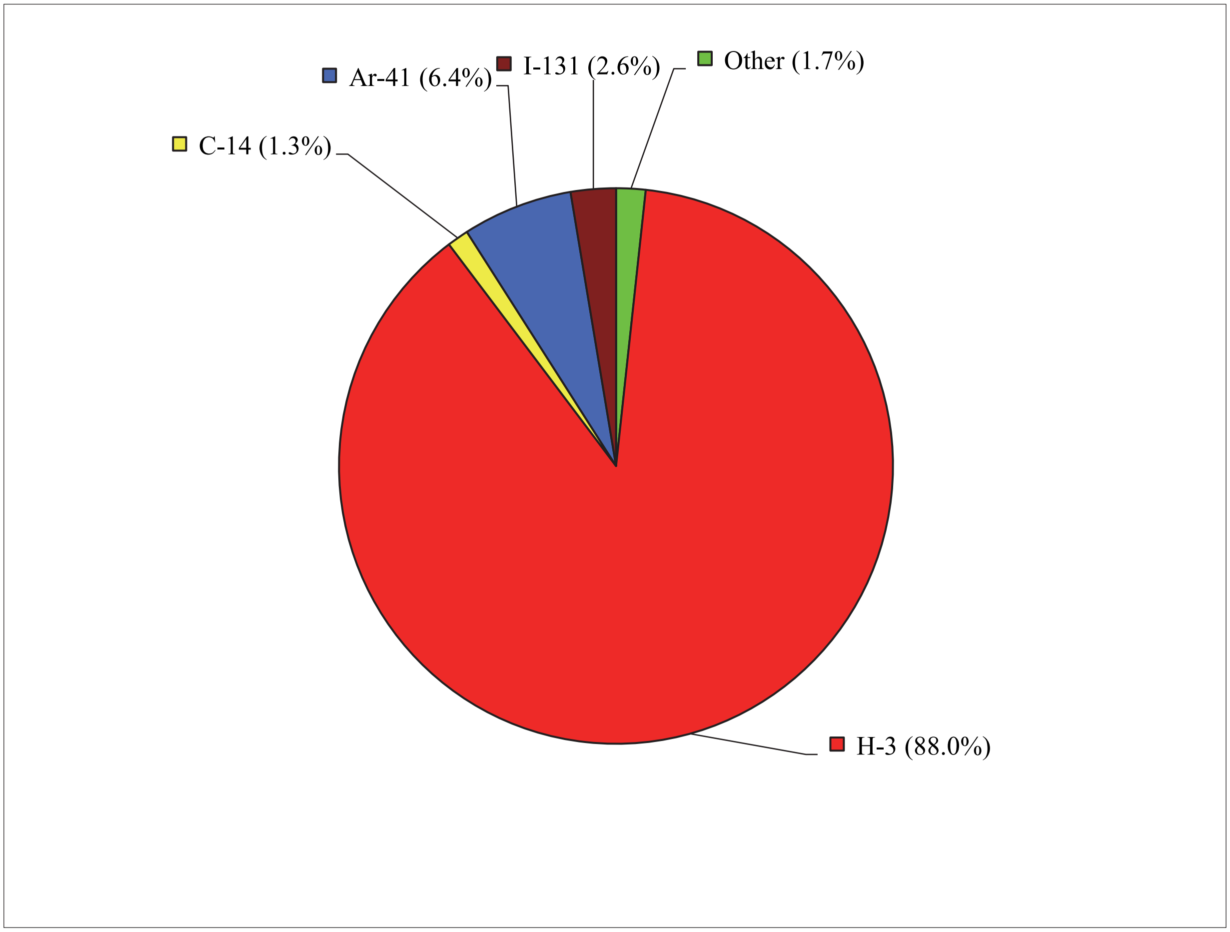


Figure 6.01: Contribution of Radionuclide to Total Dose (Airborne Pathway) - 2022 (Colour)

6.0 Dose Estimation, Continued

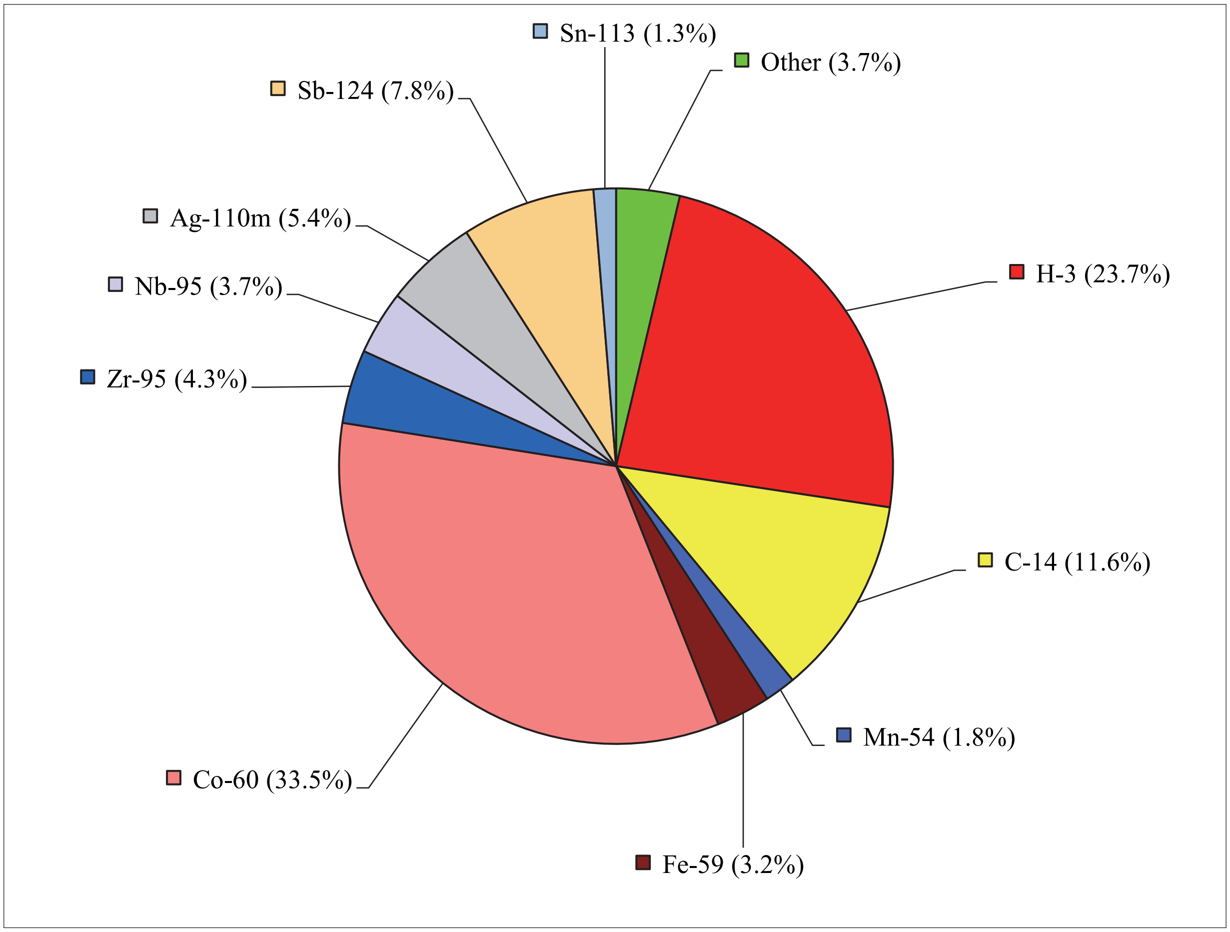


Figure 6.02: Contribution of Radionuclide to Total Dose (Liquid Pathway) – 2022 (Colour)

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 2022. The specific procedures can be found in *EXP-03541-0001, Standards, Expectations and Quality Assurance Requirements for Health Physics*. QA requirements were met in 2022.

7.1 Quality Control Checks

The main pieces of analytical equipment used in the REMP 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. Tennelec LB-5100 Gross Alpha/Beta Counter
5. Protean WPC 9550 Alpha/Beta Counter
6. Panasonic UD-716AGL TLD Reader
7. 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

Instrument	*Number of Parameters Monitored Per Check*	*Number of Checks*	*Number of Individual Parameters Tested*	*Number of Individual Parameters Outside Expected Limits*
Canberra Intrinsic Ge Gamma Spectrometer (DET1)	6	96	546	57
Canberra Intrinsic Ge Gamma Spectrometer (DET2)	6	303	1784	125
PerkinElmer Tri-Carb 2910TR Liquid Scintillation Counter	8	218	1744	27
Tennelec LB-5100 Gross Alpha/Beta Counter	8	123	982	1
Protean WPC 9550 Alpha/Beta Counter	8	185	1467	21
Panasonic UD-716AGL TLD Reader	8	12	96	2
Panasonic UD-7900 TLD Reader	8	84	672	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. The rate of liquid nitrogen consumption is monitored to verify the physical integrity of the cryostat (this parameter is not reflected in the numbers in Table 7.01). 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 is checked annually for each of the counting geometries. 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 Tennelec LB-5100 Gross Alpha/Beta Counter

Planchet standards of Am-241 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 and filter backgrounds are included in the QC checks. These same standards are used to calibrate the instrument for each analysis run.

