SWAN HILLS TREATMENT CENTRE

2024 Environmental Monitoring Program

Annual Report

Executive Summary

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1 INTRODUCTION

The Swan Hills Treatment Centre (SHTC) (Figure 1-1) provides comprehensive treatment and disposal capabilities for hazardous wastes. The SHTC is owned by the Alberta Government and was operated in 2024 by Veolia Waste Services Alberta Inc. (Veolia) under an operating contract with Alberta Infrastructure.

The SHTC is located approximately 17 kilometers northeast of the Town of Swan Hills, as shown in Figure 1-2.

Figure 1-1: **Swan Hills Treatment Centre**

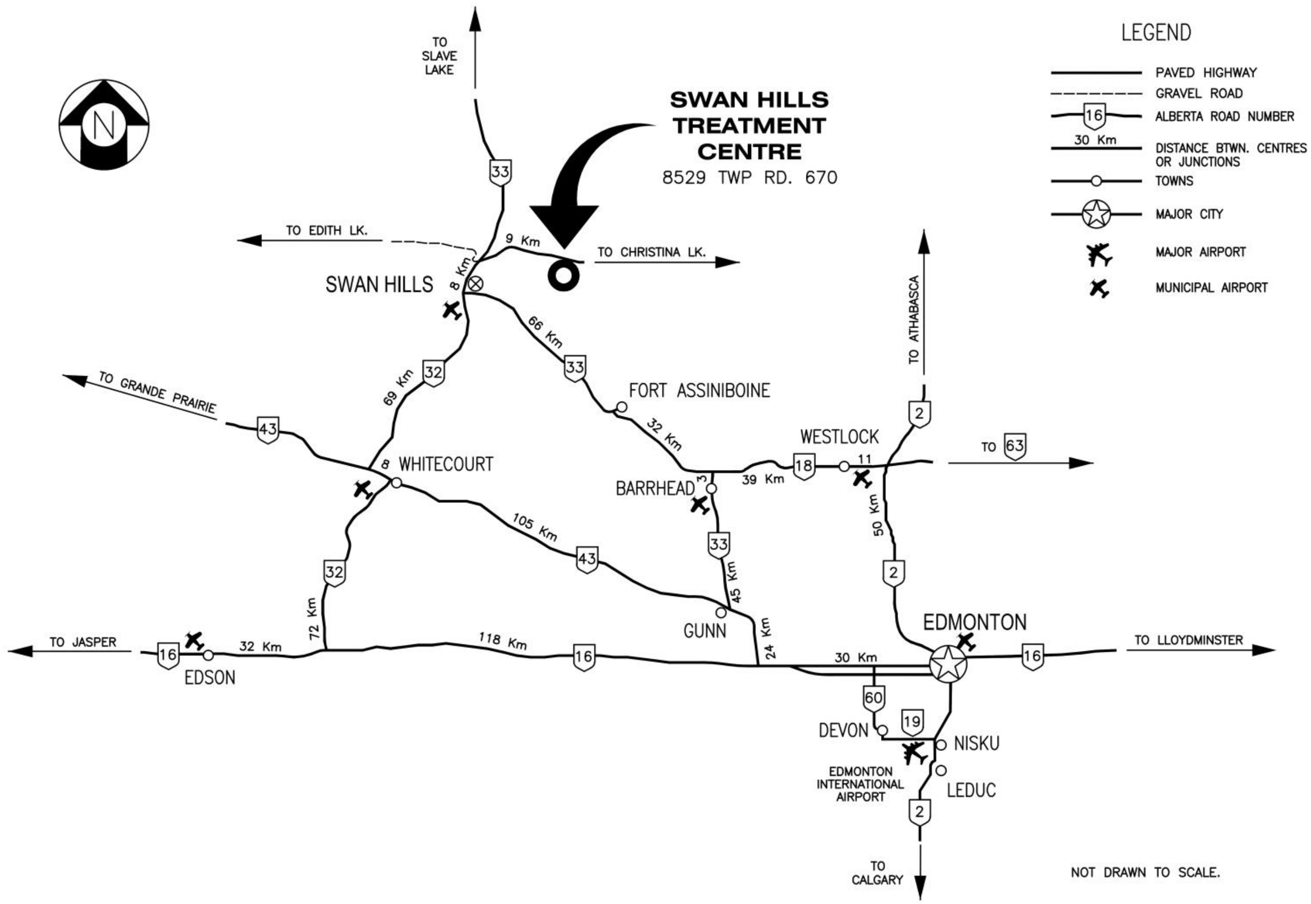


Figure 1-2: Site Location Map

A thorough environmental baseline data collection program was initiated around the SHTC in 1985, two years before it officially commenced operation in 1987. This program has evolved into an extensive environmental monitoring program that provides early detection of potential environmental impacts associated with SHTC operations. The program includes the monitoring of meteorological, air quality, soils, groundwater, vegetation, wildlife, surface water, sediment, and fish. A human health risk assessment, based on consumption of fish from local lakes, is also performed annually.

Key environmental monitoring program (EMP) items include:

Source and On-site Monitoring

Extensive source and on-site monitoring are conducted annually in accordance with Approval 1744-03-00, as amended. Specific requirements include the following:

- Continuous process monitoring and monthly reporting for the following parameters: Waste Feed Rate, Combustion Temperature, Flue Gas Flow Rate and other key incinerator operating parameters.
- Continuous (on-line) monitoring and reporting of stack emissions including Oxygen (O_2) Carbon Dioxide (CO_2) Carbon Monoxide (CO), Oxides of Nitrogen (NO_X), Sulphur Dioxide (SO_2) Total Hydrocarbon (THC), Hydrogen Chloride (HCl) and Mercury[a].
- Regular manual stack surveys are performed to ensure that the total particulate, dioxin and furan TEQ, metals and destruction and removal efficiency (DRE) criteria are being achieved.
- Monthly monitoring of Carbon Adsorption Unit (CAU) stack emissions for THC and PCBs
- Containment of all surface water runoff in retention ponds for use as process water. Excess water is released only if it is necessary and must meet the off-site discharge limits.
- Ambient air is monitored for PCBs, Volatile Organic Compounds (VOCs), Total Suspended Particulate (TSP), and Fine Particulate[b] ($PM_{2.5}$) on the plant site and reported monthly (annually for VOCs).

[a] Continuous monitoring for Mercury is required by Approval 1744-03-00, as amended. A continuous analyzer installed in 2020 and operational commencing January 01, 2021. The new emission limit for Mercury (20 µg/m^3 maximum 24 hr rolling average) became effective January 01, 2023

[b] $PM_{2.5}$ monitoring commenced in July 2020

- All spills and releases are reported immediately and cleaned up in accordance with the facility's Emergency Response Plan.
- An on-site Soil Management Plan is conducted in accordance with Alberta Environment and Protected Areas (AEPA) Soil Monitoring Directive The soil management program addresses on-site contamination in order to: protect workers at the facility; minimize off-site migration of contaminants; and decrease the cost of final site remediation.
- Groundwater Monitoring is conducted at 14 locations around the process area and landfills (upgradient and downgradient). Samples are obtained at three different depths (shallow till, intermediate till and the underlying sandstone) at most locations and results are reported annually.

Off-site Environmental Monitoring Program (EMP)

A comprehensive off-site environmental monitoring program is also conducted annually. This program was initiated two years prior to operation and includes a wide range of environmental receptors. Results are compared with pre-operational data and data collected at reference locations. In addition to reporting the results of the air monitoring and groundwater monitoring programs noted above, the program includes the following components:

- Soil – organic soils predominate in the Swan Hills area and the live moss layer is sampled and analyzed annually. The live moss layer provides information on contaminants accumulating in surface soils (2 – 3 years).
- Vegetation - Labrador tea is used as an indicator species based on its wide distribution in the Swan Hills region and its demonstrated ability to retain contaminants on its leaves. It provides annual data on contaminant deposition and distribution around the SHTC. Moss bags are used to monitor metals deposition and lichen health is assessed biannually.
- Wildlife – Red-backed Voles are considered an ideal indicator of potential impacts on wildlife receptors given their small home ranges, high reproduction potential, diet, and habitat. These characteristics provide the opportunity to assess both contaminant levels and population effects.
- Water Quality – local streams and surface water bodies are monitored annually to assess potential impacts on water quality.
- Sediment – many of the contaminants processed at the facility have low solubility in water and can be persistent in the environment. Sediment provides a sensitive media to monitor potential accumulation and impacts associated with these types of compounds.

- Fish – can accumulate contaminants in their tissue and represent a potential pathway for human risk through consumption. Fish tissue is monitored for contaminant levels annually.
- Toxicology and Risk Assessment – Monitoring data are reviewed annually and a human health risk assessment is completed based on fish consumption from monitored lakes.

The monitoring program results are compiled annually and reviewed with regulatory authorities and regional stakeholders. The program is dynamic, and changes are made to the scope and methodology, as required, to maintain its effectiveness.

The environmental monitoring program has been rationalized to focus on a subset of the historic monitoring plots along with a more comprehensive analytical scope. To ensure potential issues are not overlooked, the program is expanded on a 5-year cycle to include both additional monitoring locations and chemical parameters/contaminants. Expanded monitoring has been conducted in 2004, 2009, 2014; 2019, and 2024. The next expanded monitoring program will be performed in 2029. In addition, a series of receptor-specific "triggers" that require additional data collection, were established and are reviewed annually to provide early response to address emerging trends or to respond to specific incidents.

The overall analytical scope of the environmental monitoring program includes PCB, PCDD/F, TEQ, and metals. Additional groups of compounds are added to the program during "Expanded" monitoring years. In the past, these have included Polycyclic Aromatic Hydrocarbons (PAHs), Semi-Volatile Organic Compounds (SVOCs), as well as inclusion of PCDD/F, metals, and VOCs in receptors not included in the annual program scope. To date, these additional analyses have not identified any potential issues that warrant annual surveillance.

- The most significant contaminants identified in the monitoring program include polychlorinated biphenyls (PCBs) and dioxins and furans (PCDD/F). Both include a range of congeners that exhibit slightly different characteristics (e.g. volatility, solubility and toxicity) based on the number and position of chlorine atoms in their structure. There are 209 different PCBs, 75 dioxins and 135 furans. The analytical procedures have been continually upgraded in the monitoring program and these compounds are analyzed using the most sophisticated and sensitive methods available. As a result, the program interprets the data as follows: PCBs are analyzed by high-resolution mass spectrometry that can identify individual PCB congeners. The term PCB denotes the total of all 209 potential congeners identified within the sample.
- Dioxins/Furans – these compounds are reported together because they are very similar and exhibit toxicity through a similar mechanism. However, the toxicity of individual dioxin/furan congeners varies significantly based on the location and number of chlorine atoms in its structure. The most

toxic dioxin is 2,3,7,8 tetra-chloro dibenzodioxin (2,3,7,8 TCDD). The World Health Organization supports a methodology whereby the toxicity of this group of compounds can be interpreted by using Toxicity Equivalent Factors (TEFs) to calculate the overall toxicity relative to 2,3,7,8 TCDD. There are 7 dioxins and 10 furans that contribute to the toxicity associated with this group of chemicals. Each of the toxic congeners is multiplied by its respective TEF to establish the overall toxicity represented by the analytical result (i.e. PCDD/F TEQ).

- Toxic PCBs – twelve PCB congeners have been shown to exhibit similar toxicity as the toxic dioxins and furans. TEFs have been established for these congeners and the results are reported as PCB TEQ.

- Total TEQ – because toxic dioxins, furans and PCBs all exhibit their toxicity through the same mechanism, the combined toxicity of a sample is expressed as its Total TEQ. This simply represents the sum of the PCDD/F TEQ and the PCB TEQ results. Toxicity assessments conducted in this report are all conducted using Total TEQ.

- Polycyclic Aromatic Hydrocarbons (PAHs) – are organic compounds containing only carbon and hydrogen and are composed of multiple aromatic (benzene) rings. They include over 100 different chemicals that can occur naturally in coal, tar and crude oil or can be formed during the incomplete burning of organic substances. They are ubiquitous and are found in tobacco or on charbroiled meat. PAHs are usually found as a mixture containing two or more of these compounds. Some PAHs are manufactured for use in the manufacture of medicines, dyes, plastics, and pesticides. Several of the PAHs and some specific mixtures of PAHs are considered to be cancer-causing chemicals.

- Volatile Organic Compounds (VOCs) –include organic (carbon-based) chemical compounds that can evaporate into the atmosphere under normal indoor conditions of temperature and pressure. Some common examples include solvents, fuels and individual compounds such as toluene, xylenes, benzene, ethylbenzene, and formaldehyde. In addition, VOCs may also include chlorine and fluorine atoms which significantly change their chemical properties. Common examples include dry-cleaning solvents and chloro-fluorocarbons (freon). VOCs of interest from an environmental or human health risk perspective are commonly analyzed as a group. When monitoring for VOCs, they can be reported as a group (i.e. total VOC)) or speciated to provide a list of individual compounds.

- Semi-Volatile Organic Compounds (SVOCs) – are not as volatile as VOCs and generally include larger molecules with more carbon atoms. They include common materials such as pesticides, plasticizers, and fire retardants. Like VOCs, SVOCs of interest from an environmental or human health risk perspective are commonly analyzed as a group. When monitoring for SVOCs, a list of the individual compounds included in the analysis is provided in the report.

The following provides an overview of SHTC operations and presents a summary of the results for both on-site and environmental monitoring programs conducted in 2024. The scope of individual monitoring components is presented along with any proposed changes for implementation in 2025. Detailed information including sampling and analytical methods, QA/QC procedures, statistical analysis and interpretation of results, supporting data and recommendations are all presented in the Annual Report.

2 OPERATIONS

The Swan Hills Treatment Centre employs a variety of processes to treat hazardous waste. These include the following:

Incineration: The FBD Incinerator is the primary process unit with a capability of treating approximately 35,000 tonnes per year.

Physical/Chemical Treatment: Inorganic liquid wastes are treated through a variety of processes including neutralization, oxidation, reduction, phase separation and precipitation in the physical/chemical treatment plant.

Stabilization: The Stabilization plant treats heavy metal contaminated fly ash from the FBD Incinerator, by immobilizing the hazardous constituents in a cement-like matrix. The end product is an inert, non-hazardous solid.

The non-hazardous solid residues resulting from treatment are disposed in secure, onsite landfills and liquid residuals are sent to the onsite disposal well.

2.1 2024 Operations

The Swan Hills Treatment Centre has treated over 481,000 tonnes of commercial hazardous waste since commencing operations in 1987 (Figure 2-1). In 2024, approximately 1,929 tonnes of hazardous waste were treated including:

- 39 tonnes of PCBs
- 639 tonnes of Plant Generated, Decommissioning and Secondary Waste of which 90 tonnes were sent for off-site disposal/recycling
- 1,251 tonnes of Biomedical Waste (includes pharmaceuticals and expired medication)

The SHTC accepted all waste streams until May 31, 2021 and has moved to the base scope operation.

The base scope allows for 1,500 tonnes of commercial waste (300 tonnes of high-level PCB waste and 1,200 tonnes of Alberta Biomedical & Pharmaceutical waste) to be processed each fiscal year (April – March).

Waste streams that have no alternate option for disposal or waste from special projects must be approved by Alberta Infrastructure through a change order.

The SHTC plans to stop accepting biomedical waste October 31 and PCB December 31. This is so that the majority of the commercial waste (including liability pit waste) on site can be processed by December 31, 2025.

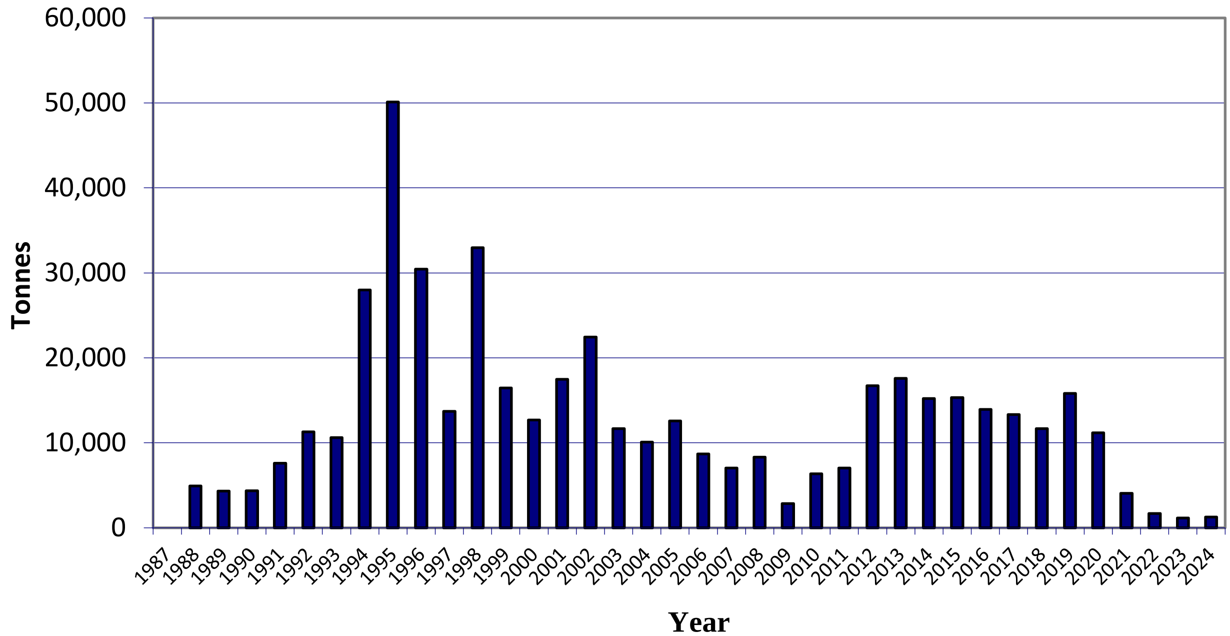


Figure 2-1: Commercial Waste Treatment Summary

Significant events and achievements in 2024 included the following:

- The FBD Incinerator was operational for approximately 6,430 hours between January 1 and December 31, 2024.
- There were two scheduled maintenance shutdowns of the FBD Incinerator from May 4 to June 12 and August 3 to October 6.
    - The May 4 - June 12 maintenance included: kiln refractory inspection; crossover inspection; spray dryer inspection & repair; baghouse inspection & repair; deslagger inspection, repair & control panel with PLC upgrade; live bottom inspection & repair; vent cap project executed.

  - The August 3 - October 6 maintenance included: the spray dryer and kiln refractory was repaired; various fiberglass repairs were done; performed incinerator PM's & inspections. The shutdown was extended due to mercury analyzer issues.

- Site improvements included: completed underground firewater loop repairs; purchased a HovaCAL calibration gas generator to perform the CEMS analyzer moisture calibration (trained on site personnel to perform the calibration); upgraded the deslagger PLC; replaced the Hastelloy spray dryer and blowdown valves & the obsolete blowdown slurry pump; continued the Water Treatment Plant decommissioning which included cleaning a process tank that was contaminated with PCB's so that the metal can be recycled; completed the North Pumphouse domestic water line repairs.

2.2 2024 Manual Stack Surveys

A manual stack survey for organics was performed on April 16-17 to follow up on the dioxin and furan results from the December 2023 testing. The scope of the survey is based on the waste-specific requirements as noted in Table 2-1. The manual stack survey conducted October 16-17, assessed incinerator performance while processing hazardous waste. The scope of the survey is based on the waste-specific requirements as noted in Table 2-2.

Table 2-1: 2023 Manual Stack Survey Results (Redo for total dioxin and furan toxic equivalent)

Parameter	Operating Approval Limit	Result
Halogenated POHC[1]	100 mg/hr of POHC when halogenated POHC feed rate is ≤100 kg/hour	0.55 mg/hr
PCDD/F TEQ[2,3,4] (dry @ 11% O_2)	80 pg/m^3	Average = 18.3 pg/m^3 Test 1 = 13.6 pg/m^3 Test 2 = 24.5 pg/m^3 Test 3 = 16.9 pg/m^3

[1] DRE – Primary Organic Hazardous Constituent
[2] PCDD/F TEQ – Dioxin/Furan Toxic Equivalent
[3] When analytical results were < Method Detection Limit (MDL), the MDL was used to calculate concentrations and emission results.
[4] The results of each test are listed to satisfy AEPA reporting requirements

Table 2-2: 2024 Manual Stack Survey Results

Parameter	Operating Approval Limit	Result
Halogenated POHC[1]	100 mg/hr of POHC when halogenated POHC feed rate is ≤100 kg/hour	0.108 mg/hr
Total Particulate (dry @ 11% O_2)	20 mg/m^3	4.59 mg/m^3
PCDD/F TEQ[2,3,4] (dry @ 11% O_2)	80 pg/m^3	Average = 1.37 pg/m^3 Test 1 = 1.56 pg/m^3 Test 2 = 0.126 pg/m^3 Test 3 = 2.44 pg/m^3
Mercury (dry @ 11% O_2)	20 µg/m^3	0.683 µg/m^3
HCl (dry @ 11% O_2)	75 mg/m^3	0.012 mg/m^3
SO_2 (dry @ 11% O_2)	325 mg/m^3	0.132 mg/m^3
CO (dry @ 11% O_2)	57 mg/m^3	<4.75 mg/m^3

[1] DRE – Primary Organic Hazardous Constituent
[2] PCDD/F TEQ – Dioxin/Furan Toxic Equivalent
[3] When analytical results were < Method Detection Limit (MDL), the MDL was used to calculate concentrations and emission results.
[4] The results of each test are listed to satisfy AEPA reporting requirements

2.3 2024 Process Monitoring Activities

- Successful relative accuracy test audits (RATA) were performed on the continuous stack emission monitoring systems (CEMS) to verify the emission monitors are calibrated and reporting accurate data.
- There were issues completing a successful RATA on the mercury analyzer due to incorrect moisture readings when the values were corrected to 11% O_2.
- Two cylinder gas audits (CGA) were performed in 2024.
- The CEMS Code (AEPA 2021[c]) requires that the CEMS and Quality Assurance Manual be audited on an annual basis. In 2024, Global Analyzer Systems Ltd. completed this audit on September 5.
- The Air Monitoring Directive, Chapter 5, Quality System (AEPA 2016[d]) requires that the Ambient Air Monitoring Quality Manual be audited every three years. In 2023, Global Analyzer Systems Ltd. completed this audit on August 16-17. The next audit will be done in 2026.
- The annual fugitive emission survey was conducted at the Organic Tank Farm. None of the components were found to be leaking.
- There were no vent cap releases were reported in 2024. The emergency vent cap is a safety device that prevents hot combustion gases from damaging the pollution control system in the event an emergency shutdown is required. An emergency shutdown is a controlled event that terminates waste feeds prior to implementing a sequence of steps (including vent cap openings) to ensure worker safety and equipment integrity is protected.
- Stack exhausts from buildings equipped with activated carbon air management systems are monitored, monthly, for PCBs and THC to evaluate the performance of the fugitive emission control systems. These include the Organic Tank Farm, Heated Storage Building and the FBD Incinerator Feed and Container Staging buildings. In 2024, there were no exceedances of the 6.0 µg/m^3 PCB limit or 500 ppm THC limits.
- The SHTC did not receive any air-related complaints in 2024.

[c] AEPA, 2021. "Continuous Emissions Monitoring System (CEMS) Code." Alberta Environmental and Protected Areas, Edmonton, AB, 111 pp.
[d] AEPA, 2016, "Air Monitoring Directive (AMD), Chapter 5, Quality System." Alberta Environmental and Protected Areas, Edmonton, AB, 19 pp.

- The annual bottom hole survey and packer isolation test on the Deepwell were completed as per AER Approval 7742 confirming that the Class 1a injection well is in good mechanical condition. A successful Packer Isolation Test was performed August 29. The pressure survey was completed October 31-November 12. Since the well workover and acid stimulation in 2021, the injection flow rate was restored to over 30 m3/hr and has not deteriorated since. No mechanical repairs are required or anticipated in the upcoming operating year. The well and reservoir continue to operate under gravity injection, have surplus injection capability, and the well and reservoir should be able to handle the plant's disposal requirements for the near future and reservoir fill up is not a concern. At injection volumes of 50,000 m3/year (2019 - 2020 volume), it will take over 50 years to reach a reservoir pressure of 14,900 kPag (i.e., 120% of initial reservoir pressure). Temperature injection logs demonstrate gradual injectivity deterioration in the Winterburn Formation; however, the overall well injectivity remains high.

3 ON-SITE MONITORING

On-site monitoring conducted at the SHTC includes ambient air and groundwater monitoring in accordance with requirements specified in Approval 1744-03-00, as amended. In addition, regular soils monitoring, and management programs are conducted in accordance with Alberta's Soil Monitoring Directive (AENV 2009[e]). Monitoring results and soil management program activities undertaken in 2024 are discussed in the following sections.

3.1 Ambient Air Monitoring

The ambient air monitoring program consists of monitoring PCB levels in ambient air at five locations, total suspended particulate (TSP) at two locations, fine particulate ($PM_{2.5}$) at three locations, and total hydrocarbons (THC) and volatile organic compounds (VOCs) at one location, as shown in Figure 3-1. One sampling site (E1) is located within the waste processing area, while the others are along the fenceline of the facility, or near the property boundary (Site 11). Ambient PCB, TSP, and $PM_{2.5}$ levels are obtained monthly and THC and VOC monitoring at the Organic Tank Farm (OTF) is conducted annually.

Meteorological data is collected continuously at the Air Quality Monitoring (AQM) Station (Site 11) located southeast of the SHTC as shown in Figure 3-1. The meteorological parameters of interest for ambient air monitoring include hourly average values for ambient temperatures at a 2 m height, wind velocity and direction at a 30 m height. The predominant wind directions in 2024 were from the northwest and west-northwest at 30m which is typical for the Swan Hills region (Veolia 2025[f]). Average wind speeds at the 30 m level were 17.3 km/hr, which are similar to observations from previous years. The average monthly temperature recorded at the AQM Station ranged between -11.1°C in January and 18.3°C in July.

Polychlorinated biphenyls (PCBs) sampling was conducted monthly with 100% data completeness in 2024. Ambient air PCB monitoring results at the SHTC for the period 2015-2024 are presented in Figure 3-2. Results are summarized below. Alberta has an occupational health objective for PCBs to protect workers but does not have an ambient air quality objective. To help place these results into perspective, the Alberta Occupational Health and Safety 8-hour exposure limit is 500,000 ng/m^3 (Aroclor 1254). In addition, some jurisdictions (e.g. Ontario), have established ambient air quality objectives. The Ontario 24-hour average and annual average ambient air quality objectives for PCBs are 150 ng/m^3 and 35 ng/m^3, respectively.

[e] AENV, 2009. "Soil Monitoring Directive", Alberta Environment and Protected Areas, 32 pp
[f] Veolia, 2025. "2024 SHTC Meteorological Report", Veolia Waste Services Alberta Ltd., Swan Hills, AB, 30 pp

The following observations were noted:

- Individual site average PCB concentrations increased slightly at Sites 1, 2A, 5A, and E1 and stayed the same at site 11 compared to 2023 annual averages.
- The average PCB concentration at Site E1 increased from 7.85 ng/m3 to 11.83 ng/m3 between 2023 and 2024. The highest PCB concentration at Site E1 was 42.98 ng/m3 detected on September 5, 2024. The elevated result could be caused by elevated ambient temperatures at the time the sampling was done.
- The average fenceline PCB concentration (the average of sites 1, 2A, and 5A) was 1.26 ng/m3 which was slightly higher than in 2023 (1.12 ng/m3). The highest fenceline 24-hour Average PCB concentration in 2024 was 2.72 ng/m3 measured on August 13 and September 5, 2024.
- Ambient PCB levels were lowest at Site 11 (New AQM). The average 24-hour concentration was 0.91 ng/m^3 and the maximum 24-hour level reported was 0.91 ng/m^3, which is the laboratory detection limit.
- Consistent with previous observations, PCB levels tended to be higher during the warm summer months.
- All 24-hour PCB measurements on plant site were well below the Occupational Health and Safety limit of 500,000 ng/m^3 (Aroclor 1254). No exceedances of Veolia's fenceline trigger level of 150 ng/m^3 were observed in 2024.

Total Suspended Particulate (TSP) sampling was conducted at two sites (Site 1 and Site 9, Figure 3-1) on the same monthly schedule as PCBs. There were no exceedances of the Alberta Ambient Air Quality Objective for TSP (100 μg/m^3) for samples collected.

Fine Particulate ($PM_{2.5}$) sampling was conducted at three sites (Site 1, Site 5A, and Site 9, Figure 3-1) on the same monthly schedule as PCBs. There were exceedances of the Alberta Environment Air Monitoring Directive 24-hour $PM_{2.5}$ ambient air quality objective of 29 μg/m^3 measured at Site 1 (31.8 μg/m^3), Site 5A (30.4 μg/m^3), or Site 9 (34.9 μg/m^3) on August 13. There was heavy wildfire smoke in the area. Samples collected August 29 were below 29 μg/m^3.

Volatile Organic Compounds (VOC) and Total Hydrocarbons (THC) sampling was conducted at the Organic Tank Farm (Site E1) once in 2024 as specified in the Approval. The total VOC and THC concentrations are presented in Table 3-1. There are no Approval limits for these parameters; however, both VOC and THC were below the monitoring program "trigger" values of 3 ppm and 5 ppm, respectively.

Table 3-1: VOC and THC Results at Site E1 (2024)

Date	Average Temperature (°C)	Total VOC Concentration (ppm)	Total THC Concentration (ppm)
Trigger Limit	**n/a**	**3**	**5**
23-Jul-24	18.9	0.027	2.00

The individual VOCs are summarized and compared to the Alberta Ambient Air Quality Objectives in Table 3-2.

Table 3-2: 2024 Site E1 VOC Canister Analysis Results Compared to the Alberta Ambient Air Quality Objective[g]

Parameter	Reporting Units	Objective	Reported Result
Hydrocarbons, Total (as Methane)	ppmv		2.00
1-Butene	ppmv		<0.10
Acetylene	ppmv		<0.08
cis-2-Butene	ppmv		<0.04
Ethane	ppmv		<0.1
Ethylacetylene	ppmv		<0.06
Ethylene	ppmv		<0.07
Isobutane	ppmv		<0.1
Isobutylene	ppmv		<0.1
Methane	ppmv		2.00
n-Butane	ppmv		<0.2
n-Propane	ppmv		<0.07
Propylene	ppmv		<0.1
Propyne	ppmv		<0.1
trans-2-Butene	ppmv		<0.09
1,1,1-Trichloroethane	ppbv		<0.02
1,1,2,2-Tetrachloroethane	ppbv		<0.02
1,1,2-Trichloroethane	ppbv		<0.02
1,1-Dichloroethane	ppbv		<0.02
1,1-Dichloroethylene	ppbv		<0.02
1,2,3-Trimethylbenzene	ppbv		<0.05
1,2,4-Trichlorobenzene	ppbv		<0.3
1,2,4-Trimethylbenzene	ppbv		<0.03
1,2-Dibromoethane	ppbv		<0.02
1,2-Dichlorobenzene	ppbv		<0.03
1,2-Dichloroethane	ppbv		<0.03
1,2-Dichloropropane	ppbv		<0.03
1,3,5-Trimethylbenzene	ppbv		<0.03
1,3-Butadiene	ppbv		0.41
1,3-Dichlorobenzene	ppbv		<0.4
1,4-Dichlorobenzene	ppbv		<0.4
1,4-Dioxane	ppbv		<0.5
1-Butene/Isobutylene	ppbv		0.44
1-Hexene/2-Methyl-1-pentene	ppbv		<0.07
1-Pentene	ppbv		0.11
2,2,4-Trimethylpentane	ppbv		<0.02
2,2-Dimethylbutane	ppbv		<0.02
2,3,4-Trimethylpentane	ppbv		<0.02
2,3-Dimethylbutane	ppbv		<0.09
2,3-Dimethylpentane	ppbv		<0.02
2,4-Dimethylpentane	ppbv		<0.03
2-Methylheptane	ppbv		<0.02
2-Methylhexane	ppbv		<0.03
2-Methylpentane	ppbv		0.08
3-Methylheptane	ppbv		<0.03
3-Methylhexane	ppbv		0.02
3-Methylpentane	ppbv		0.04
Acetone	ppbv	2,400 (1-hr)	11.6
Acrolein	ppbv	1.9 (1-hr) 0.17 (24-hr)	0.8
Benzene	ppbv	9.0 (1-hr)	0.84
Benzyl chloride	ppbv		<0.3
Bromodichloromethane	ppbv		<0.03
Bromoform	ppbv		<0.02
Bromomethane	ppbv		<0.02
Carbon disulfide	ppbv	10 (1-hr)	0.03

[g] AEPA, 2024. "Alberta Ambient Air Quality Objectives and Guidelines Summary", Alberta Environment and Parks, 10pp

Parameter	Reporting Units	Objective	Reported Result
Carbon tetrachloride	ppbv		0.05
Chlorobenzene	ppbv		<0.02
Chloroethane	ppbv		<0.02
Chloroform	ppbv		<0.02
Chloromethane	ppbv		0.75
cis-1,2-Dichloroethene	ppbv		<0.02
cis-1,3-Dichloropropene	ppbv		<0.03
cis-2-Butene	ppbv		<0.03
cis-2-Pentene	ppbv		<0.02
Cyclohexane	ppbv		<0.04
Cyclopentane	ppbv		<0.02
Dibromochloromethane	ppbv		<0.02
Ethanol	ppbv		5.7
Ethyl acetate	ppbv		<0.3
Ethylbenzene	ppbv	460 (1-hr)	<0.03
Freon-11	ppbv		0.20
Freon-113	ppbv		0.03
Freon-114	ppbv		<0.03
Freon-12	ppbv		0.56
Hexachloro-1,3-butadiene	ppbv		<0.3
Isobutane	ppbv		0.60
Isopentane	ppbv		0.70

Parameter	Reporting Units	Objective	Reported Result
Isoprene	ppbv		0.99
Isopropyl alcohol	ppbv		0.3
Isopropylbenzene	ppbv		<0.04
m,p-Xylene	ppbv	530 (1-hr) 161 (24-hr)	<0.04
m-Diethylbenzene	ppbv		<0.02
m-Ethyltoluene	ppbv		<0.03
Methyl butyl ketone	ppbv		<0.4
Methyl ethyl ketone	ppbv		0.8
Methyl isobutyl ketone	ppbv		<0.3
Methyl methacrylate	ppbv		<0.08
Methyl tert butyl ether	ppbv		<0.03
Methylcyclohexane	ppbv		<0.02
Methylcyclopentane	ppbv		<0.05
Methylene chloride	ppbv		<0.3
n-Butane	ppbv		0.93
n-Decane	ppbv		<0.06
n-Dodecane	ppbv		<0.3
n-Heptane	ppbv		<0.04
n-Hexane	ppbv	5,960 (1-hr) 1,990 (24-hr)	0.12
n-Nonane	ppbv		<0.04

Parameter	Reporting Units	Objective	Reported Result
n-Octane	ppbv		0.03
n-Pentane	ppbv		0.23
n-Propylbenzene	ppbv		<0.06
n-Undecane	ppbv		<0.5
Naphthalene	ppbv		<0.3
o-Ethyltoluene	ppbv		0.02
o-Xylene	ppbv	530 (1-hr) 161 (24-hr)	<0.03
p-Diethylbenzene	ppbv		<0.02
p-Ethyltoluene	ppbv		<0.04
Styrene	ppbv	52 (1-hr)	<0.04
Tetrachloroethylene	ppbv		<0.02
Tetrahydrofuran	ppbv		<0.3
Toluene	ppbv	499 (1-hr) 106 (24-hr)	0.21
trans-1,2-Dichloroethylene	ppbv		<0.06
trans-1,3-Dichloropropylene	ppbv		<0.02
trans-2-Butene	ppbv		<0.03
trans-2-Pentene	ppbv		<0.02
Trichloroethylene	ppbv		<0.02
Vinyl acetate	ppbv		<0.3
Vinyl chloride	ppbv	51 (1-hr)	<0.02