7.1.3 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. The Tennelec standards are used to calibrate the instrument for each analysis run.

7.1.4 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.*

7.1.5 Other Instruments

Other instruments (balances, pipettors) are checked or calibrated at least annually. As per *HPF-03541-EN05, Calibration, Maintenance and Repair of Equipment Used for the Environmental Program.* 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. There were 30 results that were outside expectations out of 185 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

Medium	Nuclide	Number	Reason
Filter	Sr-90	2	Unknown
	Co-60	2	Just outside ±3s
	Fe-59	2	Just outside ±3s
Vegetation	Co-60	1	Just outside ±3s
Charcoal Cartridge	I-131	1	Sample delivery delayed. Counted over a month from reference date.
Soil	Cr-51	1	Unknown
	Cs-134	1	Unknown
Water	Sr-89	3	Just outside ±3s, Unknown
	Sr-90	3	Unknown
	Y-88	1	Unknown
	C-14	2	Unknown
	Am-241	1	Pass/Fail limits of ±10% compared to all others who use ±3s. At ±3s this would be a pass
	Cd-109	1	Pass/Fail limits of ±10% compared to all others who use ±3s. At ±3s this would be a pass
	Ce-139	1	Unknown
	Co-57	1	Pass/Fail limits of ±10% compared to all others who use ±3s. At ±3s this would be a pass
	Cs-137	1	Pass/Fail limits of ±10% compared to all others who use ±3s. At ±3s this would be a pass
	Hg-203	1	Unknown
	Sn-113	1	Unknown
	Sr-85	1	Unknown
	H-3	1	Pass/Fail limits of ±10% compared to all others who use ±3s. At ±3s this would be a pass
	Alpha	2	Just outside ±3s

7.2 External Quality Assurance, Continued

Table 7.03: External Quality Assurance Frequency

Media	*Analyses*	*Number of QA*	*External Agencies*
Filters	Gross Alpha/Beta	2	Eckert & Ziegler Analytics
		4	Kinectrics
	Gamma	2	Eckert & Ziegler Analytics
	Sr-89,90	4	Eckert & Ziegler Analytics
Charcoal Cartridges	Gamma	4	Eckert & Ziegler Analytics
Environmental Gamma	TLD	5	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)

Analysis	*NB Power (pCi·filter^{-1}) or (dpm·filter^{-1})*	*QA Agent (pCi·filter^{-1}) or (dpm·filter^{-1})*	*NB Power/ QA Agent (ratio)*
ALPHA	7.38E+01	6.81E+01	1.08
	9.64E+01	9.11E+01	1.06
	3.89E+02	3.51E+02	1.11
	4.31E+02	3.59E+02	1.20
BETA	2.29E+02	2.22E+02	1.03
	2.65E+02	2.39E+02	1.11
	3.95E+02	4.00E+02	0.99
	3.52E+02	3.66E+02	0.96
Ce-141	1.12E+02	9.77E+01	1.15
	1.62E+02	1.39E+02	1.17
Co-58	9.59E+01	9.03E+01	1.06
	1.66E+02	1.42E+02	1.17
Co-60	2.38E+02	1.70E+02	1.40*
	2.55E+02	1.79E+02	1.42*
Cr-51	2.62E+02	2.42E+02	1.08
	3.35E+02	2.87E+02	1.17
Cs-134	1.51E+02	1.21E+02	1.25
	1.51E+02	1.18E+02	1.28
Cs-137	1.64E+02	1.43E+02	1.15
	1.53E+02	1.35E+02	1.13
Fe-59	1.46E+02	1.10E+02	1.33*
	1.65E+02	1.22E+02	1.35*
Mn-54	1.86E+02	1.61E+02	1.16
	1.98E+02	1.56E+02	1.27
Sr-89	1.04E+02	9.66E+01	1.08
	7.70E+01	9.09E+01	0.85
	8.79E+01	8.58E+01	1.02
	9.54E+01	9.20E+01	1.04
Sr-90	4.97E+00	1.25E+01	0.40*
	8.37E+00	1.51E+01	0.55*
	9.94E+00	1.42E+01	0.70
	1.08E+01	1.52E+01	0.71
Zn-65	2.60E+02	2.08E+02	1.25
	2.36E+02	1.89E+02	1.25

*Outside expected range.

7.2 External Quality Assurance, Continued

Table 7.05: Charcoal Cartridge Performance (External QA)

Analysis	*NB Power ($pCi\cdot cartridge^{-1}$)*	*QA Agent ($pCi\cdot cartridge^{-1}$)*	*NB Power/QA Agent (ratio)*
I-131	4.88E+01	8.55E+01	0.57*
	9.57E+01	9.18E+01	1.04
	8.36E+01	8.53E+01	0.98

*Outside expected range.

7.2 External Quality Assurance, Continued

Table 7.06: Milk Performance (External QA)

Analysis	*NB Power ($pCi \cdot L^{-1}$)*	*QA Agent ($pCi \cdot L^{-1}$)*	*NB Power/ QA Agent (ratio)*
Ce-141	7.54E+01	6.46E+01	1.17
	1.78E+02	1.71E+02	1.04
	2.32E+02	2.25E+02	1.03
	2.24E+02	2.24E+02	1.00
Co-58	1.66E+02	1.64E+02	1.01
	1.67E+02	1.59E+02	1.05
	2.35E+02	2.30E+02	1.02
	2.36E+02	2.29E+02	1.03
Co-60	3.47E+02	3.02E+02	1.15
	3.39E+02	2.99E+02	1.13
	3.08E+02	2.90E+02	1.06
	3.13E+02	2.89E+02	1.08
Cr-51	2.82E+02	3.39E+02	0.83
	4.27E+02	4.25E+02	1.00
	5.09E+02	4.64E+02	1.10
	4.49E+02	4.63E+02	0.97
Cs-134	2.03E+02	1.82E+02	1.12
	2.41E+02	2.12E+02	1.14
	1.90E+02	1.91E+02	0.99
	1.99E+02	1.91E+02	1.04
Cs-137	2.32E+02	2.23E+02	1.04
	2.57E+02	2.52E+02	1.02
	2.21E+02	2.19E+02	1.01
	2.25E+02	2.18E+02	1.03
Fe-59	1.91E+02	1.85E+02	1.03
	2.03e+02	1.97E+02	1.03
	1.99E+02	1.94E+02	1.03
	2.03E+02	1.98E+02	1.03

7.2 External Quality Assurance, Continued

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

Analysis	*NB Power (pCi·L^{-1})*	*QA Agent (pCi·L^{-1})*	*NB Power/ QA Agent (ratio)*
I-131	8.41E+01	9.05E+01	0.93
	9.77E+01	9.51E+01	1.03
	8.85E+01	9.47E+01	0.93
Mn-54	1.76E+02	1.64E+02	1.07
	3.01E+02	2.83E+02	1.06
	2.47E+02	2.52E+02	0.98
	2.59E+02	2.51E+02	1.03
Zn-65	2.62E+02	2.46E+02	1.07
	3.86E+02	3.66E+02	1.05
	3.00E+02	3.05E+02	0.98
	3.10E+02	3.04E+02	1.02

Table 7.07: Water Performance (External QA)

Analysis	*NB Power (pCi·L^{-1}) or (uCi·kg^{-1})*	*QA Agent (pCi·L^{-1}) or (uCi·kg^{-1})*	*NB Power/ QA Agent (ratio)*
ALPHA	1.48E+02	1.09E+02	1.36*
	1.12E+02	8.55E+01	1.31*
BETA	2.90E+02	2.79E+02	1.04
	2.92E+02	2.83E+02	1.03
	2.39E+02	2.18E+02	1.10
	3.08E+02	3.28E+02	0.94
Am-241	1.05E+00	1.18E+00	0.89*
	6.56E-01	7.38E-01	0.89
C-14	5.08E+00	2.10E+01	0.24*
	1.02E+01	1.02E+01	1.00
	1.66E-01	7.70E-01	0.22*
	1.02E-01	1.10E-01	0.93
Cd-109	1.53E+01	1.60E+01	0.96
	8.91E+00	1.00E+01	0.89*
Ce-139	5.43E-01	5.60E-01	0.97
	2.40E-01	3.55E-01	0.68*

*Outside expected range.

7.2 External Quality Assurance, Continued

Table 7.07: Water Performance (External QA), Continued

Analysis	*NB Power (pCi·L⁻¹) or (uCi·kg⁻¹)*	*QA Agent (pCi·L⁻¹) or (uCi·kg⁻¹))*	*NB Power/ QA Agent (ratio)*
Ce-141	1.53E+02		N/A
	2.42E+02	2.24E+02	1.08
	2.28E+02	2.21E+02	1.03
Co-57	3.56E-01	3.70E-01	0.96
	1.96E-01	2.39E-01	0.82*
Co-58	2.10E+02	1.93E+02	1.09
	1.38E+02		N/A
	2.31E+02	2.29E+02	1.01
	2.16E+02	2.27E+02	0.95
Co-60	4.08E+02	3.55E+02	1.15
	2.92E+02		N/A
	3.27E+02	2.89E+02	1.13
	3.42E+02	2.86E+02	1.20
	8.13E-01	7.60E-01	1.07
	5.16E-01	4.75E-01	1.09
Cr-51	3.66E+02		N/A
	5.26E+02	4.62E+02	1.14
Cs-134	2.42E+02	2.14E+02	1.13
	1.97E+02		N/A
	2.05E+02	1.91E+02	1.07
	2.08E+02	1.89E+02	1.10
Cs-137	2.70E+02	2.63E+02	1.03
	2.11E+02		N/A
	2.08E+02	2.16E+02	0.96
	4.59E-01	5.50E-01	0.83*
	3.00E-01	2.98E-01	1.01
Fe-59	2.41E+02	2.18E+02	1.11
	1.78E+02		N/A
	2.34E+02	1.97E+02	1.19
	2.04E+02	1.95E+02	1.05

*Outside expected range.