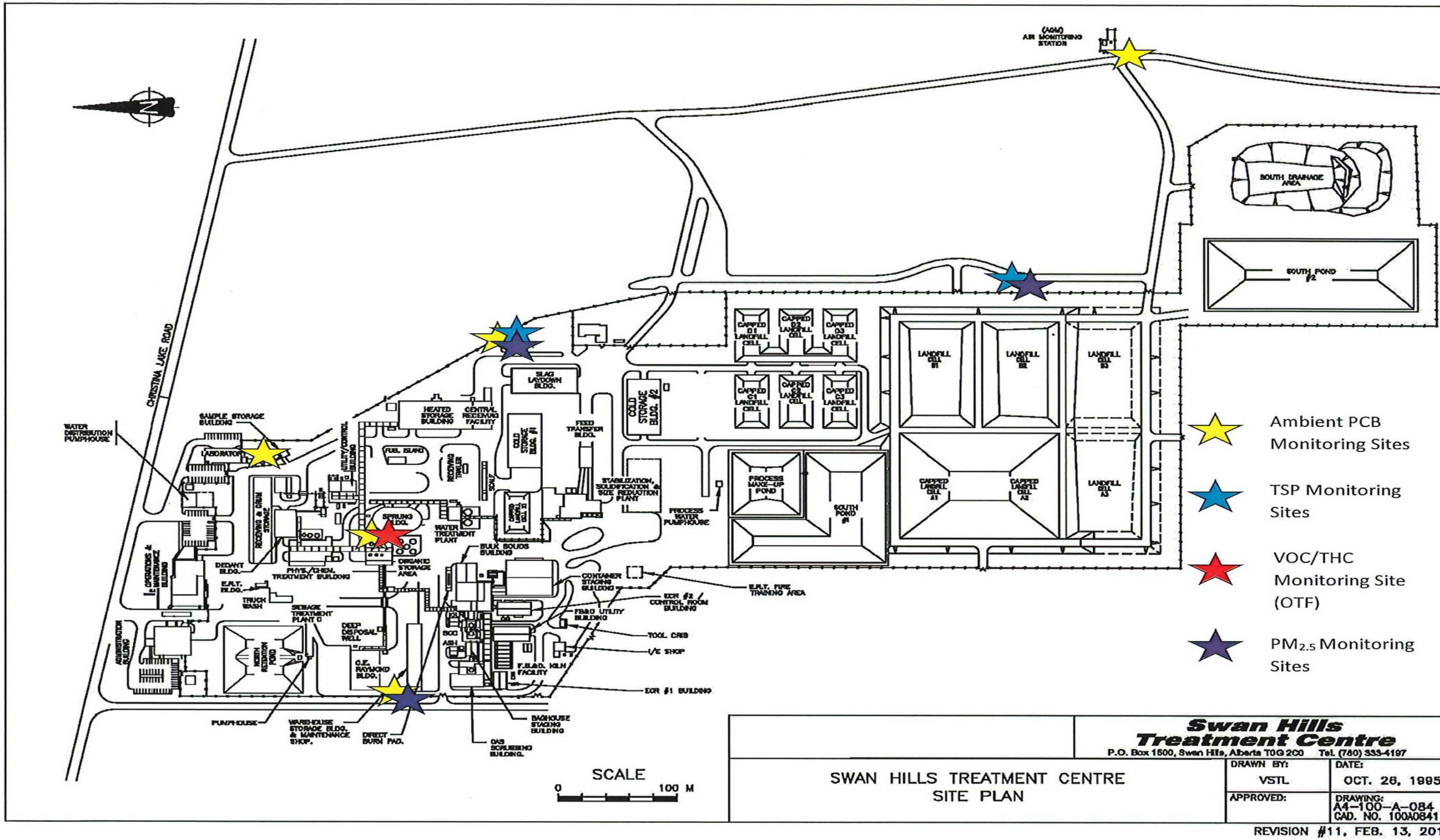


Figure 3-1: SHTC Site Plan Locations of Air Monitoring Stations

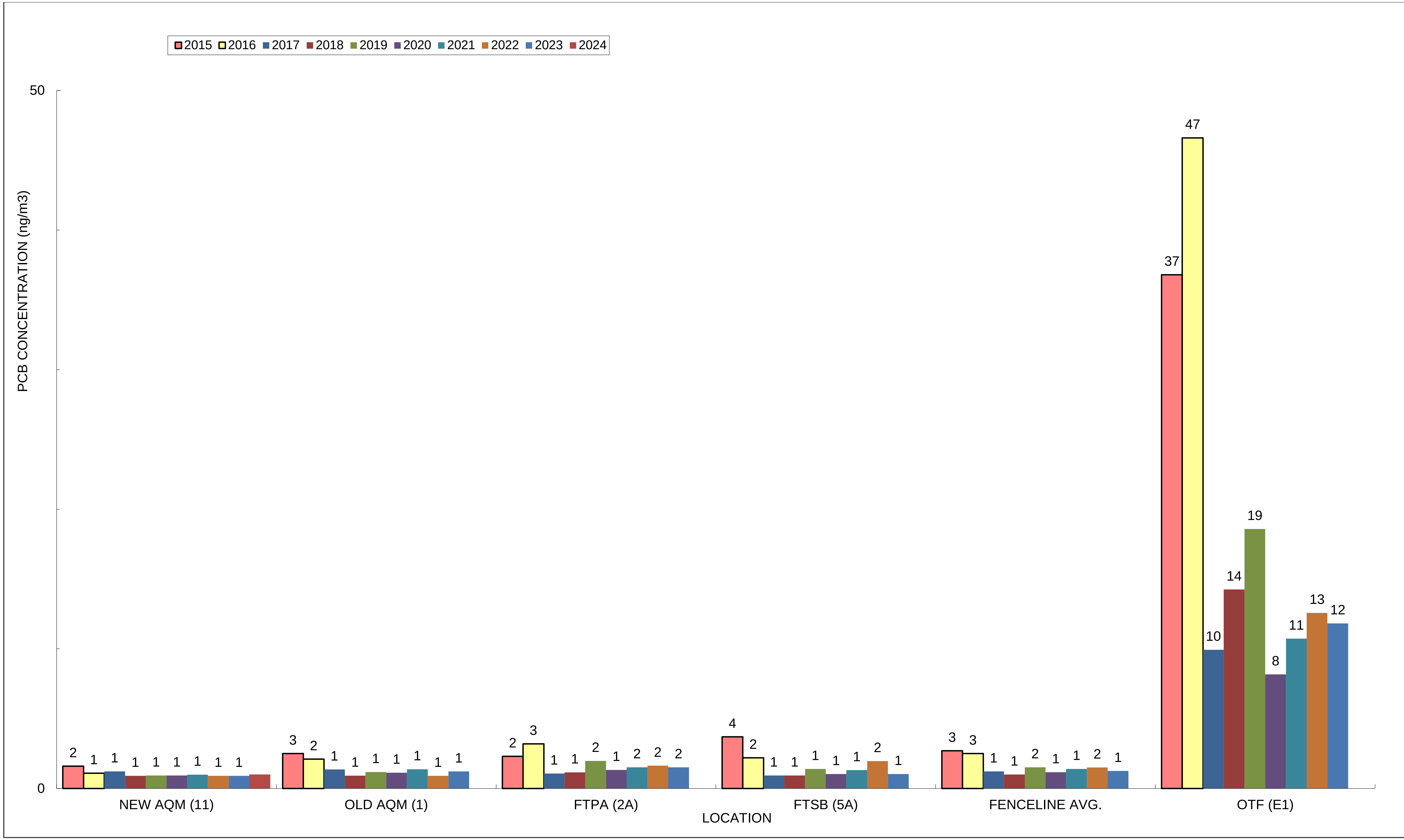


Figure 3-2: Ambient Air PCB Monitoring Results (2015-2024)

3.2 Soil Management Program

Alberta's Soil Monitoring Directive requires all industrial Approval holders to conduct on-site soil monitoring and management programs (if necessary) to address potential contamination resulting from operations. The first on-site Soil Monitoring Program (SMP) was completed in 1998 and subsequent SMPs have been completed every five years (2002, 2007, 2012, 2017, and 2019) in compliance with the Directive. Soil management programs (SMaPs) are undertaken to manage any identified on-site contamination to protect worker safety and minimize the potential for off-site migration.

There were no scheduled activities for the 2024 Soil Management Program, concluding the current SMaP.

The next Soil Monitoring Program Proposal will be submitted to AEPA on or before May 30, 2025.

3.3 Groundwater Monitoring

Three depth intervals are monitored. The shallow and intermediate intervals monitor groundwater in the surficial till deposits. The clay-till soils on the plant site are approximately 10 metres thick, and have very low hydraulic conductively, providing a significant barrier for contaminant migration via a groundwater pathway. The sandstone interval wells monitor the groundwater in the Paskapoo Formation between 50 and 70 metres Below Ground Surface (mBGS). This zone provides a useable groundwater aquifer and the SHTC is the only local groundwater user.

The groundwater flow in the shallow and intermediate intervals is generally to the east at an estimated velocity of 0.0023 metres per year (m/yr) for the shallow till and 0.018 m/yr for the deeper till (intermediate interval wells). The groundwater flow in the sandstone interval is generally to the south. The flow velocity in 2024 is 14.07 m/yr.

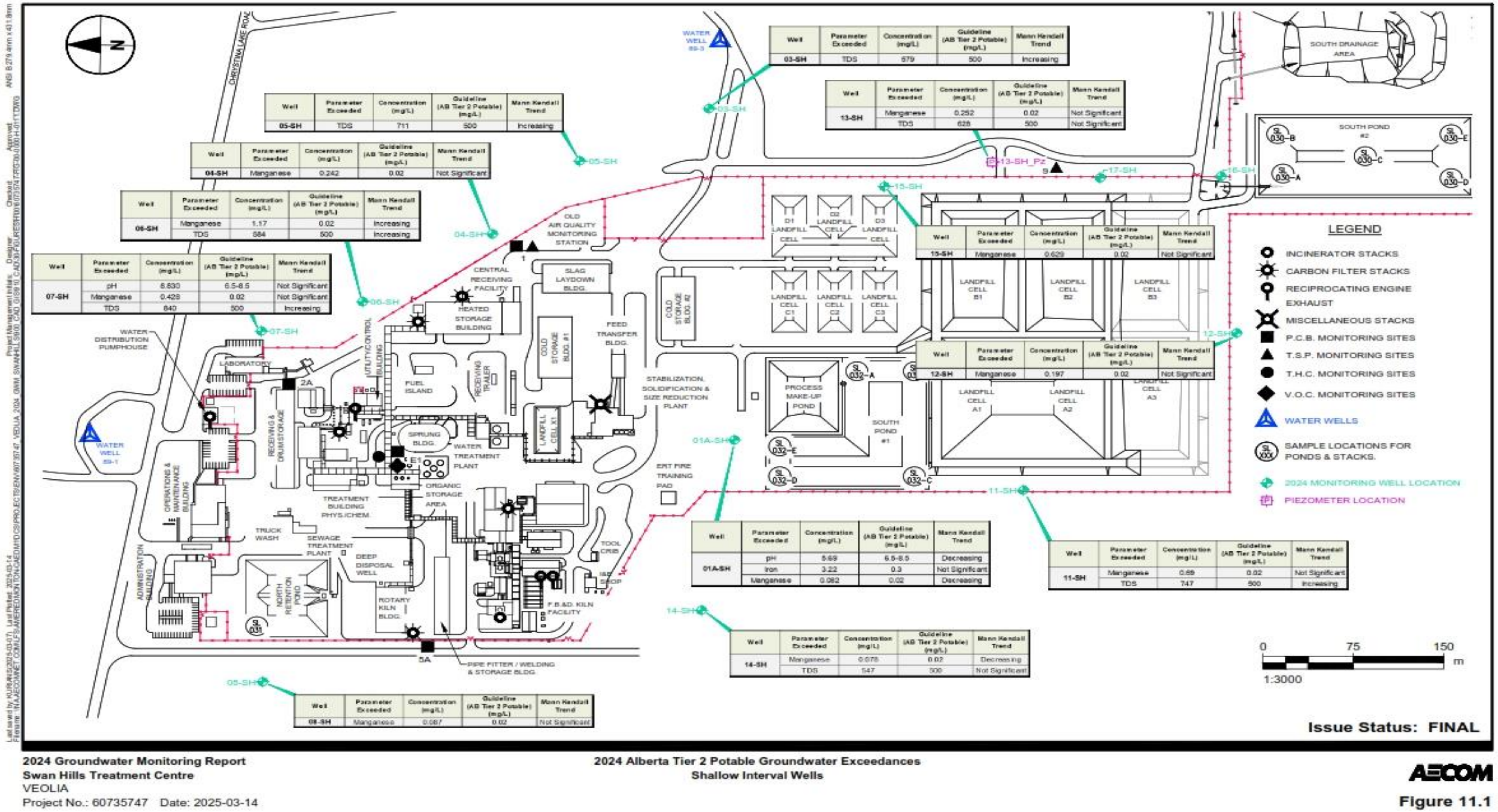
The following presents the key findings of the 2024 groundwater monitoring program. The specific locations are referenced by the well location number and its depth interval with the following designations (SH=Shallow, IN=Intermediate, SS=Sandstone). Well locations and notable results are presented in Figures 3-3 – 3-5:

Based on the 2024 groundwater monitoring, the following conclusions can be made:

- Petroleum hydrocarbon (BTEX, PHC F1) concentrations were below the laboratory detection limit for all wells sampled in 2024.
- Polychlorinated Biphenyl (PCB) Aroclor and total PCB concentrations were below the laboratory detection limit for all wells sampled in 2024.

- Adsorbable Organic Halogen (AOX) results were below the laboratory detection limit for all select wells tested
- Twelve of the wells completed in the till interval (shallow and intermediate wells) have Total Dissolved Solids (TDS) concentrations above the Alberta Tier II Potable Groundwater Guidelines. For all twelve wells these concentrations are consistent with baseline and/or historical observations, as well as expected TDS concentrations for a till lithology.
- Manganese concentrations exceeding the Alberta Tier II Potable Groundwater Guideline were observed in all monitoring wells except 03-SH, 03-IN, 05-SH, 08-IN, 13(R)SS, 16-SH, and 17-SH. Manganese concentrations have been measured since the 1990s and have typically exceeded the guideline in both up-gradient and down-gradient wells; therefore, it is likely naturally occurring. Manganese concentrations above the Alberta Tier II Potable Guideline for Commercial/Industrial Land Use (0.02 milligrams per litre; mg/L) in till are of little concern since this source is not capable of supporting a potable water supply.
- Elevated iron and manganese concentrations may be a result of biological activity. Orange and black residues and/or oxidation was noted on several bladder pumps and tubing during well maintenance in May 2014. Iron reducing bacteria (IRB) tests from 2015 confirmed the presence of anaerobic iron related and enteric bacteria in monitoring wells 01A-SH, 01A-IN, 04-IN, 04-SS, 07-SH, 07-IN, and 16-SH.
- The elevated chloride concentrations in 07-SH may be caused by infiltration of run-off containing road salt from the adjacent parking lot and road. Increasing chloride trends are observed in 01A-SH and 07-SH. Monitoring well 07-SH is located in a low-lying area adjacent to a road while 01A-SH is located on the plant site. Monitoring well 17-SH had an increase in chloride concentration in 2015 compared to historical results, but the level is well below the guideline and has been falling in the following years. Monitoring wells 05-SH and 13-SH have increasing trends but both are an order of magnitude below the guideline.
- Monitoring well MW-01A:
    - The TDS and major ion groundwater chemistry of 01A-SH and 01A-IN appears to be affected by rain and surface water infiltration.
    - High Dissolved Organic Carbon (DOC) concentrations may be a result of the composition of the engineered fill, as well as activity at the ERT Fire Training Pad. The high DOC probably results in anaerobic conditions in the monitoring well. It is noted that no Aroclor PCBs or petroleum hydrocarbons were detected in this well, thus the elevated DOC concentrations are from other compounds.

  - Sulphur odour and reduced pH in 01A-SH indicates the presence of sulphur reducing bacteria that is confirmed by the results of the sulphate reducing bacteria (SRB)
- Figures 3-3 to 3-5 show the groundwater sample locations and exceedances.



Well	Parameter Exceeded	Concentration (mg/L)	Guideline (AB Tier 2 Potable) (mg/L)	Mann Kendall Trend
05-SH	TDS	711	500	Increasing
04-SH	Manganese	0.242	0.02	Not Significant
06-SH	Manganese	1.17	0.02	Increasing
	TDS	884	500	Increasing
07-SH	pH	6.830	6.5-8.5	Not Significant
	Manganese	0.428	0.02	Not Significant
	TDS	840	500	Increasing
03-SH	TDS	579	500	Increasing
13-SH	Manganese	0.252	0.02	Not Significant
	TDS	628	500	Not Significant
15-SH	Manganese	0.629	0.02	Not Significant
12-SH	Manganese	0.197	0.02	Not Significant
01A-SH	pH	5.69	6.5-8.5	Decreasing
	Iron	3.22	0.3	Not Significant
	Manganese	0.082	0.02	Decreasing
11-SH	Manganese	0.69	0.02	Not Significant
	TDS	747	500	Increasing
14-SH	Manganese	0.078	0.02	Decreasing
	TDS	547	500	Not Significant
08-SH	Manganese	0.087	0.02	Not Significant

Figure 3-3: 2024 Alberta Tier 2 Potable Groundwater Exceedances Shallow Interval Wells (AECOM Figure 11.1)

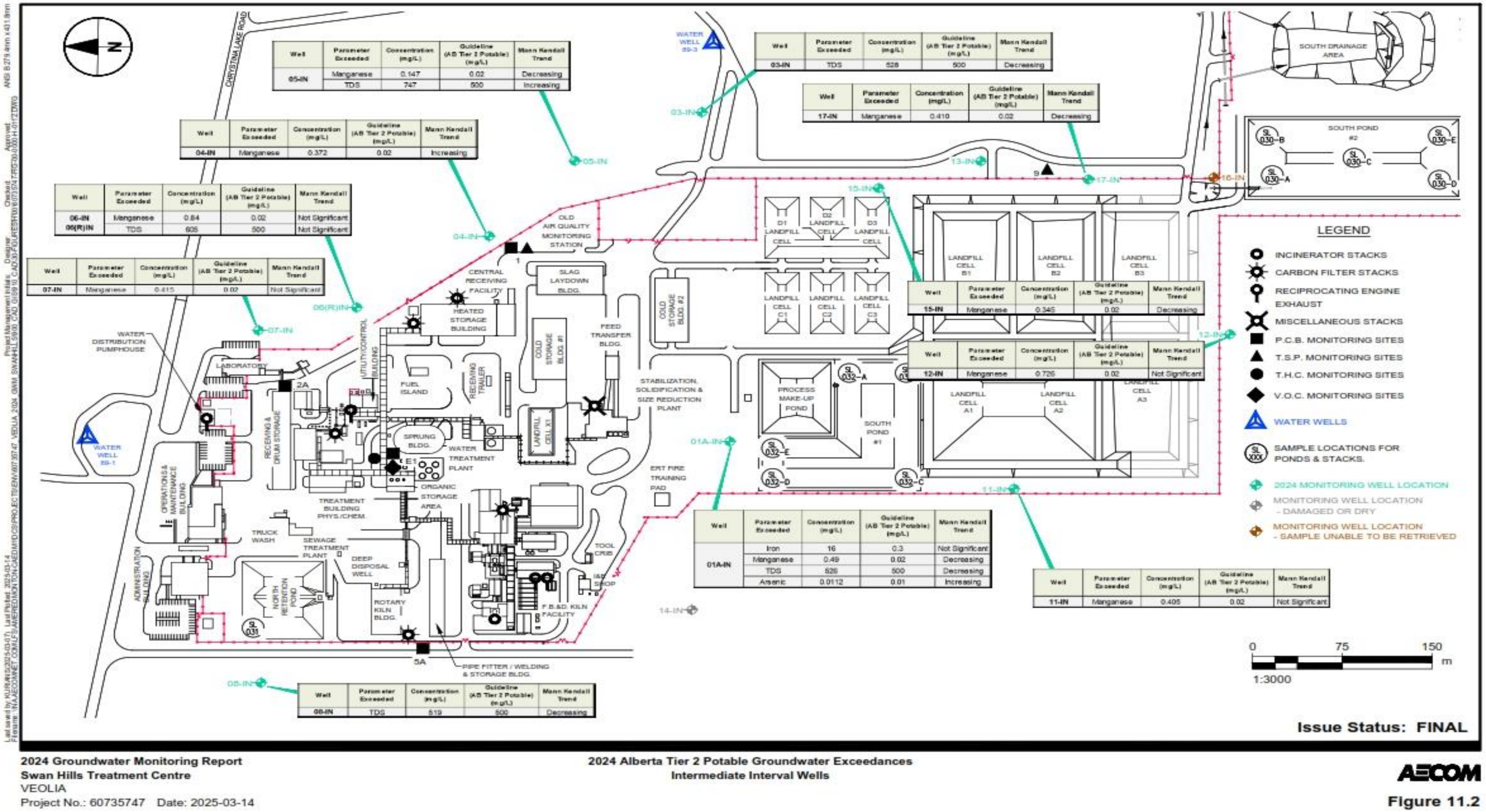
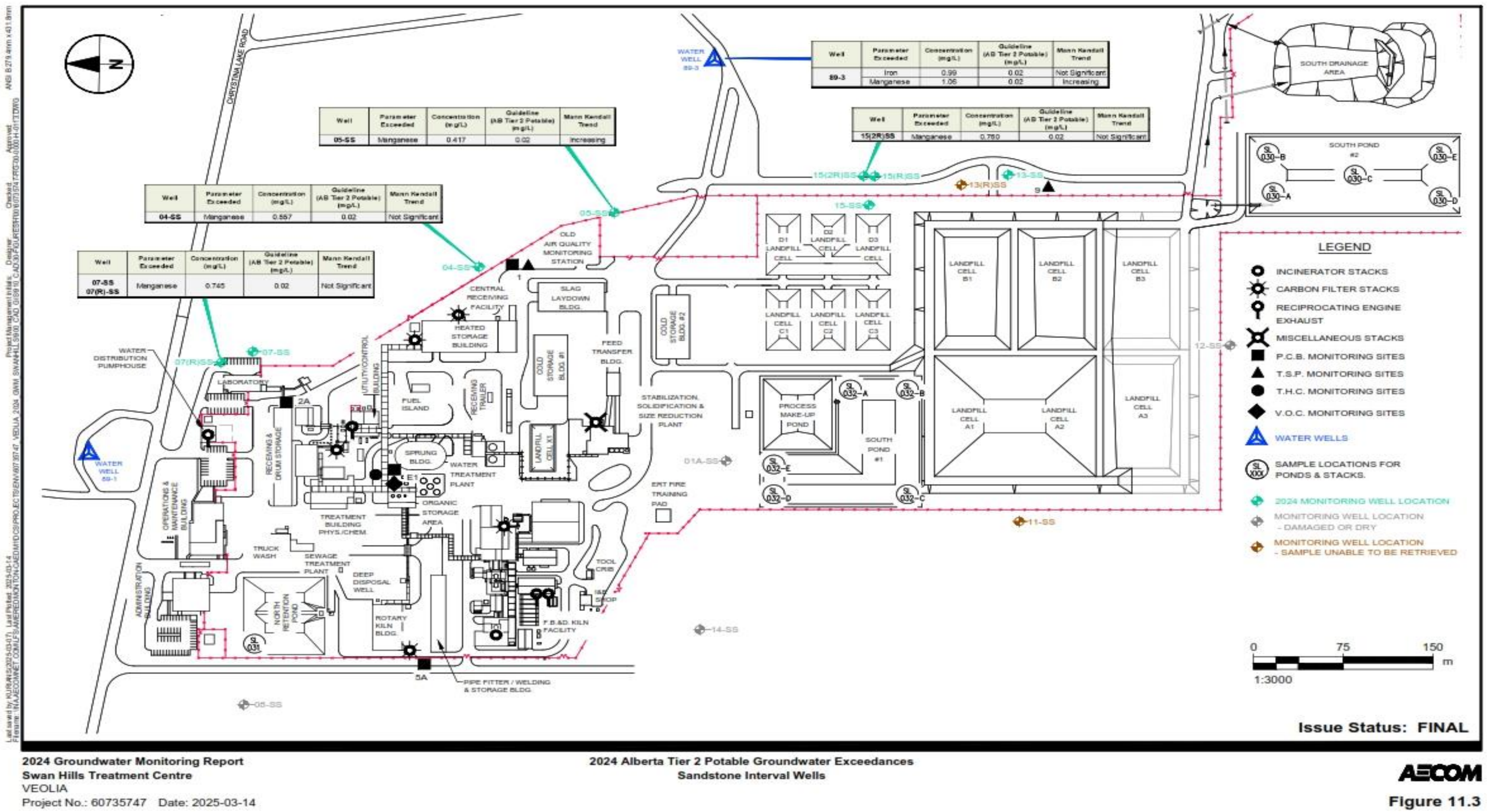


Figure 3-4: 2024 Alberta Tier 2 Potable Groundwater Exceedances Intermediate Interval Wells (AECOM Figure 11.2)



Well	Parameter Exceeded	Concentration (mg/L)	Guideline (AB Tier 2 Potable) (mg/L)	Mann Kendall Trend
89-3	Iron	0.99	0.02	Not Significant
	Manganese	1.06	0.02	Increasing

Well	Parameter Exceeded	Concentration (mg/L)	Guideline (AB Tier 2 Potable) (mg/L)	Mann Kendall Trend
15(2R)SS	Manganese	0.760	0.02	Not Significant

Well	Parameter Exceeded	Concentration (mg/L)	Guideline (AB Tier 2 Potable) (mg/L)	Mann Kendall Trend
05-SS	Manganese	0.417	0.02	Increasing

Well	Parameter Exceeded	Concentration (mg/L)	Guideline (AB Tier 2 Potable) (mg/L)	Mann Kendall Trend
04-SS	Manganese	0.557	0.02	Not Significant

Well	Parameter Exceeded	Concentration (mg/L)	Guideline (AB Tier 2 Potable) (mg/L)	Mann Kendall Trend
07-SS 07(R)-SS	Manganese	0.745	0.02	Not Significant

Figure 3-5: 2024 Alberta Tier 2 Potable Groundwater Exceedances Sandstone Interval Wells (AECOM Figure 11.3)

4 TERRESTRIAL ENVIRONMENT

The objective of the terrestrial environmental monitoring program is to assess changes in concentrations of chemicals of concern in the forested area surrounding the SHTC with emphasis on vegetation, soils and wildlife

Based on previous monitoring results, elevated PCB, dioxin (PCDD), and furan (PCDF) concentrations in the live moss, Labrador tea leaves and vole tissue near the SHTC are primarily related to fugitive emissions from the SHTC. Compounds measured in the live moss layer are representative of the cumulative accumulation of these compounds via atmospheric deposition over a period of several years. Labrador tea renews its leaves annually and therefore, results are representative of compounds deposited from the atmosphere over a one-year exposure period (June 2023 – June 2024). Compounds detected in vole tissue are a result of exposure to all potential pathways including inhalation, food consumption and dermal contact throughout their life span. Samples are collected in early June and focus on collection of mature, over-wintering adults.

4.1 Soil and Vegetation

The 2024 program included:

- Assessing changes in chemical concentrations within 10 annual monitoring plots and 22 expanded program monitoring plots by collecting vegetation samples and comparing the analytical results to those of previous sampling events.
    - Samples of moss and Labrador tea leaves were collected from each plot and analyzed for inorganic and organic parameters.
- Collecting moss bags from 15 moss bag plots and deploying unexposed moss bags at these plots for collection in the following year.
- Assessing lichen health at the 15 moss bag plot locations to determine if emissions from the SHTC are having a deleterious effect on air quality as it relates to lichen health.
- Collecting moss bags from three additional sites situated around the SHTC's fenceline.
- Archived total suspended particulate (TSP) filter samples from 2023 were also analyzed for metals.
- Completing plot maintenance on those plots with identified maintenance issues.

Overall, the monitoring program indicates that historical emissions from the facility have caused certain metals and polychlorinated compounds to accumulate in the surrounding terrestrial environment. However, current emissions from the SHTC do not appear to be leading to continued accumulation in the surrounding environment, except for zinc in the live moss. In 2024 zinc and TEQ concentrations in the Labrador tea decreased to pre-fire (pre-2023) levels and concentrations in the live moss did not increase substantially between 2022 and 2024; the monitoring data reported in 2024 indicates that the effect of the 2023 wildfires on metallic and polychlorinated compounds was transient. The reduced activity at the SHTC also may be further reducing emissions to the surrounding terrestrial environment.

Figure 4-1: Location of Soil and Vegetation Monitoring Sites

The following summarizes the results for 2024

Live Moss

- Concentrations of metals (one or more of aluminum, antimony, arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, silver, tin, and zinc) have been elevated at plots near the SHTC (plots 4, 109, and 114). Metal concentrations are below the *Alberta Tier 1 Soil and Groundwater Remediation Guidelines* (Tier 1; EPA 2024) protective of the eco soil contact pathway providing assurance that current metal levels are not affecting plant productivity and health.
    - Cadmium is increasing at Plot 114 but it still within its historical range and similar fluctuations in cadmium levels have occurred in the past.
    - Zinc concentrations have increased at plots near the SHTC (Plots 4, 109, 114, 117, and 123), although concentrations have stabilized in recent years.
- Polychlorinated organic compounds (PCBs and total TEQ) are most elevated at the plots surrounding the SHTC Plots 4, 11, 109, 110, and 114, but concentrations are decreasing in the live moss.

Soils

- Samples collected from the underlying organic and mineral soil (0 to 15 cm depth) confirmed that PCBs are sequestered in the organic layer at the surface of the forest floor.

Labrador Tea

- The concentration of antimony, arsenic, cadmium, lead, molybdenum, nickel, and zinc were elevated at the plots near the SHTC, which is consistent with historical results. Overall, the rate or magnitude of metal deposition near the SHTC may be somewhat elevated relative to background locations.
    - Zinc concentrations increased in the Labrador tea leaves collected in June 2023, however, zinc concentrations in Labrador tea leaves collected in 2024 decreased to pre-fire (2022) levels indicating any increase in zinc concentrations was transient.
- TEQ values in the Labrador tea leaves increased substantially in 2023 due to the wildfires. In 2024 TEQ concentrations decreased to pre-wildfire (2022) levels.
- PCBs and the total TEQ value in the Labrador tea surrounding the SHTC is decreasing over time.

Table 4-1: 2024 Live Moss Results - PCBB/PCDF, PCB, and TEQ

TABLE 4-1

Live Moss Quality Results - PCDD/PCDF, PCB, and TEQ[1]

Veolia

W ½ 06-067-08 W5M

Sample Point	Sample Date	PCBs mg/kg	PCB TEQ ng TEQ/kg	PCDD/PCDF TEQ ng TEQ/kg	Total TEQ ng TEQ/kg
Live Moss					
Plot 4	29-May-24	0.199	26.2	4.21	30.41
Plot 11	28-May-24	0.017	2.32	0.761	3.081
Plot 70	30-May-24	0.000092	0.0178	0.277	0.2948
Plot 71	30-May-24	0.000104	0.0247	0.222	0.247
Plot 109	29-May-24	0.091	11.9	3.05	14.95
Plot 110	29-May-24	0.0110	1.34	0.871	2.211
Plot 114	30-May-24	0.034	3.51	0.804	4.314
Plot 117	30-May-24	0.0091	0.98	0.439	1.419
Plot 123	28-May-24	0.0027	0.394	0.368	0.762
Plot 402	27-May-24	0.00043	0.0296	0.232	0.2616

Notes:

[1] - a value equal to 1/2 the detection limit was used for all non-detected congeners to calculate sample TEQ.

Table 4-2 and Table 4-3: Historical Live Moss Results - PCB, and Total TEQ

TABLE 4-2

Historical Moss Quality Results - PCB Concentrations (Congeners) - mg/kg
Veolia
W ½ 06-067-08 W5M

Date	Plot 4	Plot 11	Plot 70	Plot 71	Plot 109	Plot 110	Plot 114	Plot 117	Plot 123	Plot 402
May-06	1.90	0.11	0.0021	0.0012	0.36	0.042	0.21	0.058	0.014	0.0053
Jun-07	0.77	0.17	0.0017	0.0012	0.27	0.027	0.69	0.045	0.011	0.0023
May-08	0.96	0.14	0.0013	0.0040	0.50	0.037	0.097	0.033	0.015	0.0064
Jun-08	0.96	0.14	0.0013	0.0040	0.50	0.037	0.097	0.033	0.015	0.0064
Jun-09	1.05	0.065	0.0013	0.00085	0.27	0.020	0.19	0.037	0.011	0.0020
Jul-09	0.86	0.093	0.024	0.0025	0.47	0.032	0.22	0.051	0.015	0.0057
May-10	1.95	0.19	0.0020	0.0023	0.60	0.066	0.35	0.070	0.010	0.0027
May-11	1.73	0.19	0.0036	0.0017	0.76	0.052	0.50	0.14	0.024	0.0039
Jun-12	1.62	0.17	0.00077	ND	0.61	0.034	0.24	0.035	0.0035	0.0011
Jun-13	1.98	0.14	0.0031	0.0022	0.72	0.038	0.38	0.10	0.020	0.0068
May-14	0.34	0.017	0.00096	0.00023	0.24	0.0063	0.087	0.013	0.00055	0.00068
Jun-15	0.98	0.12	0.00051	0.00095	0.54	0.015	0.17	0.066	0.011	0.0019
May-16	0.44	0.026	0.00013	0.00014	0.16	0.0046	0.13	0.016	0.0040	0.00068
Jun-17	0.88	0.074	0.00014	0.00029	0.51	0.017	0.064	0.036	0.0048	0.0013
May-18	1.09	0.056	0.00052	0.00012	0.75	0.013	0.20	0.026	0.011	0.0014
May-19	0.86	0.051	0.00046	0.00028	0.35	0.010	0.14	0.028	0.003	0.0014
Jun-20	0.43	0.029	0.00020	0.00014	0.21	0.004	0.04	0.006	0.013	0.0019
Jun-22	0.22	0.017	0.00014	0.00019	0.09	0.003	0.04	0.004	0.002	0.0017
Jun-23	0.16	0.024	0.00007	0.00007	0.07	0.002	0.04	0.005	0.001	0.0003
May-24	0.20	0.017	0.00009	0.00010	0.09	0.011	0.03	0.009	0.003	0.0004

TABLE 4-3

Historical Moss Quality Results - Total TEQ - ng TEQ/kg[1]
Veolia
W ½ 06-067-08 W5M

Date	Plot 4	Plot 11	Plot 70	Plot 71	Plot 109	Plot 110	Plot 114	Plot 117	Plot 123	Plot 402
May-06	272.99	38.36	0.52	0.48	75.11	13.64	37.92	12.06	3.89	0.55
Jun-07	157.73	33.34	0.50	0.36	55.5	4.04	58.42	9.73	3.87	0.48
May-08	206.89	38.64	2.01	2.21	117.52	9.87	16.12	7.69	4.77	2.06
Jun-08	222.57	41.33	1.83	1.81	126.09	10.80	17.45	7.70	4.59	1.88
Jun-09	230.88	21.21	0.78	0.42	76.41	7.30	36.43	8.36	3.42	0.38
Jul-09	118.13	18.22	1.84	0.32	84.33	6.00	25.31	7.40	3.35	0.94
May-10	174.27	36.85	1.46	0.86	79.01	9.77	39.83	8	1.39	0.80
May-11	157.10	28.68	1.21	0.23	72.19	8.73	48.17	14.58	3.74	0.61
Jun-12	231.17	36.19	0.79	0.76	78.94	9.85	33.59	1.46	0.67	2.73
Jun-13	277.78	26.38	0.95	0.22	109.50	6.85	41.72	13.33	5.96	0.56
May-14	115.40	13.63	5.37	0.72	75.90	7.00	31.20	4.02	1.78	1.19
Jun-15	138.40	29.00	0.61	0.69	75.20	3.38	27.02	12.12	2.44	1.27
May-16	53.80	4.43	0.21	0.29	19.86	1.14	12.77	2.14	0.76	0.21
Jun-17	131.70	16.88	0.30	0.26	81.50	4.98	9.47	6.16	1.06	0.35
May-18	170.40	10.27	0.40	0.16	151.30	2.87	28.29	4.33	1.70	0.45
May-19	130.00	10.82	0.68	0.23	58.80	2.95	23.93	5.23	0.74	0.53
Jun-20	58.75	4.41	0.14	0.25	28.93	0.81	5.50	0.96	2.45	0.59
Jun-22	29.49	1.93	0.24	0.14	10.46	0.56	3.93	0.50	0.44	0.44
Jun-23	22.86	4.42	0.24	0.13	10.01	0.53	4.51	0.87	0.34	0.24
May-24	30.41	3.08	0.29	0.25	14.95	2.21	4.31	1.42	0.76	0.26

Notes:
ND - results reported as zero in lab report
[1] - a value equal to 1/2 the detection limit was used fo all non-detected congeners to calculate sample TEQ. Prior to 2014 a value of zero was used for all non-detected congeners.

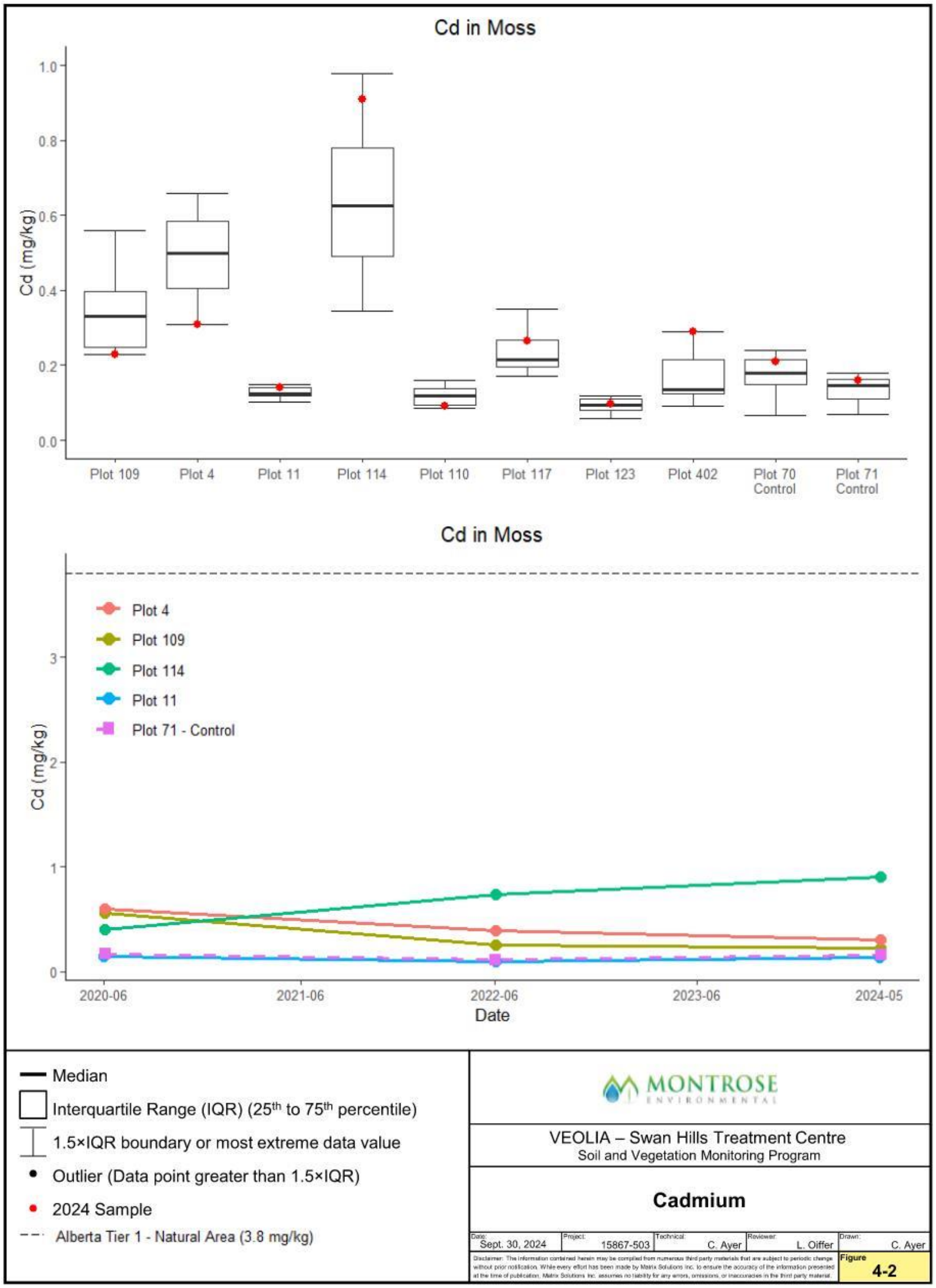


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Figure 4-2: Cadmium in Live Moss Box Plots