7.2 External Quality Assurance, Continued

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

Analysis	NB Power ($pCi \cdot L^{-1}$) or ($uCi \cdot kg^{-1}$)	QA Agent ($pCi \cdot L^{-1}$) or ($uCi \cdot kg^{-1}$)	NB Power/ QA Agent (ratio)
H-3	2.81E+02	2.50E+02	1.12*
	2.35E+02	2.40E+02	0.98
	1.45E+01	1.40E+01	1.04
	4.97E+00	5.10E+00	0.97
Hg-203	1.26E+00	1.20E+00	1.05
	2.39E-01	7.49E-01	0.32*
I-131	8.54E+01		N/A
	1.15E+02	9.63E+01	1.19
	1.14E+02	9.54E+01	1.19
Mn-54	2.12E+02	1.93E+02	1.10
	2.42E+02		N/A
	2.68E+02	2.51E+02	1.07
	2.77E+02	2.49E+02	1.11
Sn-113	9.23E-01	9.40E-01	0.98
	3.70E-01	5.96E-01	0.62*
Sr-85	1.15E+00	1.18E+00	0.97
	3.11E-01	7.39E-01	0.42*
Sr-89	1.35E+02	9.13E+02	0.15*
	6.68E+01	9.58E+01	0.70
	1.25E+02	9.52E+01	1.31*
	2.49E+01	9.43E+01	0.26*
Sr-90	7.35E+00	1.19E+01	0.62*
	1.04E+01	1.59E+01	0.65*
	1.51E+01	1.58E+01	0.96
	5.14E+00	1.56E+01	0.33*
Y-88	1.66E+00	1.63E+00	1.02
	6.37E-01	9.85E-01	0.65*
Zn-65	2.93E+02	2.90E+02	1.01
	3.19E+02		N/A
	3.03E+02	3.04E+02	1.00
	3.21E+02	3.01E+02	1.07

*Outside expected range.

7.2 External Quality Assurance, Continued

Table 7.08: Food/Vegetation Performance (External QA)

Analysis	*NB Power ($pCi \cdot g^{-1}$)*	*QA Agent ($pCi \cdot g^{-1}$)*	*NB Power/ QA Agent (ratio)*
Ce-141	2.29E-01	2.13E-01	1.08
	3.34E-01	2.80E-01	1.19
Co-58	2.23E-01	1.96E-01	1.14
	3.26E-01	2.87E-01	1.14
Co-60	4.99E-01	3.71E-01	1.35
	4.35E-01	3.62E-01	1.20
Cs-134	3.40E-01	2.63E-01	1.29
	2.68E-01	2.39E-01	1.12
Cs-137	3.47E-01	3.12E-01	1.11
	2.89E-01	2.73E-01	1.06
Fe-59	2.59E-01	2.40E-01	1.08
	3.09E-01	2.47E-01	1.25
Mn-54	3.88E-01	3.51E-01	1.11
	3.25E-01	3.15E-01	1.03
Zn-65	3.96E-01	4.54E-01	0.87
	3.95E-01	3.81E-01	1.04

*Outside expected range.

7.2 External Quality Assurance, Continued

Table 7.09: Soil Performance (External QA)

Analysis	*NB Power ($pCi \cdot g^{-1}$)*	*QA Agent ($pCi \cdot g^{-1}$)*	*NB Power/ QA Agent (ratio)*
Ce-141	1.53E-01	1.95E-01	0.78
	4.52E-01	4.45E-01	1.02
Co-58	1.65E-01	1.81E-01	0.91
	4.29E-01	3.54E-01	1.21
Co-60	3.65E-01	3.40E-01	1.07
	5.71E-01	4.45E-01	1.28
Cr-51	1.08E+00	7.14E-01	1.51
Cs-134	2.47E-01	2.41E-01	1.02
	4.14E-01	2.94E-01	1.41*
Cs-137	2.75E-01	3.60E-01	0.76
	5.00E-01	4.09E-01	1.22
Fe-59	4.44E-01	4.04E-01	1.10
Mn-54	3.19E-01	3.22E-01	0.99
	5.07E-01	3.98E-01	1.27
Zn-65	3.90E-01	4.17E-01	0.94
	6.41E-01	5.69E-01	1.13

*Outside expected range.

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

Analysis	*NB Power (mR ± 2 sigma)*	*QA Agent (mR ± 2 sigma)*	*NB Power/QA Agent (ratio)*
Gamma	N/A*	N/A*	N/A*

*Test TLD data not available for 2022.

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 173 radionuclide comparisons performed. Six 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

Medium	***Duplicate/Replicate***	***Number of Radionuclide Comparisons***	***Analyses***
Airborne Carbon Dioxide	Replicate analysis (single location)	12	LSC C-14
Airborne Iodine	Replicate count (1 composite set)	24	Gamma
Airborne Particulates	Replicate analysis	6	Gamma
		22	Alpha/Beta
Parshall Flume	Replicate analysis	12	LSC H-3
LEM Composite	Replicate analysis	35	Gamma
		28	Alpha/Beta
		15	Sr-89,90
Sediment / Soil	Duplicate sample	13	Gamma
Environmental Gamma	Duplicate sample	4	TLD

7.3 Internal Quality Assurance, Continued

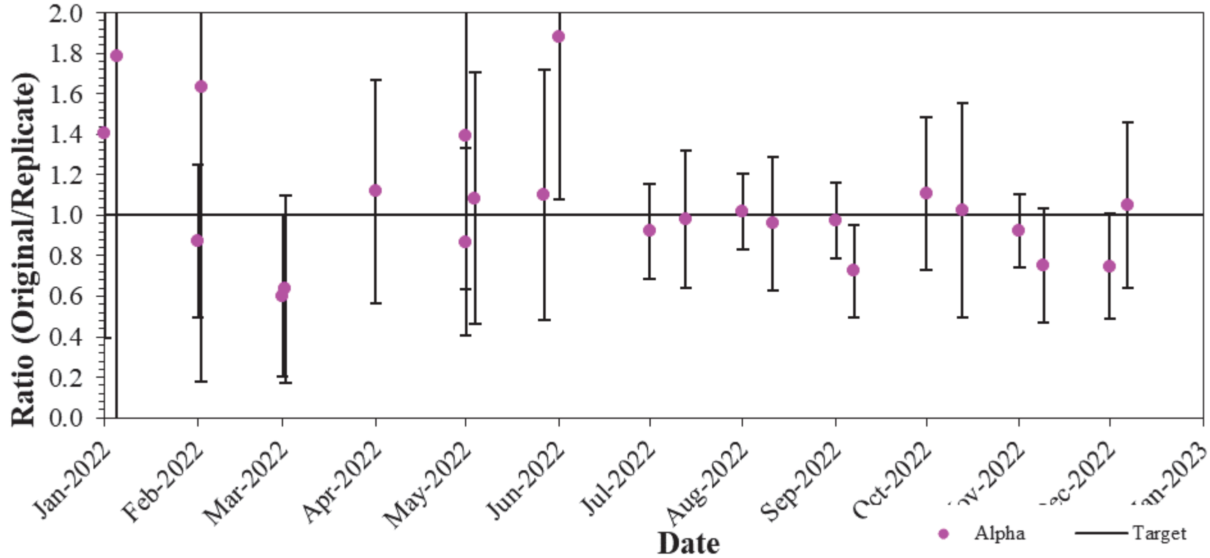


Figure 7.01: Alpha Performance (Internal QA – duplicate/replicate) (Colour)