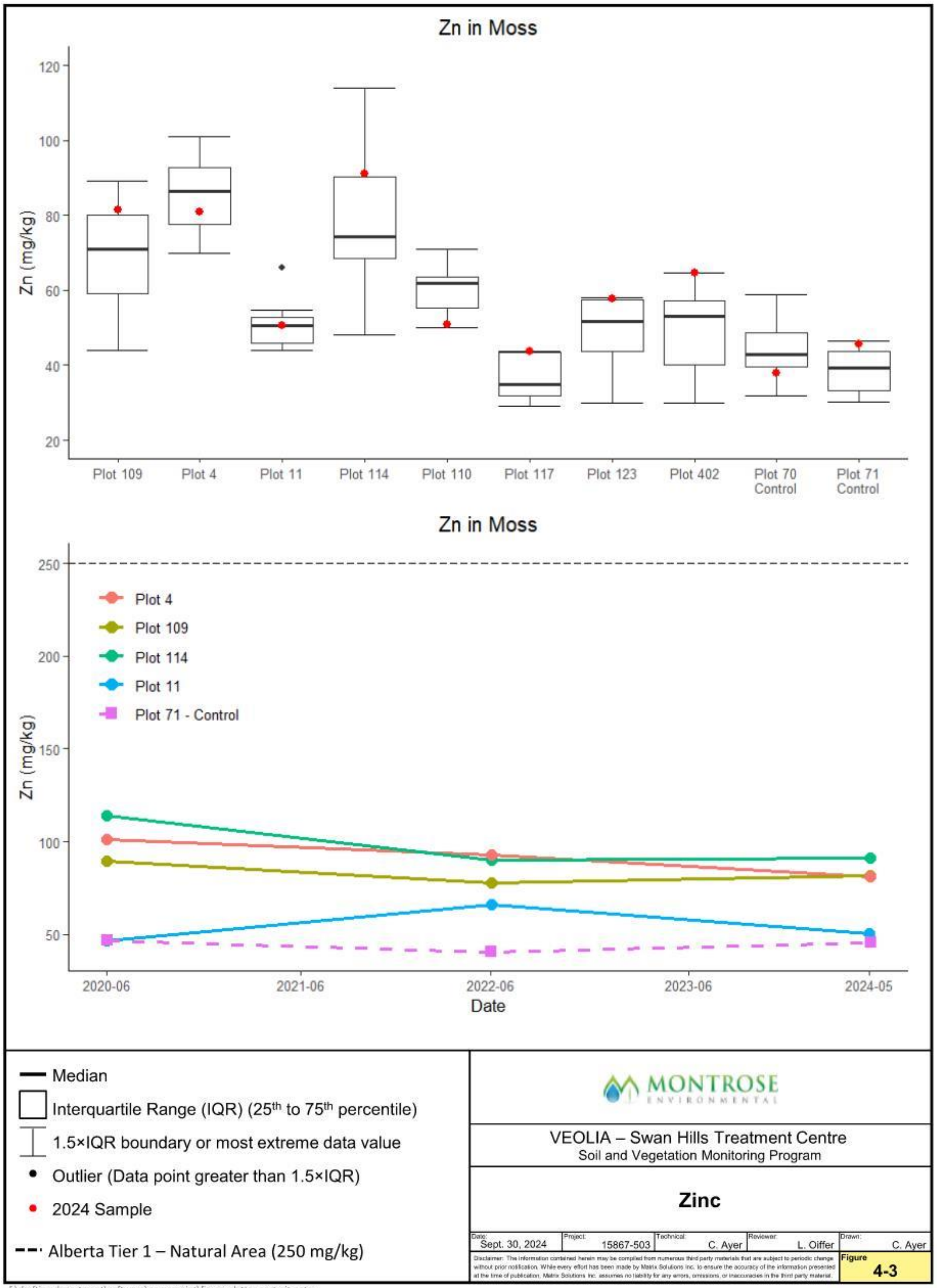

Figure 4-3: Zinc in Live Moss Box Plots

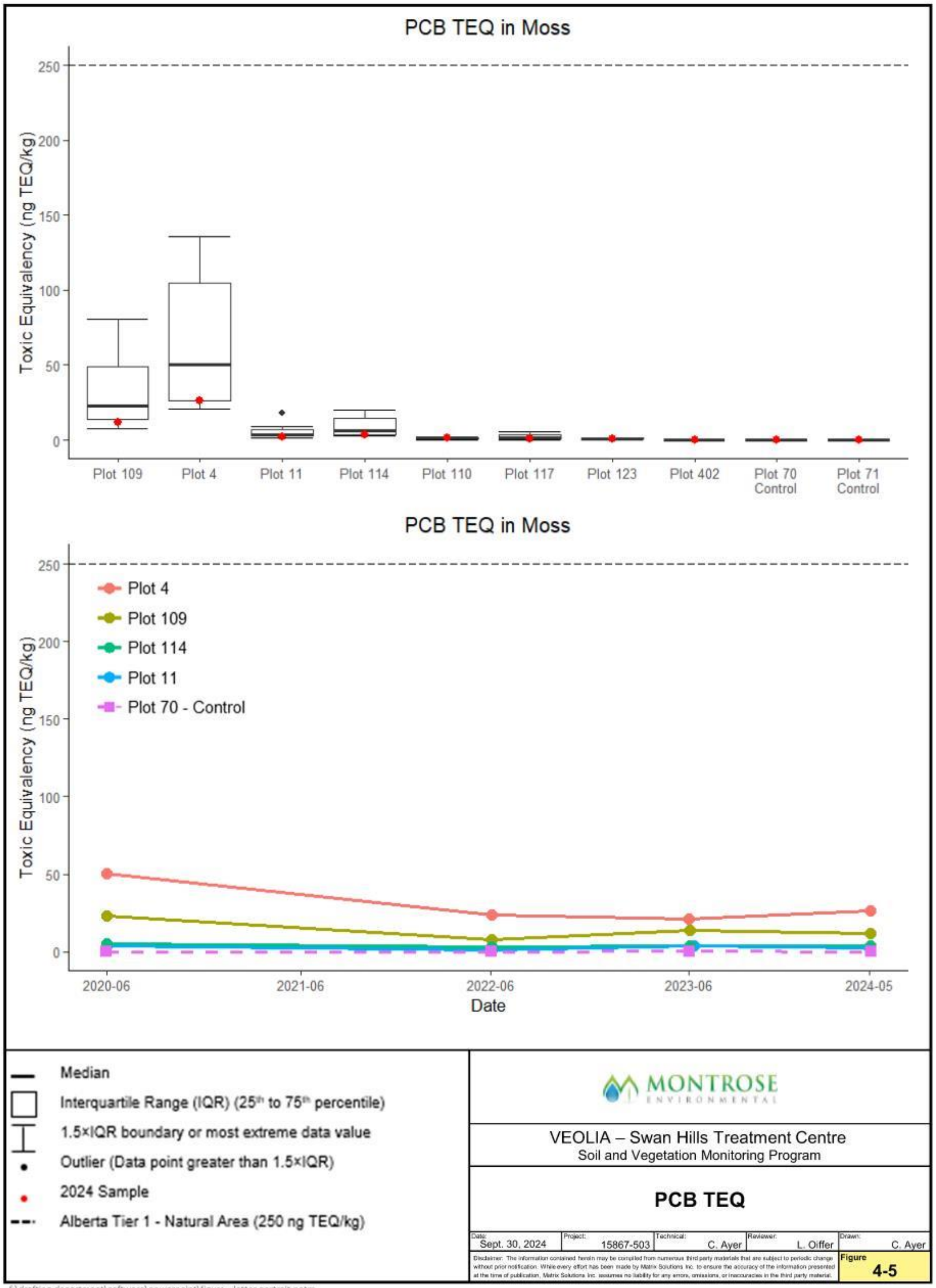

Figure 4-4: PCB TEQ in Live Moss Box Plots

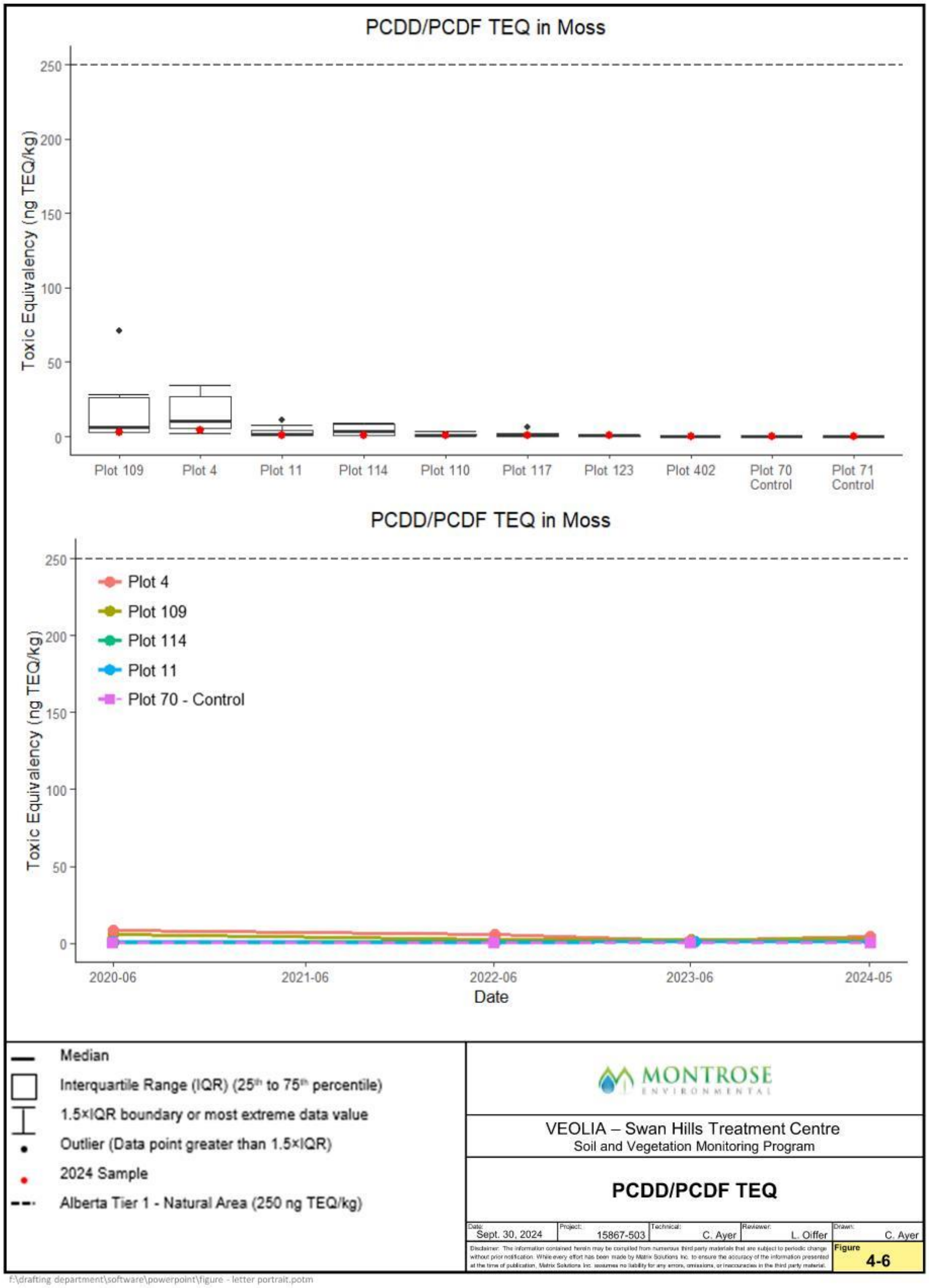

Figure 4-5: PCDD/PCDF TEQ in Live Moss Box Plots

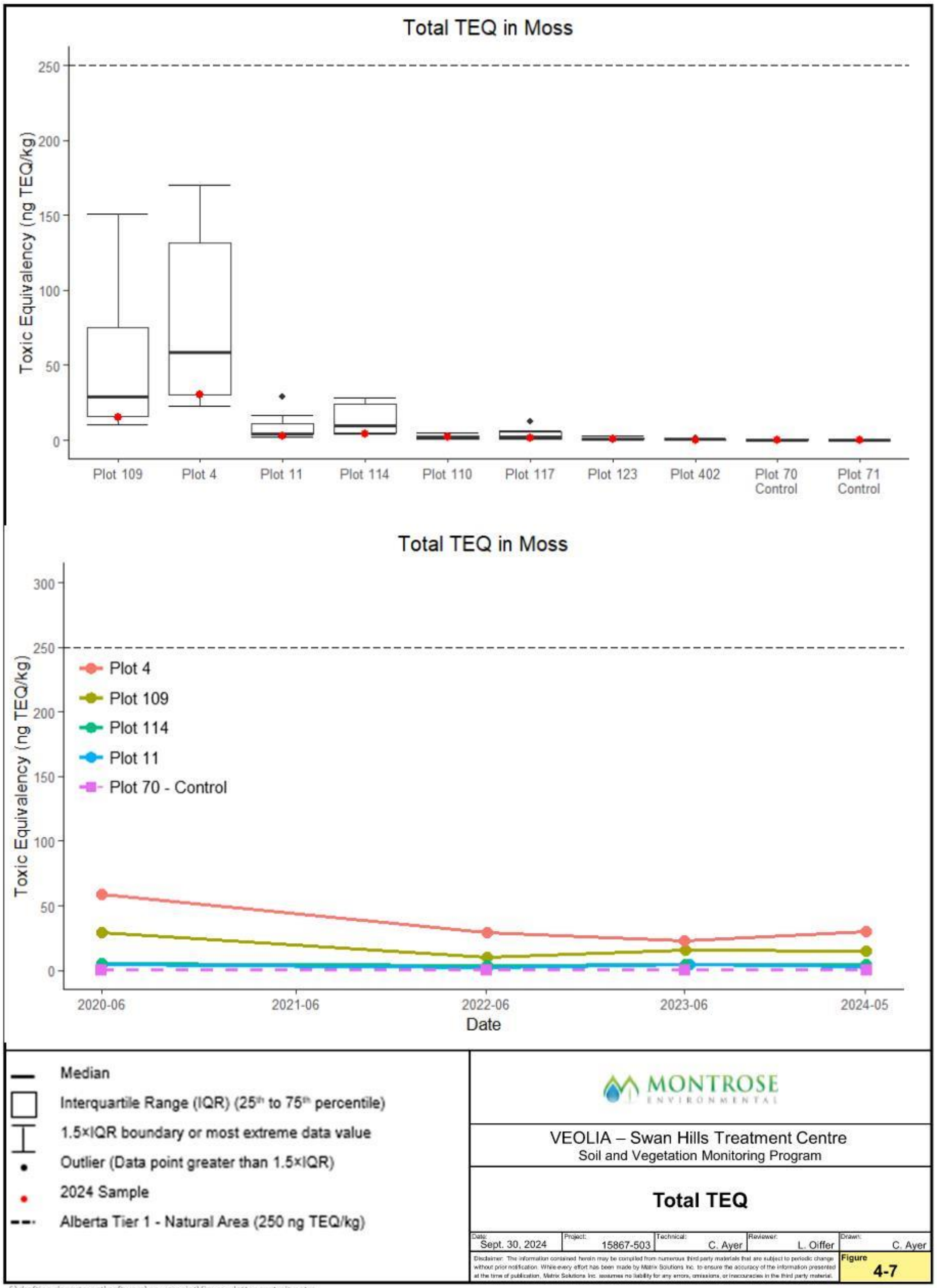

Figure 4-6: Total TEQ in Live Moss Box Plots

Table 4-4: 2024 Labrador Tea Results - PCBB/PCDF, PCB, and TEQ

TABLE 4-4

Labrador Tea Quality Results - PCDD/PCDF, PCD, and TEQ[1]
Veolia
W ½ 06-067-08 W5M

Sample Point	Sample Date	PCBs mg/kg	PCB TEQ ng TEQ/kg	PCDD/PCDF TEQ ng TEQ/kg	Total TEQ ng TEQ/kg
Labrador Tea Leaves					
Plot 4	29-May-24	0.0428	5.95	0.797	6.75
Plot 11	28-May-24	0.00343	0.922	0.463	1.39
Plot 70	30-May-24	0.000342	0.208	0.711	0.92
Plot 71	30-May-24	0.000223	0.195	0.714	0.91
Plot 109	29-May-24	0.0104	1.26	0.617	1.88
Plot 110	29-May-24	0.00141	0.162	0.485	0.65
Plot 114	30-May-24	0.00896	1.49	0.542	2.03
Plot 117	30-May-24	0.00248	0.189	0.608	0.80
Plot 123	28-May-24	0.000818	0.254	0.861	1.12
Plot 402	27-May-24	0.000558	0.203	0.91	1.11

Notes:
[1] - a value equal to 1/2 the detection limit was used for all non-detected congeners to calculate sample TEQ.

Table 4-5 and Table 4-6: Historical Labrador Tea Results - PCB, and Total TEQ

TABLE 4-5

Historical Labrador Tea Quality Results - PCB Concentrations (Congeners) - mg/kg

Veolia

W ½ 06-067-08 W5M

Date	Plot 4	Plot 11	Plot 70	Plot 71	Plot 109	Plot 110	Plot 114	Plot 117	Plot 123	Plot 402
May-06	0.15	0.025	0.0034	0.0028	0.076	0.0080	0.060	0.013	0.0050	0.0029
Jun-07	0.23	0.093	0.014	0.026	0.13	0.036	0.10	0.039	0.021	0.020
May-08	0.30	0.025	0.0035	0.010	0.15	0.013	0.075	0.021	0.0089	0.010
Jun-08	0.30	0.025	0.0035	0.010	0.15	0.013	0.075	0.021	0.0089	0.010
Jun-09	0.24	0.020	0.0038	0.00093	0.052	0.0077	0.069	0.014	0.0050	0.0029
Jul-09	0.22	0.049	0.0028	0.027	0.42	0.015	0.075	0.012	0.0081	0.012
May-10	0.52	0.067	0.0057	0.0028	0.41	0.015	0.21	0.035	0.0084	0.0040
May-11	0.25	0.046	0.0026	0.00089	0.24	0.024	0.12	0.021	0.0039	0.0015
Jun-12	0.44	0.021	0.0057	0.00022	0.17	0.0023	0.052	0.0055	0.0012	ND
Jun-13	0.30	0.023	0.0020	0.0022	0.21	0.013	0.052	0.011	0.0026	0.0027
May-14	0.19	0.024	0.00024	0.00018	0.10	0.0072	0.037	0.0059	0.0020	0.00076
Jun-15	0.19	0.020	0.00028	0.00010	0.11	0.0062	0.041	0.0053	0.0013	0.00064
May-16	0.13	0.011	0.00015	0.000092	0.049	0.0027	0.021	0.0073	0.0017	0.00049
Jun-17	0.10	0.0076	0.00014	0.00016	0.073	0.0035	0.017	0.0052	0.0012	0.00041
May-18	0.065	0.0074	0.00031	0.00030	0.028	0.0032	0.013	0.0032	0.00080	0.00036
May-19	0.071	0.0051	0.00015	0.00019	0.026	0.0016	0.010	0.0022	0.00060	0.00030
Jun-20	0.062	0.0048	0.00018	0.00007	0.024	0.0016	0.010	0.0026	0.00079	0.00032
Jun-21	0.063	0.0048	0.00033	0.00144	0.018	0.0016	0.012	0.0025	0.00059	0.00064
Jun-22	0.035	0.0050	0.00045	0.00044	0.025	0.0017	0.008	0.0028	0.00089	0.00057
Jun-23	0.068	0.0113	0.00159	0.00131	0.038	0.0034	0.020	0.0078	0.00176	0.00073
May-24	0.043	0.0034	0.00034	0.00022	0.010	0.0014	0.009	0.0025	0.00082	0.00056

TABLE 4-6

Historical Labrador Tea Quality Results - Total TEQ - ng TEQ/kg[1]

Veolia

W ½ 06-067-08 W5M

Date	Plot 4	Plot 11	Plot 70	Plot 71	Plot 109	Plot 110	Plot 114	Plot 117	Plot 123	Plot 402
May-06	40.50	0.76	0.62	0.50	10.75	0.26	8.92	0.67	0.74	0.29
Jun-07	36.60	5.24	0.57	0.33	10.72	0.71	12.24	0.64	0.37	0.35
May-08	31.20	4.14	0.29	1.16	13.59	1.33	8.34	1.82	1.33	0.20
Jun-08	34.90	4.12	0.31	1.63	15.45	1.45	9.41	2.03	1.89	0.20
Jun-09	33.17	3.35	0.49	0.16	5.39	0.57	6.84	1.40	0.38	0.18
Jul-09	8.51	1.19	0.86	0.67	13.29	0.65	4.90	0.81	0.88	0.67
May-10	46.13	8.44	0.72	0.64	31.99	0.51	23.06	3.42	0.98	0.20
May-11	28.70	4.35	0.14	0.16	20.05	4.04	10.59	2.52	0.13	0.13
Jun-12	66.53	1.14	2.86	0.94	1.50	0.32	0.87	0.88	0.93	1.11
Jun-13	43.16	3.64	0.22	0.20	27.63	0.46	7.18	0.47	0.29	0.50
May-14	29.90	4.10	0.46	0.64	12.59	1.59	5.80	0.58	0.71	0.55
Jun-15	23.00	2.79	0.21	0.19	14.93	1.01	5.62	0.85	0.31	0.31
May-16	18.26	2.20	0.14	0.55	6.76	1.19	2.74	0.89	0.90	0.80
Jun-17	15.11	1.53	0.38	0.40	8.39	1.28	3.98	1.45	0.73	1.58
May-18	10.88	1.28	0.28	0.40	4.46	1.26	1.97	2.09	2.46	0.55
May-19	12.56	1.48	0.17	1.22	3.93	1.00	2.34	1.33	1.36	1.24
Jun-20	8.76	1.05	0.54	0.12	2.86	0.31	1.34	0.52	0.29	0.41
Jun-21	8.35	0.88	0.58	0.96	3.21	1.93	3.45	1.08	1.41	2.16
Jun-22	4.24	1.19	0.68	0.89	2.26	0.77	1.01	0.78	0.60	0.75
Jun-23	18.92	6.71	6.68	9.07	8.32	2.64	5.76	10.32	6.78	4.62
May-24	6.75	1.39	0.92	0.91	1.88	0.65	2.03	0.80	1.12	1.11

Notes:

ND - results reported as zero in lab report

[1] - a value equal to 1/2 the detection limit was used fo all non-detected congeners to calculate sample TEQ. Prior to 2014 a value of zero was used for all non-detected congeners.

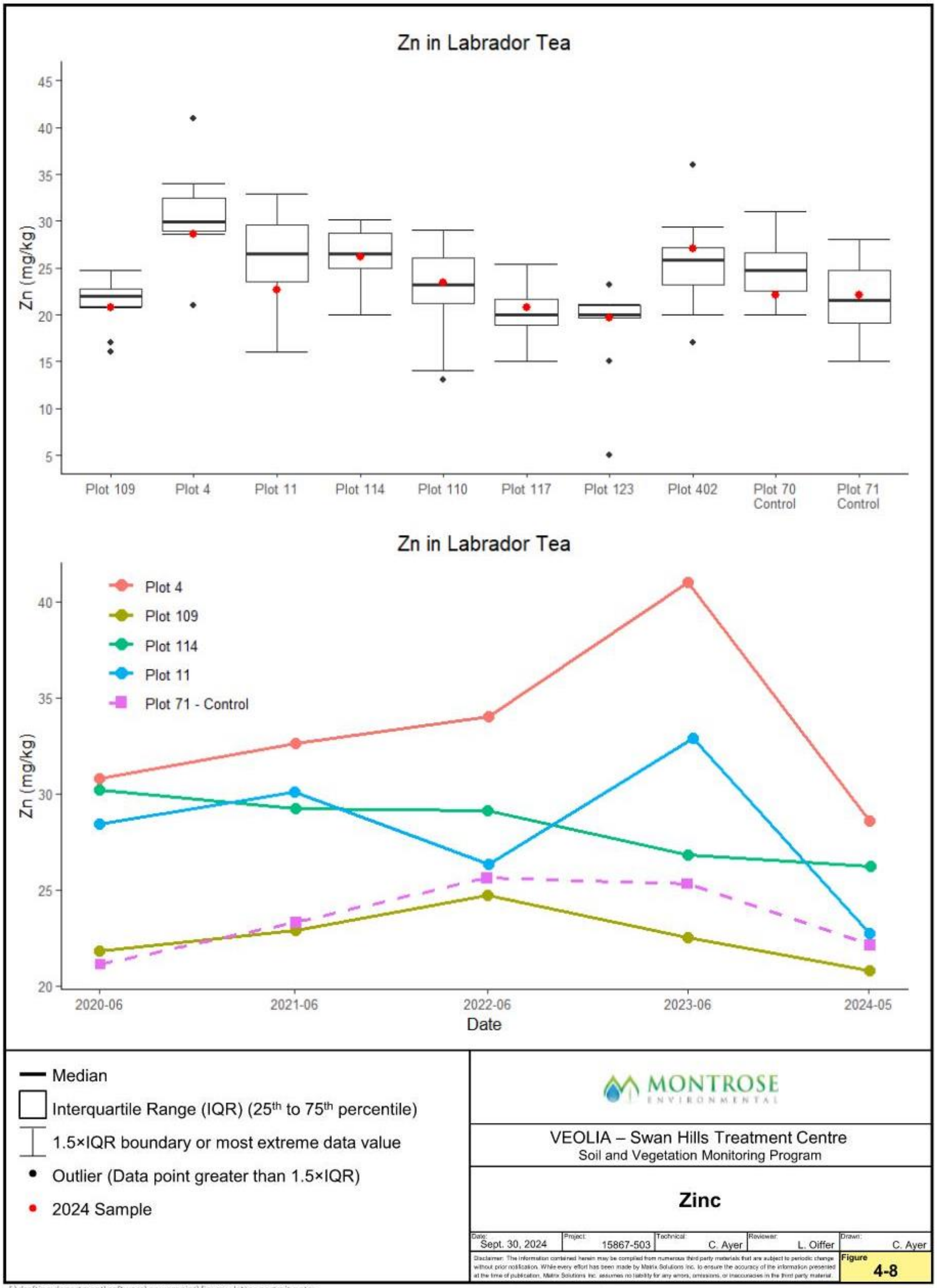

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Figure 4-7: Zinc in Labrador Tea Box Plots

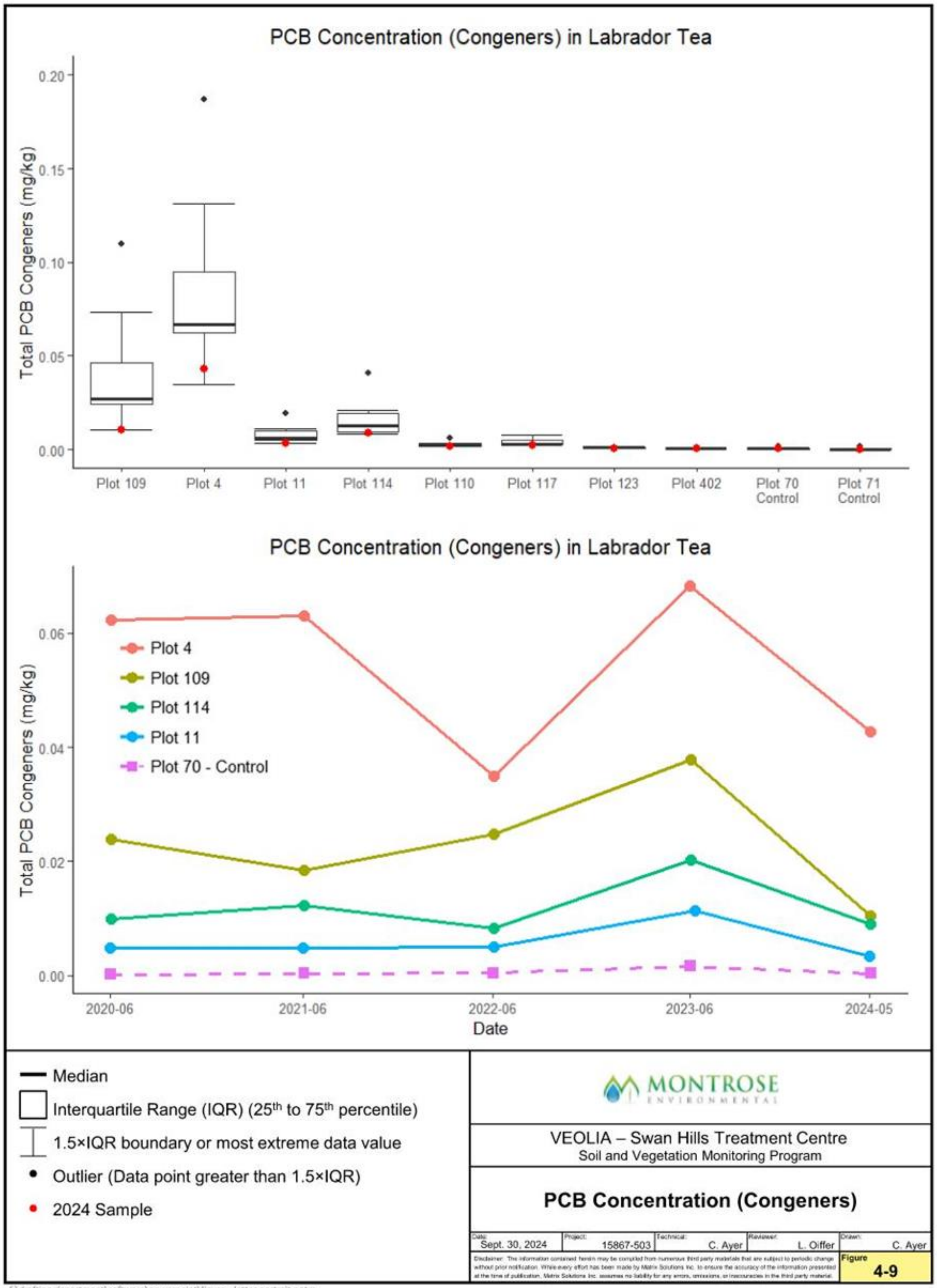

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Figure 4-8: PCB Concentration in Labrador Tea Box Plots

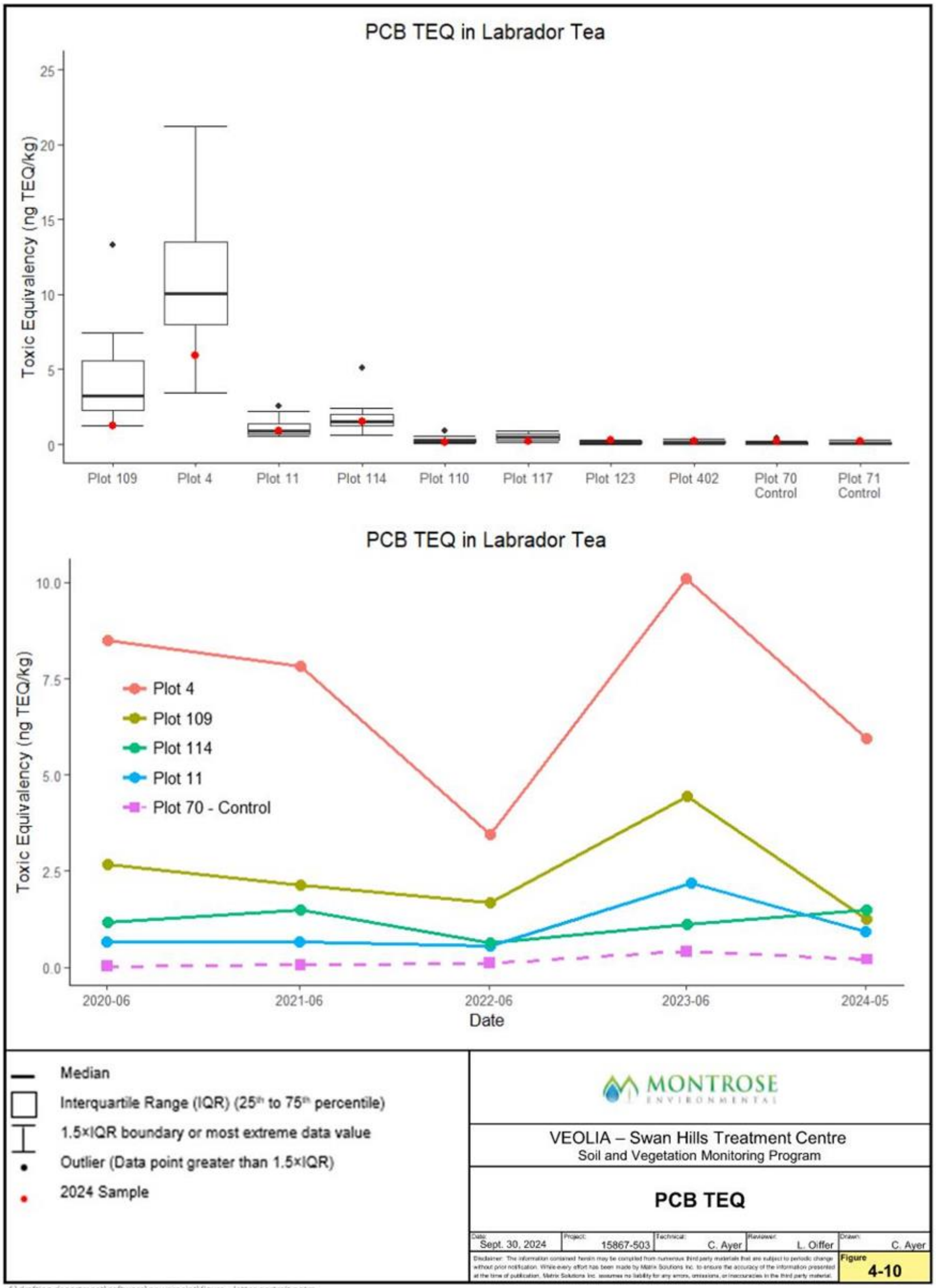

Figure 4-9: PCB TEQ in Labrador Tea Box Plots

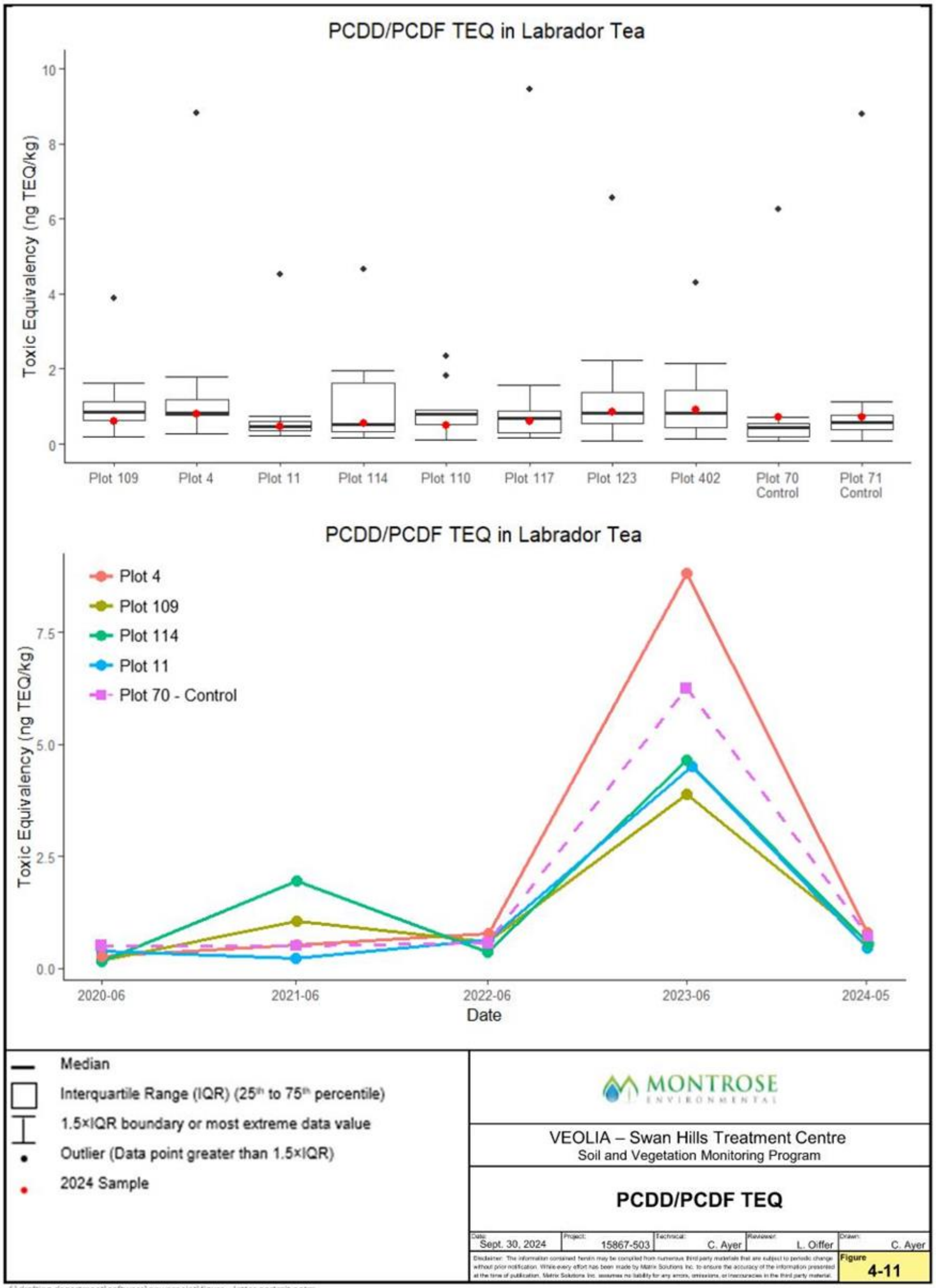

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Figure 4-10: PCDD/PCDF TEQ in Labrador Tea Box Plots

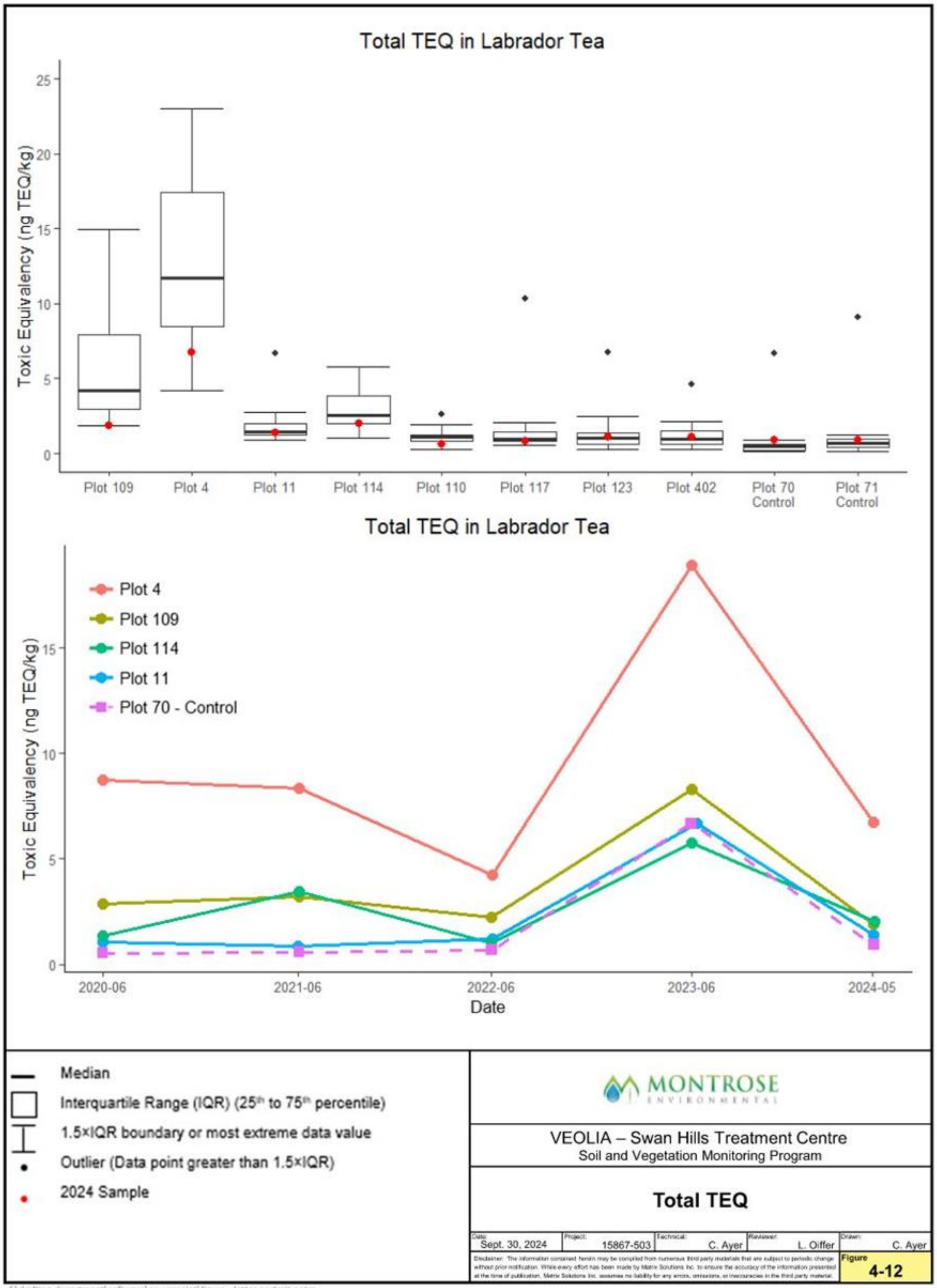

Figure 4-11: Total TEQ in Labrador Tea Box Plots

4.2 Vole Tissue Chemistry and Population Monitoring

During 2024, the wildlife monitoring program was initially conducted on an annual basis on 3 population and 10 tissue collection plots although in 2000, the scope of monitoring program was changed so that plots monitored prior to 2000 (10 population and 24 tissue collection plots, refer to Figure 4-12) would be included as part of an expanded monitoring program once every 5 years. However, based on recommendations made in the 2023 annual monitoring report (WMC 2024), sampling effort of the expanded monitoring program was reduced to focus on the 3 annually monitored population plots (Plots 11, 114, 70) and the 10 annually monitored tissue collection plots (Plots 11, 109, 4, 110, 114, 123, 117, 402, 70, 71). If warranted in the future, plots previously part of the expanded monitoring program (10 population and 24 tissue collection plots) would be sampled in the event of an upset at the SHTC based on the key trigger responses developed for red-backed voles. Therefore, the 2024 expanded wildlife monitoring program was focused on demographic studies of voles on 3 live-trapping plots in June and September (Table 4-7) while concentrations of Aroclor PCBs, PCB congeners and TEQs, dioxin/furan congeners and TEQs, total TEQs, metals and PAHs were determined for animals collected from 10 plots in May (Table 4-7).