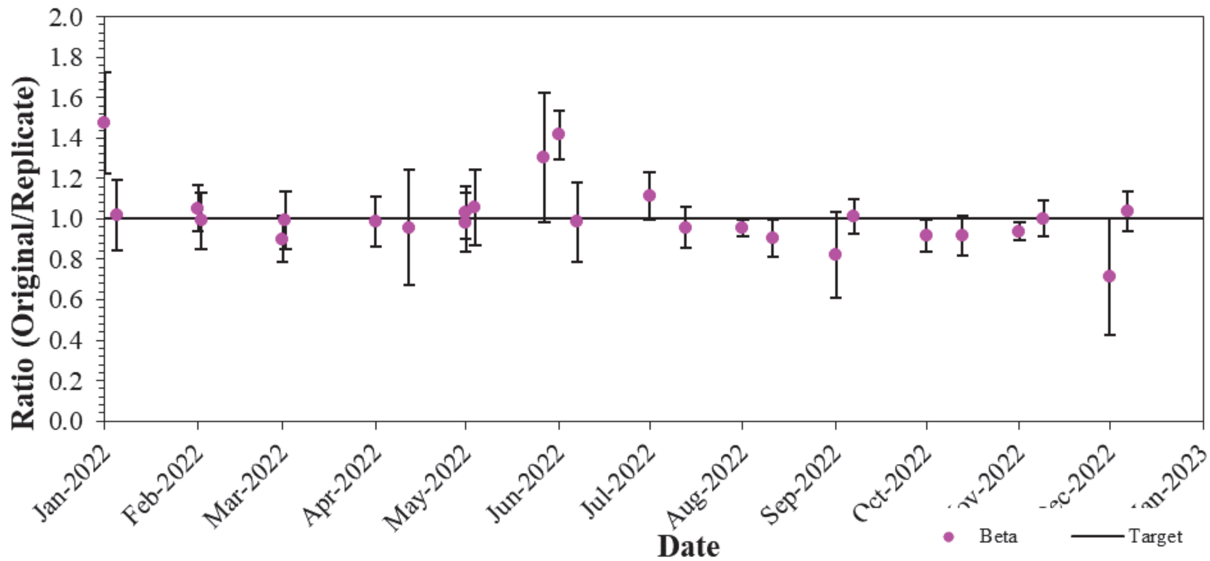


Figure 7.02: Beta Performance (Internal QA – duplicate/replicate) (Colour)

7.3 Internal Quality Assurance, Continued

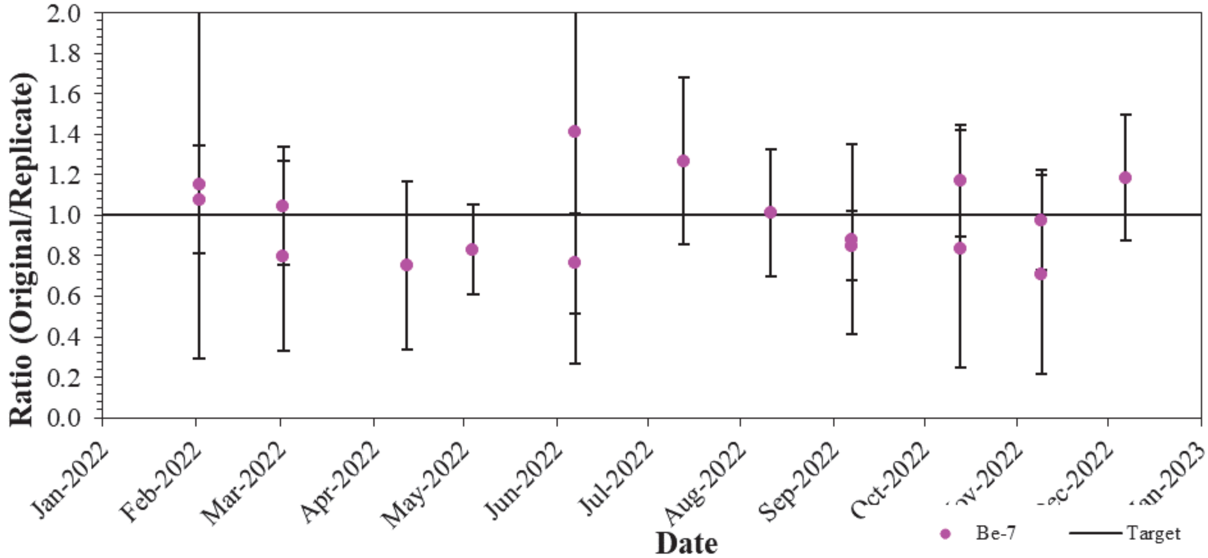


Figure 7.03: Beryllium-7 Performance (Internal QA – duplicate/replicate) (Colour)

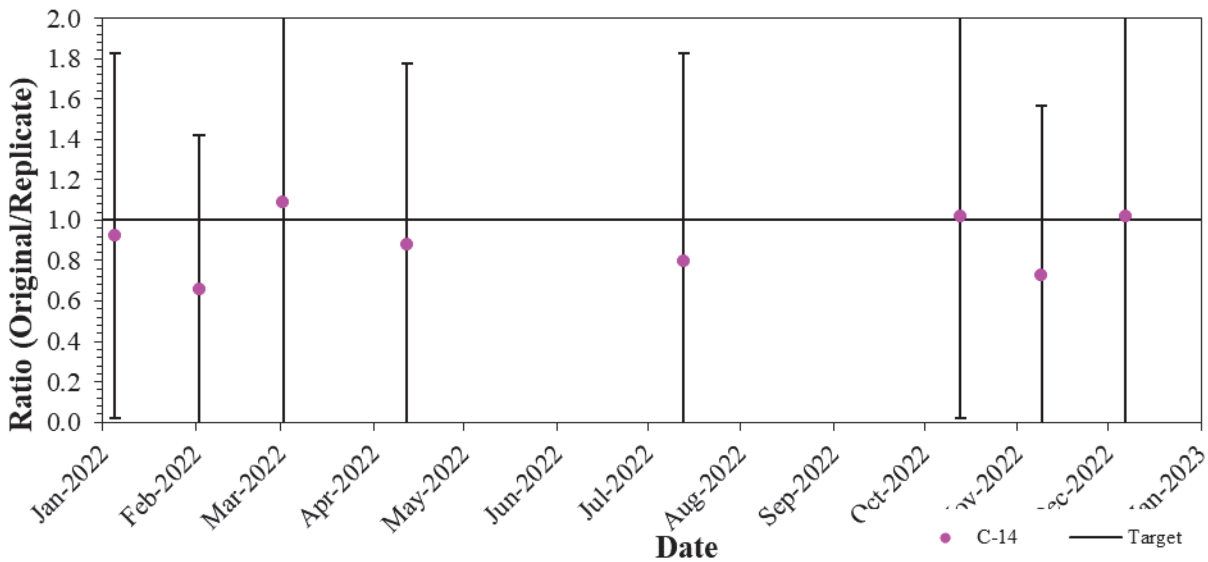


Figure 7.04: Carbon-14 Performance (Internal QA – duplicate/replicate) (Colour)

7.3 Internal Quality Assurance, Continued

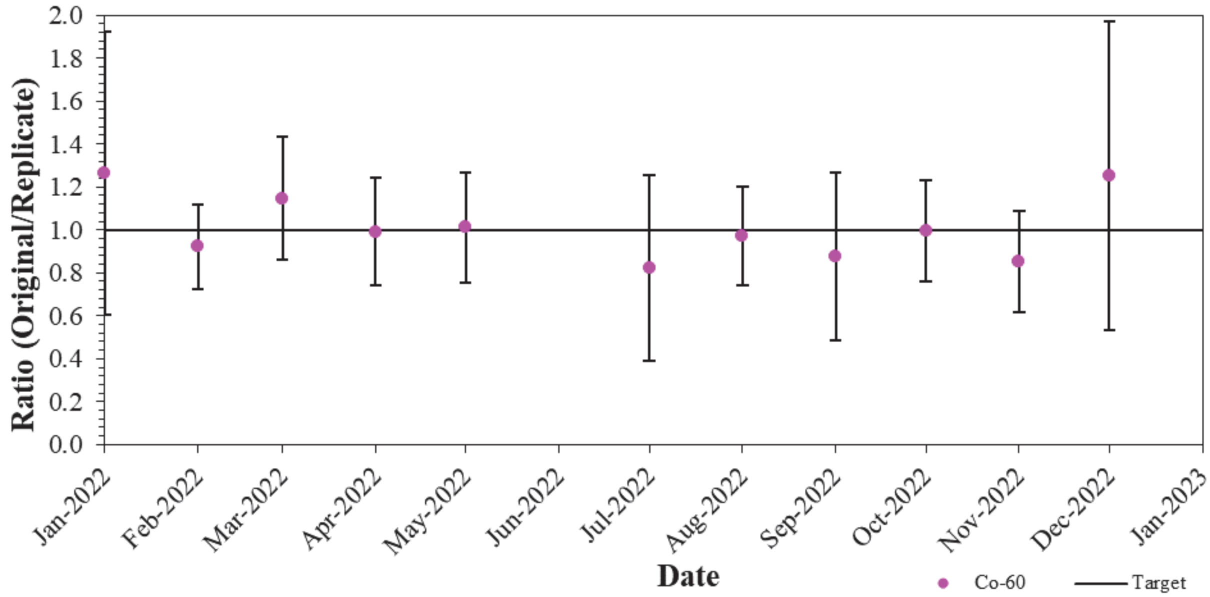


Figure 7.05: Cobalt-60 Performance (Internal QA – duplicate/replicate) (Colour)

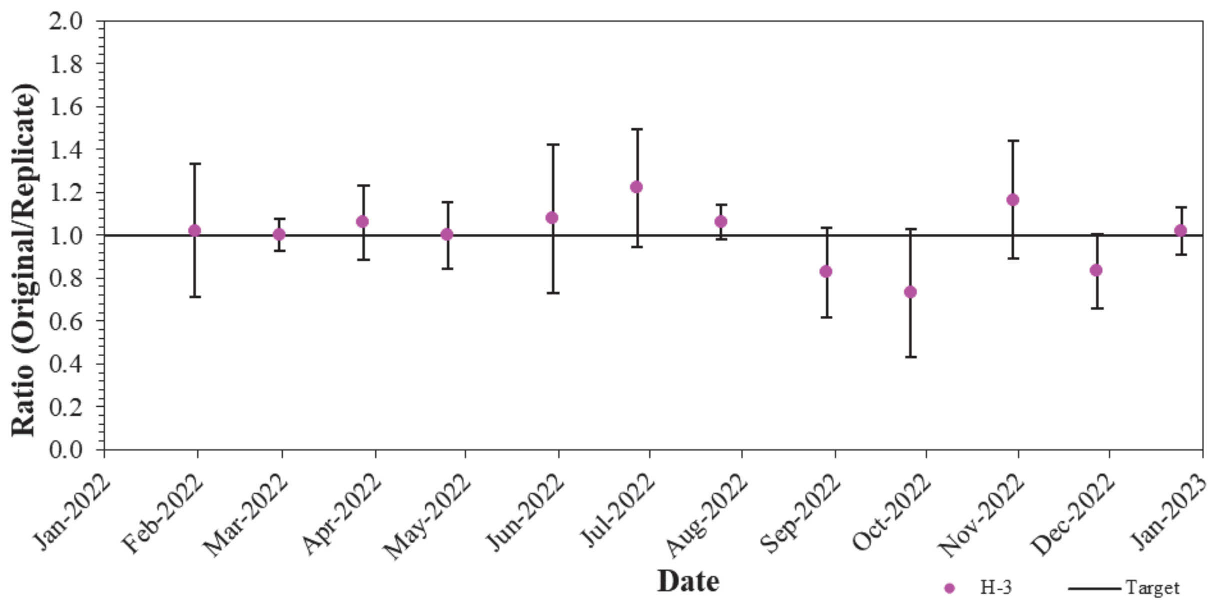


Figure 7.06: Tritium Performance (Internal QA – duplicate/replicate) (Colour)

7.3 Internal Quality Assurance, Continued

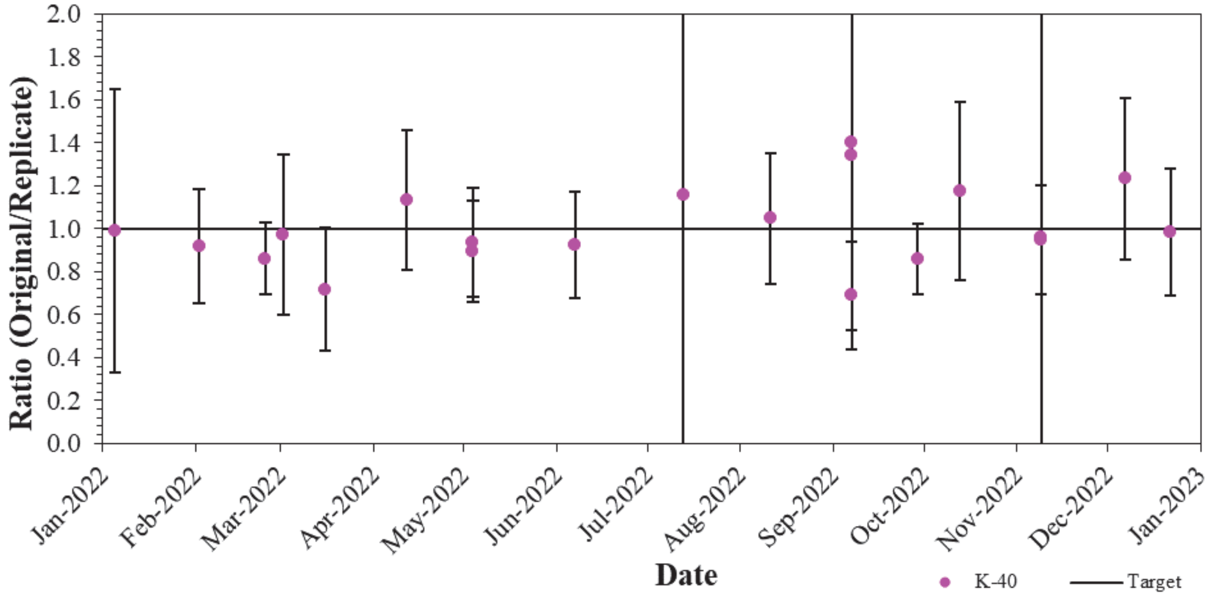


Figure 7.07: Potassium-40 Performance (Internal QA – duplicate/replicate) (Colour)

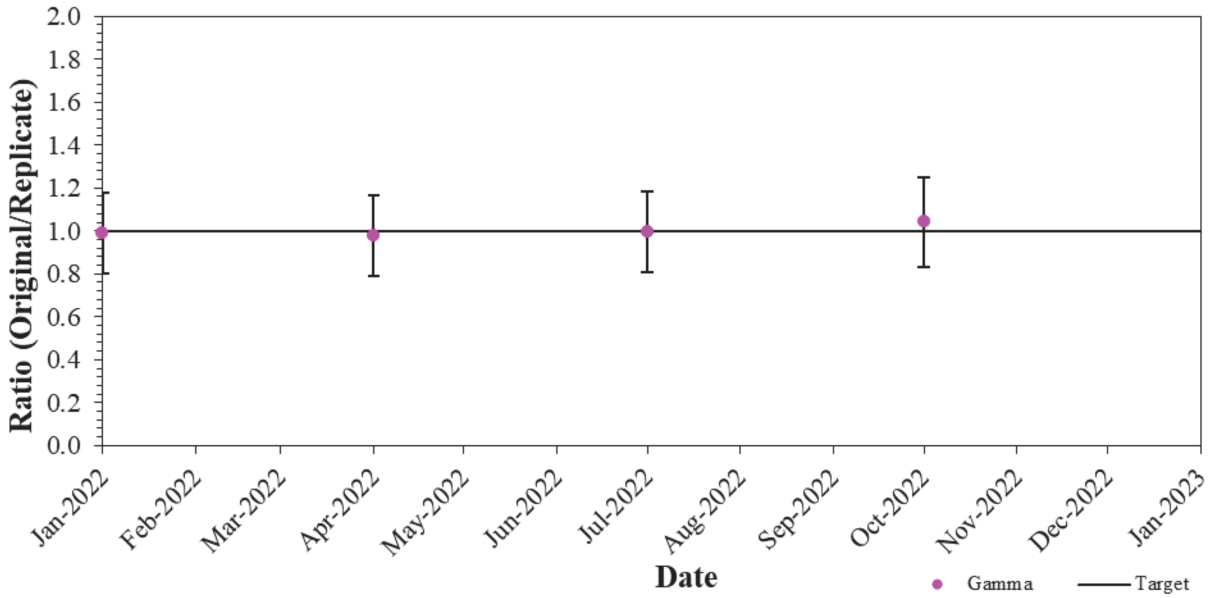


Figure 7.08: Gamma Performance (Internal QA – duplicate/replicate) (Colour)

7.3 Internal Quality Assurance, Continued

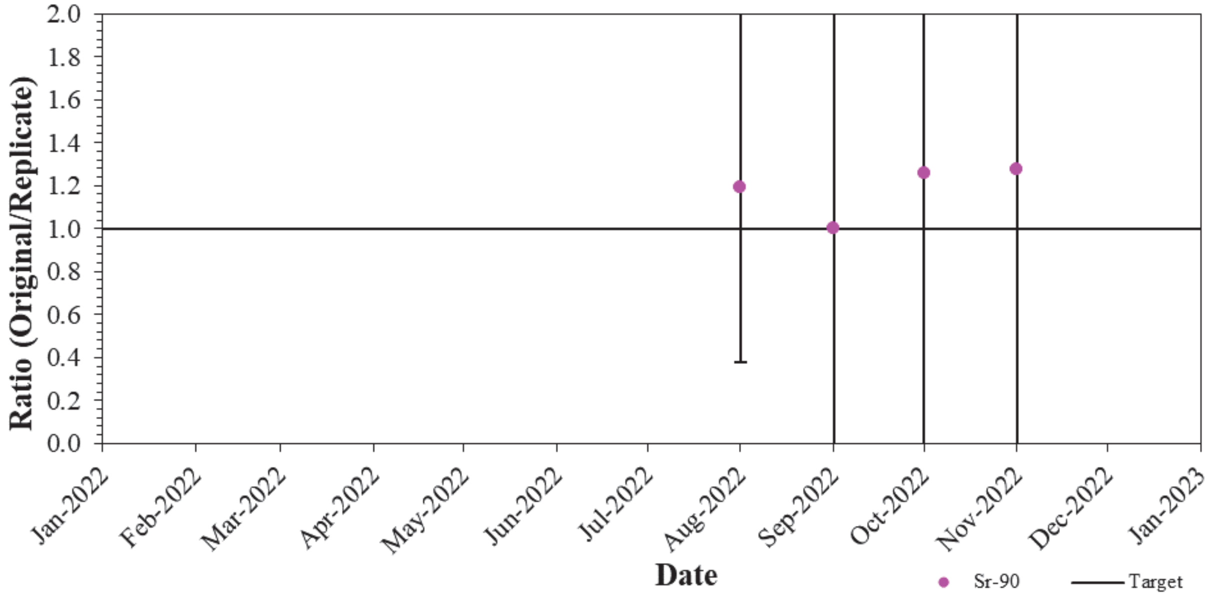


Figure 7.09: Strontium-90 Performance (Internal QA – duplicate/replicate) (Colour)