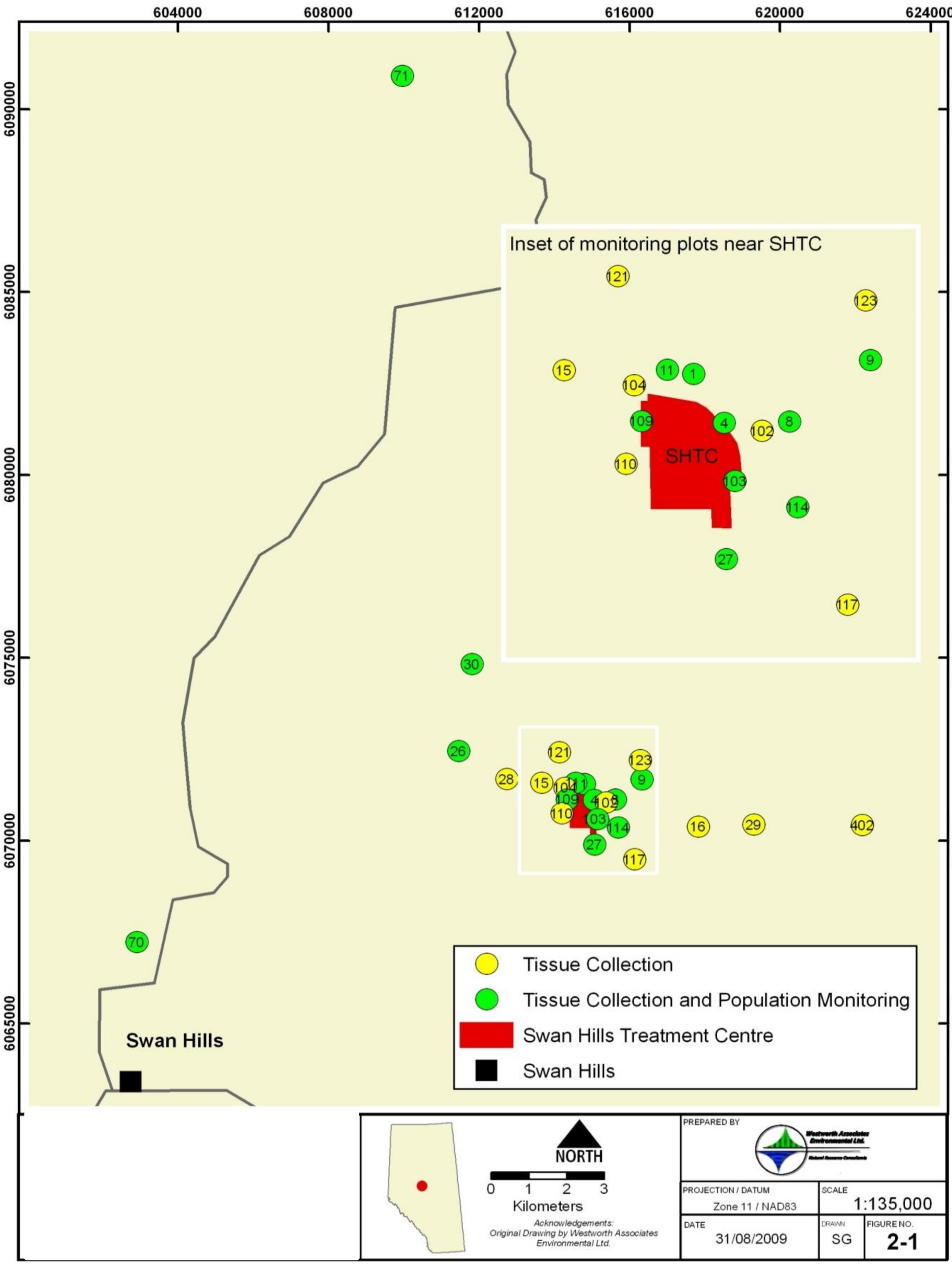

Figure 4-12: Location of the Wildlife Monitoring Plots in the Vicinity of the SHTC

Table 4-7: Summary of Previous and Current Annual/Expanded Red-backed Vole Monitoring Programs

Plot No.	Distance from SHTC the (km)	Direction from the SHTC	Tissue Collection/Snap-trapping[1]			Population Monitoring/ Live-trapping[1]
			Metals, PAHs[1]	Aroclor PCBs[2]	PCB Congeners and TEQs, Dioxins/Furans and TEQs, Total TEQs[3]	
Previous Annual and Expanded Monitoring Programs (Prior to 2024):						
11	0.1	N	✓	✓	☑	☑
109	0.2	W	✓	✓	☑	✓
103	0.2	SE	✓	✓	-	✓
4	0.3	E	✓	✓	☑	✓
110	0.3	W	✓	✓	☑	-
104	0.4	NW	✓	✓	-	-
102	0.4	E	✓	✓	-	-
1	0.4	NE	✓	✓	-	✓
27	0.5	S	✓	✓	-	✓
8	0.6	E	✓	✓	-	✓
15	0.6	NW	✓	✓	-	-
114	0.7	E	✓	✓	☑	☑
121	1.2	N	✓	✓	-	-
9	1.4	ENE	✓	✓	-	✓
28	1.4	WNW	✓	✓	-	-
123	1.6	NE	✓	✓	☑	-
16	2.4	E	✓	✓	-	-
117	2.4	SE	✓	✓	☑	-
26	2.6	WNW	✓	✓	-	✓
30	3.6	NW	✓	✓	-	✓
29	3.9	E	✓	✓	-	-
402	7.5	E	✓	✓	☑	-
70	11.5	SW	✓	✓	☑	☑
71	21.0	NNW	✓	✓	☑	✓
Current Annual and Expanded Monitoring Programs (2024 and Onward):						
11	0.1	N	✓	-	☑	☑
109	0.2	W	✓	-	☑	-
4	0.3	E	✓	-	☑	-
110	0.3	W	✓	-	✓	-
114	0.7	E	✓	-	☑	☑
123	1.6	NE	✓	-	✓	-
117	2.4	SE	✓	-	✓	-
402	7.5	E	✓	-	✓	-
70	11.5	SW	✓	-	☑	☑
71	21.0	NNW	✓	-	☑	-

Vole Population Monitoring

Between 1991 and 2015, average red-backed vole densities in the SHTC area have varied between 1.9 (2000) and 18.8 (2013) voles/ha in June, and between 4.9 (2011) and 37.5 (2013) voles/ha in September. However, vole populations in the SHTC area reached their highest average densities ever recorded for June (19.2 voles/ha) and September (39.8 voles/ha) during the 2016 vole monitoring year. These densities were 2.4 and 2.3 times higher than the respective 25-year average (1991 – 2015) vole densities for June (8.2 voles/ha) and September (17.5 voles/ha). Then in 2017, vole densities declined to some of the lowest levels recorded since monitoring began in the SHTC area (e.g., plots 11 and 70 fell to the lowest recorded September densities since 1991). Vole densities between 2018 and 2021 returned to similar densities recorded prior to the respective population peak and population low reported in 2016 and 2017. In comparison, while vole densities at the 3 monitoring plots in both June and September 2024 were within historical ranges previously recorded in the SHTC study area, they approached population lows similar to those recorded in 1993, 1997, 2000, and 2017.

Historically, population increases, and decreases have almost been synchronous at the 3 annually monitored plots in the SHTC study area, although periodically there have been differences in population dynamics among the plots, particularly in the June populations (Figure 4-13). The observed variability in June populations as compared to the more synchronous cycles observed in September (Figure 4-14) is likely influenced by recruitment into the June population when breeding typically occurs. During 2024, both June and September vole densities decreased at all 3 plots with the greatest decline recorded at plot 114 June while only a slight decrease in vole density was recorded at plot 11.

The reason(s) for these inconsistencies in vole densities among plots is unclear but likely reflect subtle differences in habitat structure at the plots (or site conditions) and therefore, their ability to support voles under variable weather conditions (e.g., overwinter survival), levels of predation, and food supply. However, vole population synchronicity in June and September within the SHTC area appears to have returned since 2012 and is similar to the population cycles observed prior to 2009. In contrast, September vole densities between 2019 and 2024 were somewhat more erratic, similar to density fluctuations recorded between 2008 and 2011. With June and September densities approaching historic population lows in 2024, it seems likely that vole populations at the 3 annually monitored plots will begin the increase phase of their cycle in 2025.

Compared to previous expanded monitoring years (which were comprised of 10 plots), the average June vole density for the 2024 expanded monitoring program (3 plots) was the lowest recorded since the 5-year expanded monitoring program was initiated in 1999 as well as in monitoring years between 1988 and 1998 (Table 4-8). The highest June densities occurred at plots 4 (at 23.6 voles/ha), 109 (at 20.0 voles/ha, and 27 (at 19.1 voles/ha) in 2019, and plot 70 at19.117.3 voles/ha in 1999. In comparison, the density of voles at plot 11 in 2024 (2.1 voles/ha) was the second lowest recorded compared to previous expanded monitoring years, while the June 2024 vole density (of 0.7 voles/ha) at plot 114 was the lowest recorded, the same as that recorded in 2009 (0.7 voles/ha) (Table 4-8). The vole density at plot 70 (3.5 voles/ha) during the June 2024 expanded monitoring year was the lowest recorded since the initiation of the expanded monitoring in 1999. In contrast to June, the average September vole density in 2024 for the expanded monitoring program (3 plots) was lower than the overall average of 14.8 voles/ha recorded in 2019 when expanded monitoring program was comprised of 10 plots (Table 1-3). The highest vole densities were recorded plot 11 (10.4 voles/ha) during the 2024 expanded monitoring program, followed by plot 70 (9.0 voles/ha) and 114 (6.3 voles/ha). During previous expanded monitoring years, the highest September densities occurred at plots 70 (38.9 voles/ha) in 2009, 114 (21.8 voles/ha) in 1999, and 11 (12.7 voles/ha) in 1999. Overall, average September vole densities during 4 (1999, 2004, 2014 and 2019) of the previous 5 expanded monitoring years were higher (ranging from = 6 to 99% lower) than those recorded at the 3 expanded monitoring plots except for the 2009 expanded monitoring year when densities were 22% lower (Table 4-9). Aside from some variability in vole weight classes and breeding voles in the heavy weight class (i.e., breeding proportions) among the 3 annually and 10 expanded monitoring plots, most other demographic parameters were consistent with those recorded during previous years of monitoring, suggesting that plot proximity in relation to the SHTC did not affect vole demography in 2024.

Table 4-8: Minimum Densities (no./ha) of Red-backed Voles Captured During the Expanded Monitoring Programs Conducted in the SHTC Study Area, June 1986-2024

Plot	Distance from SHTC (km)	Direction from SHTC	Baseline Phase (1986-87)	Operations Phase						
				1988-1998	1999	2004	2009	2014	2019	2024
11	***0.1***	***N***	***1.8 - 7.3***	***0.9 -12.7***	***11.8***	***0.0***	***6.9***	***2.8***	***6.3***	***2.1***
109	0.2	E	-	0.9 - 16.4	0.9	6.4	3.6	8.2	20.0	-
103	0.2	W	-	0.9 - 7.3	12.7	3.6	5.5	3.6	16.4	-
4	0.3	E	0.0 - 12.7	1.0 - 14.5	2.7	3.6	6.4	9.1	23.6	-
1	0.4	NE	-	6.4 - 23.6	8.2	4.5	14.5	15.5	11.8	-
27	0.5	S	2.7 - 6.4	0.9 - 13.6	10.0	6.4	7.3	11.8	19.1	-
8	0.6	E	-	4.5 - 22.7	11.8	10.0	9.1	4.5	12.7	-
114	***0.7***	***E***	***-***	***0.0 - 16.4***	***15.5***	***4.9***	***0.7***	***5.6***	***7.6***	***0.7***
9	1.4	ENE	-	5.5 - 18.2	12.7	2.7	3.6	4.5	17.3	-
26	2.6	WNW	-	0.0 - 10.9	8.2	8.2	0.9	3.6	9.1	-
30	3.6	NW	4.5 - 19.1	0.0 - 22.7	14.6	1.8	10.9	12.7	15.5	-
70	***11.5***	***SW***	***-***	***2.7 - 25.5***	***19.1***	***6.3***	***10.4***	***11.1***	***16.0***	***3.5***
71	23.0	NNW	-	0.9 - 20.0	3.6	17.3	17.3	11.8	10.0	-
Annually Monitored Plot Averages (3)			**4.6**	**8.5**	**15.5**	**3.7**	**6.0**	**6.5**	**10.0**	**2.1**
Expanded Monitoring Plot Averages (10)			**7.6**	**8.0**	**8.5**	**6.5**	**7.9**	**8.5**	**15.6**	**2.1[2]**

Table 4-9: Minimum Densities (no./ha) of Red-backed Voles Captured During the Expanding Wildlife Monitoring Program in the SHTC Study Area, September 1988-2024

Plot	Distance from SHTC (km)	Direction from SHTC	Baseline Phase (1986-87)	Operations Phase						
				1988-1998	1999	2004	2009	2014	2019	2024
11	***0.1***	***N***	***10.9 - 23.8***	***3.6 - 28.2***	***12.7***	***3.5***	***9.7***	***3.5***	***2.1***	***10.4***
109	0.2	W	-	3.6 - 30.9	16.4	10.9	10.9	19.1	20.0	-
103	0.2	E	-	2.7 - 23.7	16.4	5.5	8.2	4.5	13.6	-
4	0.3	E	2.7 - 18.2	2.7 - 28.2	1.8	7.3	10.9	9.1	18.2	-
1	0.4	NE	-	12.7 - 40.0	18.2	17.3	26.4	8.2	22.7	-
27	0.5	S	1.8 - 12.7	0.0 - 21.8	7.3	8.2	18.2	16.4	10.0	-
8	0.6	E	-	3.6 - 37.3	20.9	7.3	9.1	9.1	12.7	-
114	***0.7***	***E***	***-***	***0.9 - 32.7***	***21.8***	***9.7***	***9.7***	***11.1***	***6.3***	***6.3***
9	1.4	ENE	-	16.4 - 50.0	46.4	3.6	7.3	8.2	20.9	-
26	2.6	WNW	-	0.9 - 32.7	2.7	4.5	16.4	4.5	-	-
30	3.6	NW	30.9 - 58.2	4.5 - 40.9	13.6	2.7	18.2	10.0	8.2	-
70	***11.5***	***SW***	***-***	***9.1 - 45.5***	***11.8***	***5.6***	***38.9***	***7.6***	***17.4***	***9.0***
71	23.0	NNW	-	7.3 - 45.5	20.9	41.8	29.1	30.0	7.3	-
Annually Monitored Plot Averages (3)			**17.3**	**19.0**	**15.5**	**3.7**	**19.4**	**7.4**	**8.6**	**8.6**
Expanded Monitoring Plot Averages (10)			**19.0**	**17.9**	**16.5**	**10.9**	**15.5**	**11.9**	**14.8**	**8.6**[3]

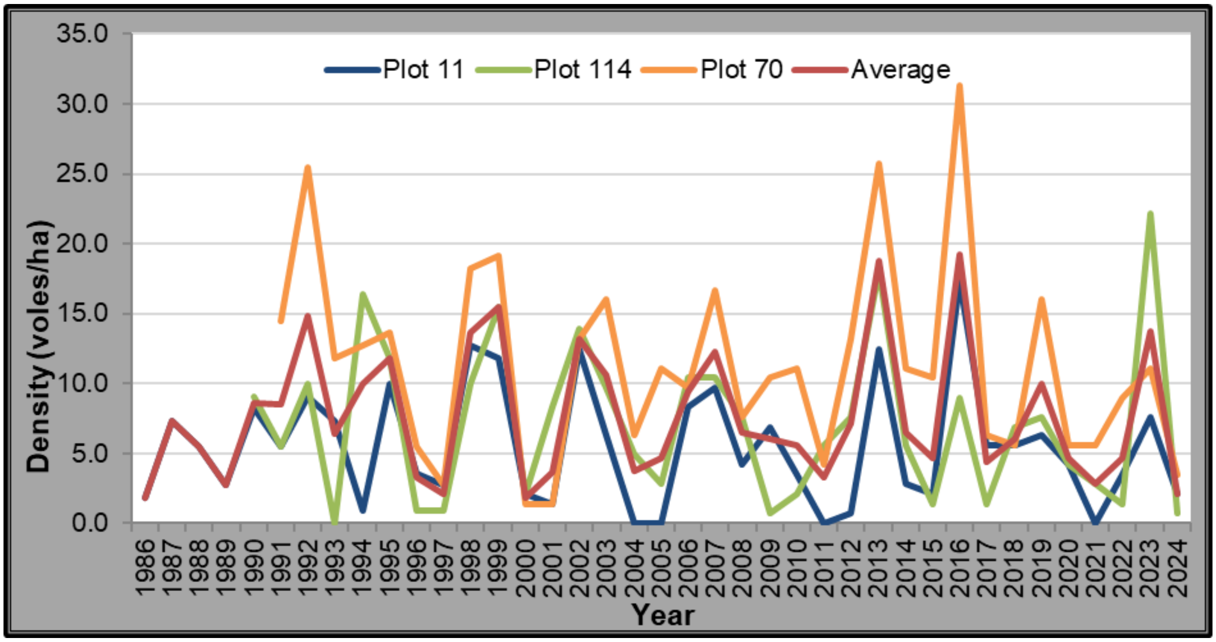

Figure 4-13: Densities of Red-Backed Voles in the SHTC Study Area, June 1986-2024