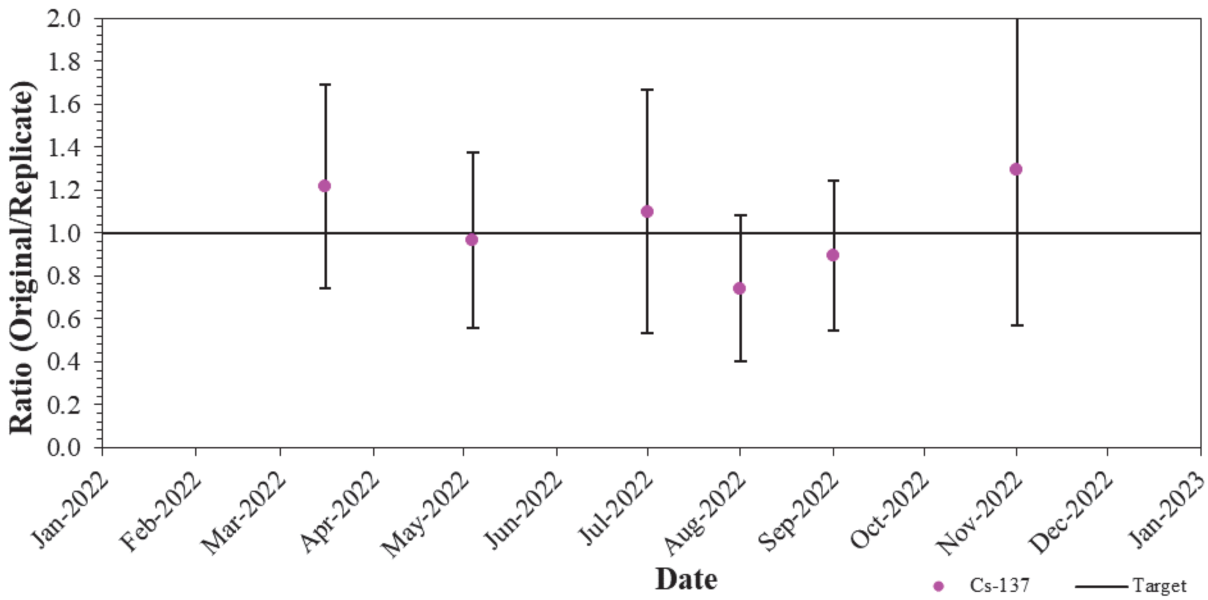


Figure 7.10: Cs-137 Performance (Internal QA – duplicate/replicate) (Colour)

7.3 Internal Quality Assurance, Continued

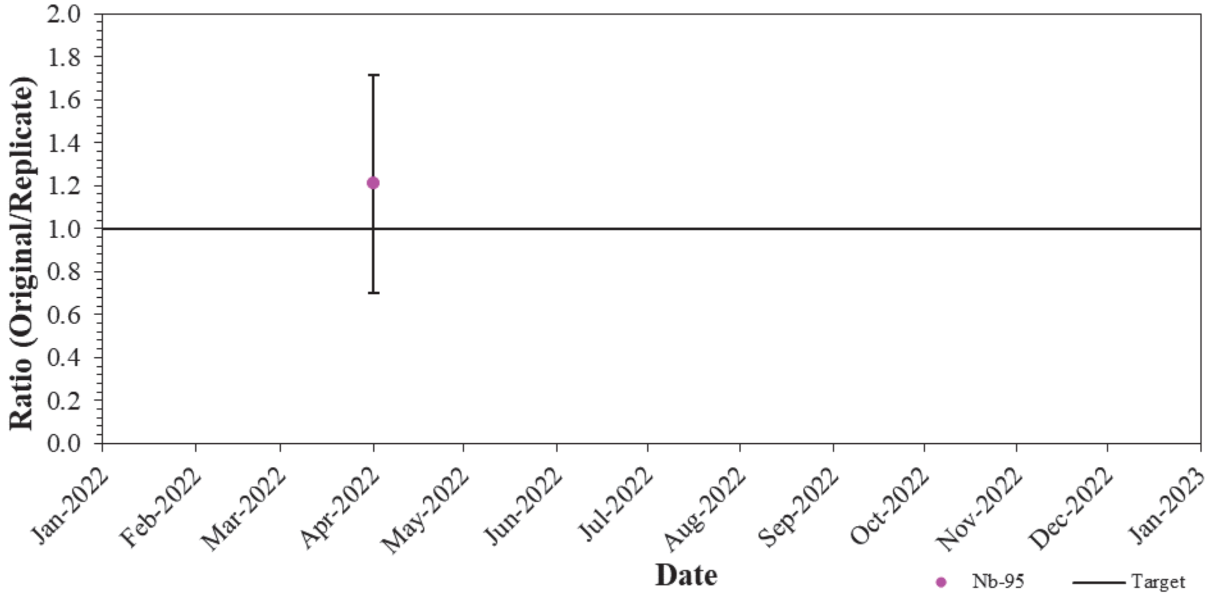


Figure 7.11: Niobium-95 Performance (Internal QA – duplicate/replicate) (Colour)

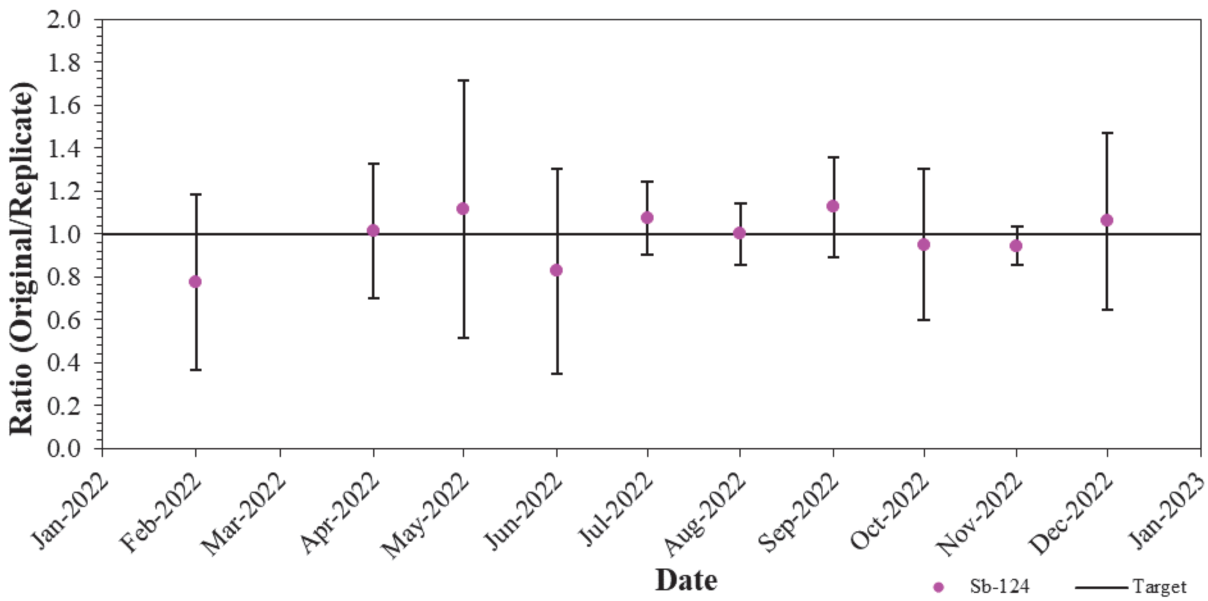


Figure 7.12: Sb-124 Performance (Internal QA – duplicate/replicate) (Colour)

7.3 Internal Quality Assurance, Continued

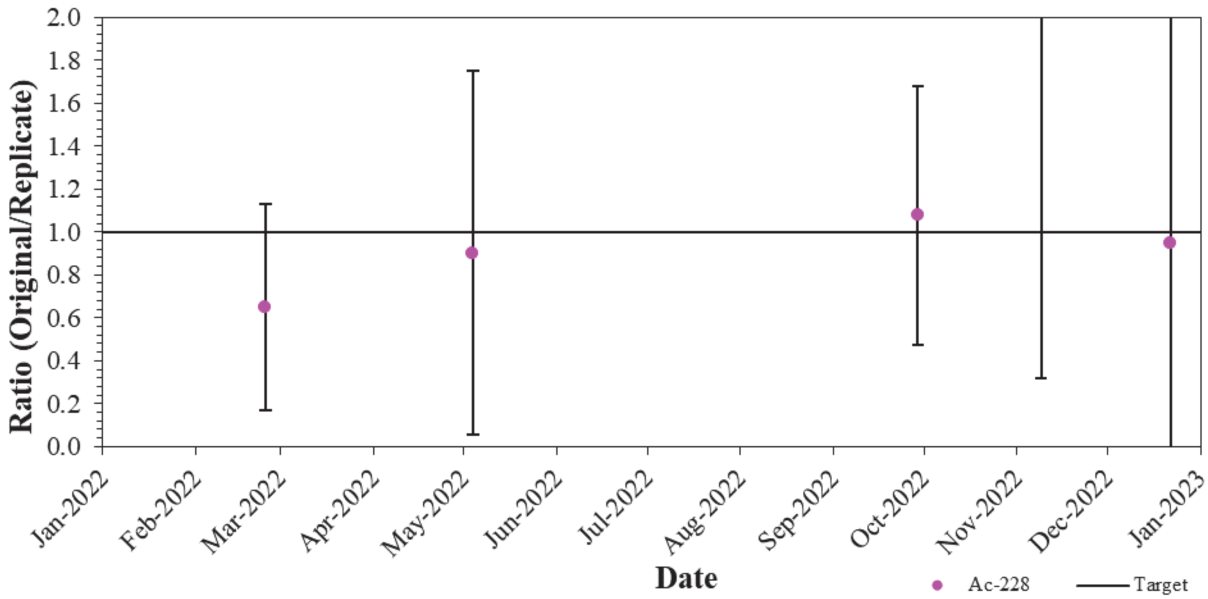


Figure 7.13: Actinium-228 Performance (Internal QA – duplicate/replicate) (Colour)

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 subsequentially analyzed. Results of performance with these samples give an indication of the quality of measurements. Acceptable performance is defined as results within ± 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 ± 20% of the expected value.

7.3 Internal Quality Assurance, Continued

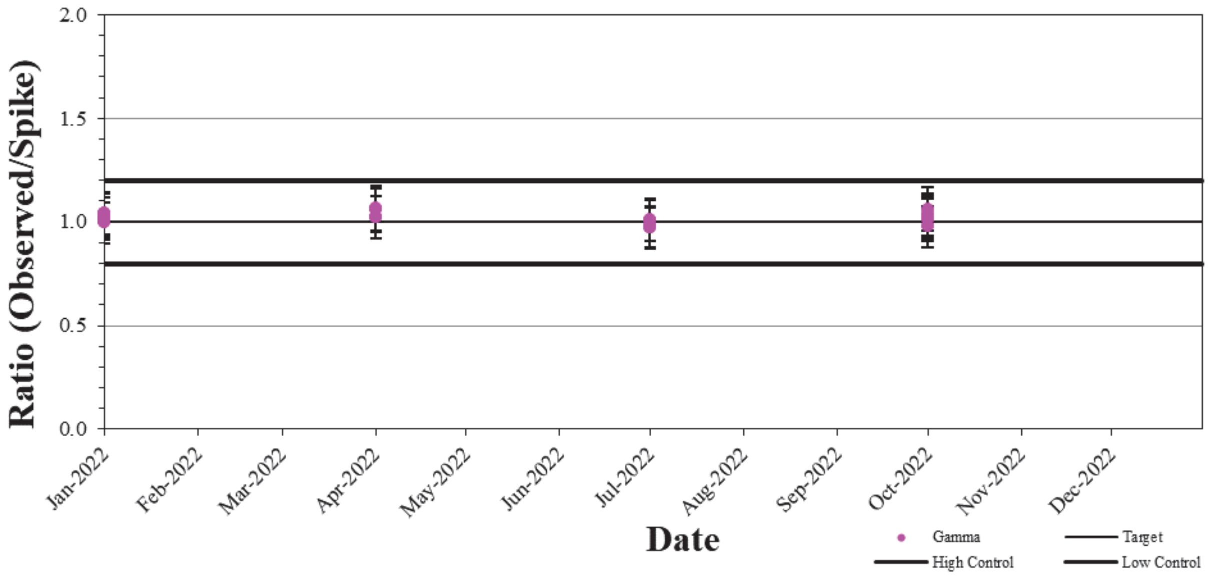


Figure 7.14: Gamma Performance (Internal QA - spikes) (Colour)

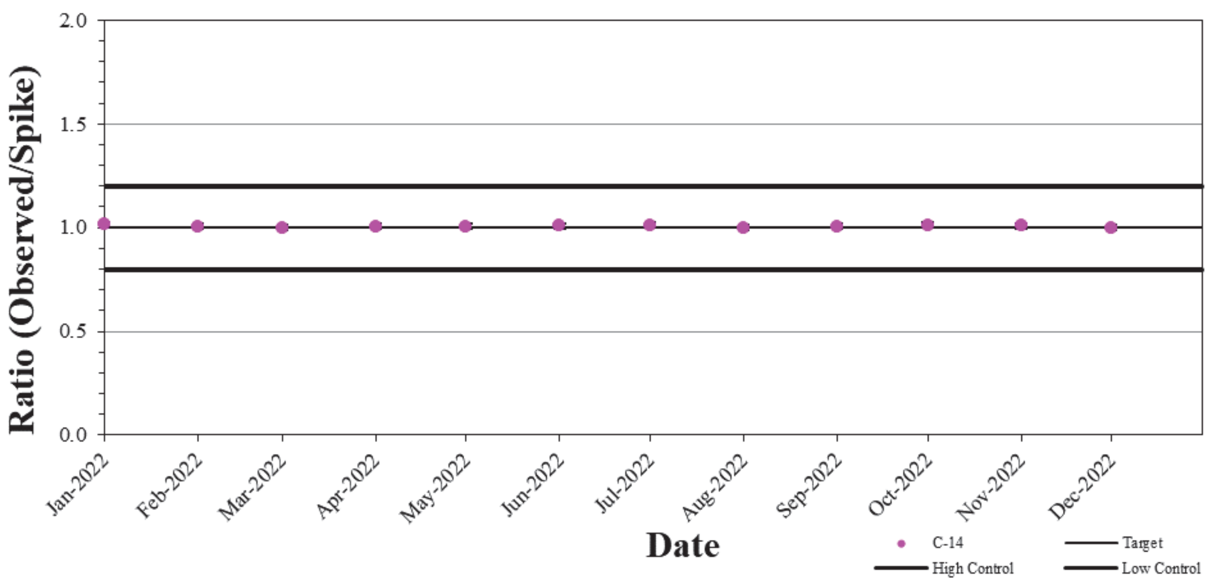


Figure 7.15: C-14 Performance (Internal QA - spikes) (Colour)

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 Nuclear Oversight (NOS) Group completed an audit on the Station's *SU-2, Provide Environmental Services* and Environmental Management System (EMS) registered to ISO 14001 in June 2022. Opportunities for improvement and any identified gaps were added to the Station's corrective action program and are being addressed; there were no major gaps that indicate non-conformance to ISO 14001 or the N288 series standards.

Similar audits are included in NOS's 5-quarter audit schedule, with the next planned audit in June 2023. Radiological releases to water and air are part of this system.

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, 2022. Corrective actions resulting from the annual review were added to the corrective action program where they will be addressed as per the Station's process.

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 Regulation, 2003* and New Brunswick Regulation *97-132, Ozone Depleting Substances and Other Halocarbon Regulation Clean Air Act*. Halocarbon releases are being reported, not just Ozone Depleting Substances.

In 2022, there was a requirement to contact Environment and Climate Change Canada on one occasion:

- On 2023/01/12 semi-annual reporting was performed via the emailed form *Template for Release Reports Relating to the Federal Halocarbon Regulations 2003 (FHR 2003) for Systems and Containers* which was submitted due to a release of 11.2 kilograms in the July to December 2022 period.

Letters submitted to either agency are sent to the CNSC staff as per *Guidance* in *REGDOC-3.1.1, Reporting Requirements for Nuclear Power Plants*, *Section 3.5*.

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 emergences that occurred during the year. This was submitted on February 13th, 2023. This letter was also submitted to the CNSC staff as per Guidance in *REGDOC-3.1.1, Section 3.5*.

The approval required to sample (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 2022.

Table 8.01: Electronic Data Submission to ERRIS (2022)

2022	Days deposited	Volume (m3)	Average CBOD (mg/L)	Average SS (mg/L)	unionized ammonia (mg/L)
Jan-Mar	90	11480	1.1	1.0	NA
Apr-Jun	91	12578	1.1	1.3	NA
Jul-Sept	92	10547	1.1	1.7	NA
Oct-Dec	92	13024	1.0	1.0	NA

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 Water Quality Regulation – Clean Environment Act. It is valid from May 1st, 2021 to April 30th, 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 0.075mg/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-PH1; pH Measurement by Glass Combination Electrode*
- *CLIP-78200-74; Accumet Excel Model 25 pH/Millivolt Meter*
- *CAP-78200-SU2; Suspended Solid*
- *CAP-78200-HY1; Hydrazine by P-Dimethylaminobenzaldehyde*
- *CLIP-78200-22; Varian Cary 50 UV/VIS Spectrometer*
- *CMP-78200-03; 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 2022 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 2022, 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. NOx is being expressed at NO_2.

During the year no barrels (0 liters) of Type 2 Light Oil and 4,091 barrels (650,469 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 0.0005 percent, and an average sulphur content of 0.0009 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.

8.4 Non-Radiological Air Emission, Continued

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)

Parameter	Tonnes	Reporting Threshold
Carbon Dioxide (CO_2)	1,917	10 000
Sulphur Dioxide (SOx)	0.009	20
Nitrogen Dioxide (NOx)	5.18	20
Volatile Organic Compounds (VOC)	0.016	10
Carbon Monoxide (CO)	0.39	20
Particulate Matter (PM)	0.27	20
Particulate Matter, (PM10)	0.167	0.5
Particulate Matter, (PM2.5)	0.062	0.3

Hydrazine in air is a newer parameter that is being reported. **Refer To** *Section 8.7, Hydrazine* 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 waste water works.

8.6 Ammonia

There are no significant sources of ammonia emissions to the environment as a result of PLNGS operations. As a result, there are no monitoring requirements.

8.7 Hydrazine

In addition to the amount reported to the NBDELG, Hydrazine is also released through boiler blowdowns (11.0 kg) and Liquid Effluent Pumpouts (LEPA) (38.3 kg). Hydrazine is also reported to the NPRI, as per the table below:

Table 8.03: Other NPRI Substances (2022)

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	28,000	Y	NA	0	0	0.00
Ethylene Glycol	10000	1194	N	NA	NA	0	1158
Cobalt	50	6	N	0	NA	NA	0
Hydrazine	1000	861	N	17.2	90.4	0	46.8

8.8 Morpholine

Morpholine is not measured in our lagoon discharges; however the bulk of morpholine releases would be through boiler blowdown. In 2022, a total of 1228 kg of morpholine was released through this pathway.

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 1st 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 25th, 2022.

The impact of the former landfill on the environment remains minimal.

8.10 Other Non-Radiological Monitoring and Reporting through the NPRI

Each year, the NPRI substances are evaluated to see if they require reporting. 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.

8.11 Conclusion

Based on the data discussed above, the non-radiological emissions monitored under the Effluent and Groundwater Compliance Monitoring Programs are of minimal significance with respect to health and safety of humans and the environment.

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, and five (5) 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.

There was also a Corporate Compliance Audit 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 2022.

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 ± 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 μSv to the Representative Person. Most radionuclides pass this criterion. The major exceptions are noble gases. Detection of this group is through TLD measurements (20 μSv 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 μSv); Ru-106 in water, food and seafood (6 to 22 μSv); Ce-144 in water and food (6 to 17 μSv); La-140 in sediment and soil (12 to 15 μSv); Zr-95 in sediment (5 μSv); I-131 in food, water, sediment and seafood (8 to 15 μSv) and 5 to 11 μSv 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 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 9E-05 $Bq \cdot m^{-3}$ (for a 2400 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 1E-01 $Bq \cdot m^{-3}$ of air for a typical sample of 10 to 70 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 4E-02 $Bq \cdot m^{-3}$ of air for a 30 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 μSv. For typical quarterly measurements in the region of 150-200 μSv, measurements can be made to ± 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

Nuclide	*LLD ($Bq{\cdot}m^{-3}$)*	*Dose at LLD (μSv)*	*Concentration That Gives 5 μSv ($Bq{\cdot}m^{-3}$)*
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

Nuclide	*LLD ($Bq \cdot L^{-1}$)*	*Dose at LLD (µSv)*	*Concentration That Gives 5 µSv ($Bq \cdot L^{-1}$)*
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

Nuclide	*LLD ($Bq{\cdot}kg^{-1}$)*	*Dose at LLD (µSv)*	*Concentration That Gives 5 µSv ($Bq{\cdot}kg^{-1}$)*
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

Nuclide	*LLD ($Bq \cdot kg^{-1}$)*	*Dose at LLD (μSv)*	*Concentration That Gives 5 μSv ($Bq \cdot kg^{-1}$)*
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

Nuclide	*LLD ($Bq \cdot L^{-1}$)*	*Dose at LLD (μSv)*	*Concentration That Gives 5 μSv ($Bq \cdot L^{-1}$)*
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

Nuclide	*LLD ($Bq \cdot kg^{-1}$)*	*Dose at LLD (µSv)*	*Concentration That Gives 5 µSv ($Bq \cdot kg^{-1}$)*
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

Nuclide	*LLD ($Bq \cdot kg^{-1}$)*	*Dose at LLD (µSv)*	*Concentration That Gives 5 µSv ($Bq \cdot kg^{-1}$)*
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

Nuclide	*LLD ($Bq{\cdot}kg^{-1}$)*	*Dose at LLD (μSv)*	*Concentration That Gives 5 μSv ($Bq{\cdot}kg^{-1}$)*
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

Nuclide	*LLD ($Bq \cdot kg^{-1}$)*	*Dose at LLD (µSv)*	*Concentration That Gives 5 µSv ($Bq \cdot kg^{-1}$)*
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

Nuclide	*LLD ($Bq \cdot kg^{-1}$)*	*Dose at LLD (µSv)*	*Concentration That Gives 5 µSv ($Bq \cdot kg^{-1}$)*
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 $\mu Sv \cdot h^{-1}$	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 summarised 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)	Tennelec LB-5100 Alpha/Beta Counting System and Protean WPC 9550 Counting System
Gamma Surveys	RadEye G-10 gamma survey meter (range 50 $nSv{\cdot}h^{-1}$ to 0.1 $Sv{\cdot}h^{-1}$ for 50 keV to 3 MeV photons).
Thermoluminescent Dosimetry	Panasonic UD-7900U and UD-716AGL TLD Readers and UD-804A1 ($CaSO_4$) 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.(20) 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 $L \cdot min^{-1}$ for a 28 day continuous sample. The volume of air sampled (approximately 2400 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^3 of air is sampled continuously over 28 days at a flow rate of about 60 $L \cdot min^{-1}$. 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® E until saturation is reached. After the addition of the scintillation cocktail Permafluor® E^+, 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 $mg \cdot cm^{-2}$. 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 (*Rhodymenia 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

A08	Back Bay
A10R	Grand Manan
A12	St. Andrews

Appendix C: Location Codes, Continued

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

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

Appendix C: Location Codes, Continued

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

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

Appendix C: Location Codes, Continued

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

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

Appendix C: Location Codes, Continued

I31F	SRWMF Phase 3, Fence W-SC
I31G	SRWMF Phase 3, Fence W-NC
I31H	SRWMF Phase 3, Fence W-N
I31I	SRWMF Phase 3, Fence W-NN
I31J	SRWMF Phase 3, Fence N-W
I31K	SRWMF Phase 3, Fence N-E
I31L	SRWMF Phase 3, Fence N-C
I31M	SRWMF Phase 3, Fence E-NN
I31N	SRWMF Phase 3, Fence E-N
I31P	SRWMF Phase 3, Fence E-NC
I31Q	SRWMF Phase 3, Fence E-WC
I31S	SRWMF Phase 3, Fence E-W
I31T	SRWMF Phase 3, Fence E-WW
I71	PLNGS - Near Plant Monitoring Well MW01-10, northeast from RB
I86	PLNGS – 2nd pole from SRWMF driveway heading toward outer gate
I87	PLNGS –3rd pole from SRWMF driveway heading toward outer gate
I88	PLNGS – 4th pole from SRWMF driveway heading toward outer gate
I89	PLNGS -5th pole from SRWMF driveway heading toward outer gate
J00	PLNGS – south, 180 m from the stack (on fence)
J01	PLNGS - Near Plant Monitoring Well MW01-1, near surge shaft

J20	PLNGS – south 19° east, 115 m from the stack (on fence)
J35	PLNGS – south 34° east, 135 m from the stack (on sign)
K00	PLNGS - Near Plant Monitoring Well MW01-3 south from RB
K01	PLNGS – 95 m west of south gate leading to the lighthouse
K02	PLNGS Cooling Water Pump-house – east fence near surge shaft
K03	PLNGS - Near Plant Monitoring Well MW01-4 SSW from RB
K04	PLNGS - Near Plant Monitoring Well MW01-5, WSW from RB
K10	Firing Range
L01	PLNGS – site of old cement plant
L03	PLNGS – outer security building (main gate)
L04	PLNGS – construction stores
L05	PLNGS - Near Plant Monitoring Well MW01-6, WNW from RB
L06	PLNGS - Near Plant Monitoring Well MW01-7, paved staff parking
L07	PLNGS - Near Plant Monitoring Well MW01-8, construction parking
L08	PLNGS - Near Plant Monitoring Well MW01-9, N beyond fire
LAB	Fredericton – Health Physics Laboratory
LEM	PLNGS – Liquid Effluent Monitor
M02	PLNGS – Administration Building (2nd floor)
MISC	Miscellaneous locations
N01	Dipper Harbour – GPS Reading – L 45˚ 05.399 N, Lo 66˚ 25.154 W

Appendix C: Location Codes, Continued

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

Appendix D: Abbreviations

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

Appendix E: Sampling Species of Cultural Importance to First Nations

Goldenrod
Yarrow
Virginia Rose Hips
Burdock Root
Bladder Wrack
Black Berries
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
Goose Berry
Cattail head
Cattail root
Red Osier Dogwood
Pineapple Weed (wild chamomile)
Pearly Everlasting
Wild Strawberry
Cinnamon Fern
Dwarf Raspberry
Low Bush Cranberry
Cedar
Juniper
Wild Oregano
Sphagnum Moss
Sweet Grass
Mountain Ash
Spruce Boughs