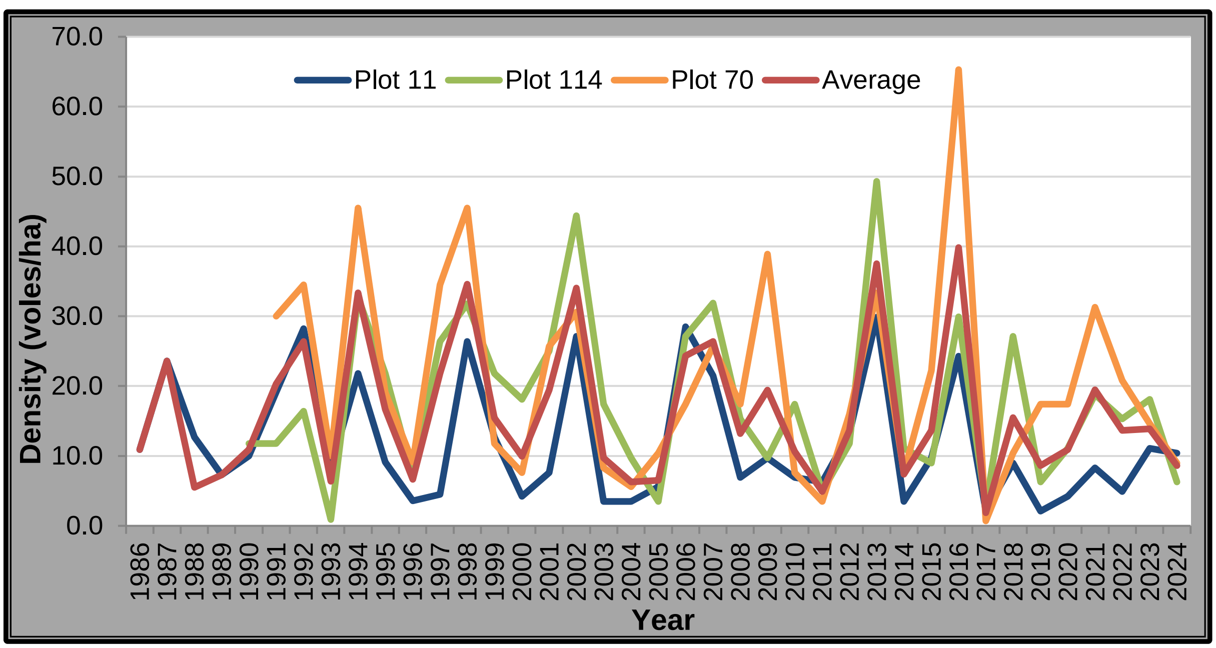

Figure 4-14: Densities of Red-Backed Voles in the SHTC Study Area, September 1986-2024

Vole Tissue Chemistry Monitoring

Aroclor PCBs

Concentrations of Aroclor PCBs were estimated from HRMS congener-specific results since the low-resolution GC-ECD method previously used for this analysis is no longer available. The average 2024 Aroclor PCB concentration of the annually monitored plots (0.02 mg/kg, n = 6 plots) was 75% less than that recorded in 2019 (0.08 mg/kg, n = 10 plots) (Table 4-10). In fact, the 2024 concentration was the lowest recorded since 1989 which was 0.04 mg/kg. Similarly, the 2024 Aroclor PCB concentration on the expanded monitoring plots (0.02 mg/kg over 4 plots) was 86% less than what was recorded in 2019 when the reported concentration was 0.07 mg/kg over 10 plots). The average 2024 concentration of Aroclor PCBs of 0.02 mg/g was slightly higher than that recorded in 1989 (0.01 mg/kg), the second lowest since monitoring began. On an individual plot basis, the highest Aroclor PCB concentrations in 2024 were recorded at plot 4 (0.06 mg/kg) and plot 109 (0.03 mg/kg), both of which are located within 300 m of the plant site. The remaining plots had concentrations equal to or less than 0.02 mg/kg in 2024 (Table 4-10).

Figure 4-15 compares the average yearly Aroclor PCB concentrations recorded for plots that were annually monitored to those plots that were monitored during the expanded monitoring program. Up until 1999, between 7 and 24 plots were monitored for Aroclor PCBs. During this period, the trend in concentrations recorded for the expanded monitoring plots was similar to that observed for annually monitored plots although the average concentrations were generally lower. Following rationalization of the monitoring program in 2000 when 24 of the plots were monitored every 5 years, Aroclor PCB concentrations for the annually monitored plots in 1999 and 2004 were higher (42% and 41%, respectively) than the average concentrations recorded for the expanded monitoring plots (Figure 4-15). In 2024, the Aroclor PCB concentrations at annually monitored and expanded monitoring plots were the same (0.02 mg/kg). Therefore, it appears that the 10 plots that were annually monitored represent reasonable indicators of the overall results for Aroclor PCBs in the vicinity of the SHTC. Furthermore, the low concentrations of Aroclor PCBs recorded in at the annually monitored and expanded monitoring plots in 2024 are consistent with a declining trend that has been occurring in the vicinity of the SHTC since 2014 (Figure 4-15).

PCB Congeners and TEQs

The average concentration of PCB congeners in vole tissues decreased (-8%) between May 2023 and May 2024. While congener PCBs decreased at 5 plots, year-over-year increases were recorded at the remaining 5 plots, the highest increases of which occurred at plots 110 (173%) and 109 (73%) (Table 4-11). Despite these increases, the average 2024 concentration across the 10 plots is 73% lower than the 24-year average (2000 – 2023) for the SHTC study area; the second lowest concentration recorded since 2000. As in previous monitoring years, the lowest PCB concentrations were recorded at plots located farthest from the SHTC (i.e., plots 402, 70 and 71) while the highest concentrations typically occurred at plots closer to the plant site (plots 11, 109, 4, 110, and 114) (Table 4-11).

Between May 2023 and May 2024, PCB TEQs decreased at 6 and increased at 4 of the 10 plots, representing an average decrease in PCB TEQ concentration of 13% (Table 4-12). The highest PCB TEQ in 2024 was recorded at plot 4, which has been the case for all but one year (plot 109 in 2012), although it represents the second lowest concentration recorded at this plot since 2000. In comparison, PCB TEQ values at plots 402, 70, and 71 were ≤1 pg/g in 2024, continuing to represent the lowest levels recorded among the 10 plots on a historical basis. Historically, the highest PCB TEQ concentrations have been found in vole tissues collected near (≤0.7 km) and lowest at plots further away (>0.7 km) the SHTC. The exceptions to this occurred in 2022 at plot 110 (7.62 pg/g) which is located only 0.3 km from the SHTC, plot 117 (28.1 pg/g) which is located 2.7 km from the SHTC, and plot 70 (11.80 pg/g) in 2023, unlike most previous monitoring years. The higher concentration of PCB TEQ at plot 70 was likely affected by the fires that were burning close to the Town of Swan Hills in 2023.

Table 4-10: PCB congener concentrations[1] (pg/g) in red-backed voles in SHTC study area, 2000 – 2024.

Year	Plot[2]										Averages
	11	109	4	110	114	123	117	402	70	71	
2000	480,000	-	300,000	-	170,000	-	24,000	5,500	8,800	3,600	**141,700**
2001	169,000	563,000	163	28,800	466,000	32,100	34,600	1,960	1,440	479	**129,754**
2002	627,382	819,944	642,093	16,715	495,810	53,724	108,457	5,557	1,799	393	**277,187**
2003	249,000	583,000	250,000	11,500	129,000	25,100	35,300	1,330	667	199	**128,510**
2004	70,359	1,034,201	687,233	133,077	136,802	14,997	17,438	734	1,084	406	**209,633**
2005	17,865	114,298	140,940	-	34,465	7,601	8,917	953	837	455	**36,259**
2006	203,545	254,766	867,215	17,820	143,851	9,468	34,099	2,944	2,363	1,273	**153,734**
2007	91,000	340,000	360,000	19,000	200,000	23,000	45,000	4,300	1,900	2,900	**108,710**
2008	100,000	99,000	410,000	17,000	85,000	23,000	69,000	47,000	7,200	3,800	**86,100**
2009	120,000	69,400	245,000	11,000	63,200	10,200	4,500	2,070	1,980	785	**52,814**
2010	192,000	98,800	351,000	43,500	294,000	19,300	74,900	3,530	1,680	795	**107,951**
2011	281,000	960,000	547,000	225,000	121,000	16,800	42,500	2,610	3,100	939	**219,995**
2012	181,000	815,000	357,000	136,000	250,000	27,400	45,900	6,150	1,860	1,280	**182,159**
2013	296,000	267,000	1,110,000	72,400	209,000	16,400	10,400	4,050	1,480	1,440	**198,817**
2014	114,000	115,000	399,000	105,000	263,000	19,900	42,500	4,570	935	716	**106,462**
2015	111,000	97,300	386,000	39,500	82,100	13,100	18,800	2,360	1,200	377	**75,174**
2016	90,400	87,700	429,000	21,600	86,900	11,300	33,300	2,330	770	356	**76,366**
2017	110,000	96,700	317,000	21,500	91,900	12,900	16,700	2,220	934	401	**67,026**
2018	84,200	187,000	368,000	26,400	102,000	14,300	34,500	2,470	779	888	**82,054**
2019	98,150	83,250	304,500	11,385	68,200	7,620	21,150	1,380	663	255	**59,832**
2020	1 63,700	60,400	161,000	7,380	45,900	12,900	17,000	1,410	533	190	**37,041**
2021	39,500	31,600	92,500	13,200	54,600	18,800	6,540	1,200	544	217	**25,870**
2022	65,200	66,100	171,000	28,000	121,000	4,650	51,600	663	471	191	**50,888**
2023	43,500	38,700	140,000	11,200	36,100	3,510	13,100	1,710	32,900[3]	143	**32,086**
2024	25,300	66,900	116,000	30,600	40,000	6,980	6,820	518	460	278	**29,386**

[1] PCB congener concentrations are the sum of the homologues.
[2] Order of plots indicate increasing distance from SHTC (Plot 11 [100 m] to Plot 71 [23 km]).

Table 4-11: TEQ of PCB congeners in red-backed voles (pg/g) collected from the SHTC study area, 2000 - 2024.

Year	Plot[1]										Averages
	11	109	4	110	114	123	117	402	70	71	
2000	500	-	670	-	144	-	33	1.3	6.7	0.06	**193.58**
2001	108	253	352	18.7	252	15	23.4	0.03	0.01	0.01	**102.22**
2002	241	346	461	5.1	215	22	53	0.1	0.05	0.00	**134.33**
2003	400	385	568	6.1	164	20.4	21.2	0.5	0.0	0.00	**156.52**
2004	94.8	120	836	29.5	3.35	11.5	11.8	0.01	0.02	0.01	**110.70**
2005	40.6	106	267	-	42.2	4.1	6.4	0.03	0.02	0.01	**51.82**
2006	369.9	133.2	1039.8	12.3	96.2	9.5	16.7	1.36	0.04	0.02	**167.90**
2007	119.6	411.2	614.2	7	152.1	18.8	26.4	0.13	0.05	0.03	**134.95**
2008a[2]	85.49	43.97	318.3	5.65	47.07	10.71	41.43	2.4	0.49	0.24	**55.58**
2008b[3]	84.59	42.8	319.02	5.42	45.52	10.42	40.32	2.26	0.47	0.23	**55.11**
2009	139.16	51.54	279.87	5.11	36.24	6.96	1.71	0.55	0.52	0.26	**52.19**
2010	146.72	74.46	207.07	22.1	114.18	6.05	18.93	0.02	0.01	0.00	**58.95**
2011	88.3	259	438	115	34.9	3.9	7.48	0.01	0.99	0.35	**94.79**
2012	74.2	313	294	49.3	52.2	5.31	12.7	0.99	0.49	0.00	**80.22**
2013	203	224	603	22.5	84.4	5.95	3.12	0.84	0.01	0.01	**114.68**
2014	86.4	59.4	305	115	57.6	7.57	10.6	1.0	0.28	0.25	**64.31**
2015	57.2	38.3	335	15.2	38.1	5.85	9.32	0.83	0.56	0.15	**50.05**
2016	43.5	28.4	289	6	26.1	3.9	8.62	0.54	0.30	0.13	**40.65**
2017	52.2	41.8	170	10.6	30.6	4.73	5.24	0.87	0.39	0.20	**40.57**
2018	39.4	98.4	232	8	33.8	4.42	11.4	0.73	0.27	0.36	**42.88**
2019	45.1	45.5	198	3.84	25.5	3.06	7.19	0.20	0.26	0.15	**32.88**
2020	40.4	25.9	113	2.12	18.7	3.7	5.6	0.51	0.24	0.07	**21.03**
2021	21.5	15.8	61.1	6.15	23	7.1	2.66	0.43	0.22	0.09	**13.81**
2022	25.2	23.7	111	7.62	54.4/2.4[4]	1.67	28.1	0.16	0.11	0.05	**25.20**
2023	22.5	17.7	96.5	3.7	14.4	1.25	3.7	0.33	11.8[4]	0.09	**17.20**
2024	11.1	33.9	65.3	5.69	12.3	3.10	2.26	0.205	0.24	0.154	**14.90**

[1] Order of plots indicate increasing distance from SHTC (Plot 11 [100 m] to Plot 71 [21 km]).
[2] WHO-TEF: World Health Organization Toxic Equivalency Factor (1998).
[3] WHO-TEF: World Health Organization Toxic Equivalency Factor (2005).

Dioxin/Furan Congeners and TEQs

Dioxin/furan concentrations in red-backed voles decreased at 6 plots and increased at 4 plots between May 2023 and May 2024. The highest concentrations occurred at plots 4 (56.36 pg/g) and 109 (31.54 pg/g) while concentrations at the remaining plots were ≤13.12 pg/g (plot 4) (Table 4-12). For the most part, the highest levels of dioxins/furans occurred at plots 11 through 114 (range = 10.58 – 56.36 pg/g) which are located ≤0.7 km of the SHTC while the lowest values were generally recorded at plots 123 through to plot 71 (range = 2.13 - 11.44 pg/g), which are located the furthest away (>0.7 km). Dioxin/furan concentrations at the 10 plots in 2024 were within previously observed ranges. Overall, dioxin/furan congener concentrations in the SHTC study area were highest between 2000 and 2006 but for the most part, have been declining since 2006 although slight increases were recorded in 2022. In 2024, dioxin/furan congers were 30.2% lower compared to 2023.

The average dioxin/furan TEQ concentration in 2024 decreased 28.9% between May 2023 and May 2024, representing the second lowest concentration (2.7 pg/g) recorded in the SHTC study area since 2000 (range = 2.1 to 1,371.4 pg/g) (Table 4-13). Since 2006, dioxin/furan TEQs have consistently declined to the low levels that have been recorded between 2017 and 2024. As with PCB TEQs, dioxin/furan TEQ concentrations in voles generally declined with increasing distance from the SHTC in May 2024 although larger increases were documented at plots 114 and 117 in 2022 and at plot 70 (likely related to the wildfires in the vicinity of the Town of Swan Hills) in 2023 compared to recent monitoring years.

Table 4-12: Concentrations of dioxin/furan congeners (pg/g) in red-backed voles collected from the SHTC study area, 2000 - 2024.

Year	Plot[1]										Averages
	11	109	4	110	114	123	117	402	70	71	
2000	5,757	11,026	11,827	2,229	1,585	1,840	591	22	110	59	**3,504.6**
2001	655	2,902	9,203	460	960	931	1,225	8	7	7	**1,635.8**
2002	3,862	4,684	6,349	86	1,550	1,533	1,017	143	23	6	**1,925.3**
2003	2,994	3,938	9,432	112	1,874	865	273	5	25	4	**1,952.2**
2004	1,177	530	6,095	323	677	370	99	n.d.[3]	1.6	0.2	**927.3**
2005	581	1,280	2,005	-[2]	344	155	66	2.8	11	1.3	**444.4**
2006	8,043	648	7,633	158	488	345	78	15	22	8	**1,743.8**
2007	1,142	2,167	2,546	54	912	716	85	29	26	8	**768.5**
2008	862	373	2,316	76	223	266	506	20	36	18	**469.6**
2009	1,013	421	1,145	44	145	194	26	7	31	3	**302.9**
2010	1,720	503	434	168	314	43	48	7	3.4	<0.2	**324.1**
2011	131	312	1,010	438	55.8	22.9	10.2	1	1.9	<0.09	**198.3**
2012	171	973	1,156	168	139	23	43.1	4.4	15.5	1	**269.4**
2013	651	732	1,493	126	183	30.6	37	7.7	44.4	7.3	**331.2**
2014	329	162	781	386	91.8	82.3	27.8	13.7	32.8	7.5	**191.4**
2015	70	12	472	159	45.4	36.9	32.3	6.6	23.2	3.5	**86.1**
2016	123	53	488	31	53.8	20.5	15.6	3.7	17.0	9.2	**81.5**
2017	49.7	66.2	309.1	24.2	26.5	15.9	8.4	4.6	13.1	4.7	**52.5**
2018	77.6	173.7	257.6	21.8	31.1	19.6	11.2	3.4	7.1	1.2	**60.4**
2019	62.2	70.4	193.3	15.6	25.3	13.1	10.5	3.2	20.3	4.3	**41.8**
2020	66.6	26.3	111.9	8.5	14.0	8.2	4.3	3.8	6.7	1.9	**25.2**
2021	27.39	17.11	37.45	11.02	15.25	6.17	9.61	5.72	11.91	3.02	**14.5**
2022	19.66	18.27	135.15	14.17	41.74	5.81	27.17	1.34	11.85	8.44	**28.4**
2023	60.70	26.41	98.15	10.00	11.82	6.07	10.23	3.17	13.29[4]	1.55	**24.1**
2024	13.12	31.54	56.36	12.16	10.58	11.44	5.73	2.13	8.91	3.65	**16.9**

[1] Order of plots indicate increasing distance from SHTC (Plot 11 [100 m] to Plot 71 [21 km]).
[2] No animals were collected for tissue samples.
[3] n.d. - Not Detected. Average values calculated based on ½ the reported detection limit.

Table 4-13: TEQ of dioxin/furan congeners (pg/g) in red-backed voles collected from the SHTC study area, 2000 - 2024

Year	Plot[1]										Averages
	11	109	4	110	114	123	117	402	70	71	
2000	2,200	4,200	4,900	820	600	700	230	7.2	37	20	**1,371.4**
2001	230	1,100	3,800	160	340	350	440	0.76	2.9	1.2	**642.5**
2002	1,460	1,750	2,450	26.4	553	593	391	19.8	2.6	1.6	**724.7**
2003	1,200	1,490	3920	28.6	682	321	89.2	0.7	3.1	0.3	**773.5**
2004	416	187	2,190	99.5	262	126	31.7	0.79	1.5	0.27	**331.5**
2005	187	465	754	-[2]	104	48.8	17.5	0.81	2	0.43	**157.8**
2006	3,071	219	2,851	32.5	154	109	19.2	2.2	0.5	1.1	**646.0**
2007	421	765	885	14	283	274	21	4	3	2	**267.2**
2008a[3]	310	110	830	14	58	87	44	3.6	3.4	0.92	**146.1**
2008b[4]	200	71	530	11	40	56	30	2.8	4.5	0.94	**94.6**
2009	217	81	241	7	24	36	3	1	2	0	**61.2**
2010	366	100	88	32	58	8	7	1	3	0	**66.3**
2011	19.3	53.4	234	104	8.6	4.5	2.2	1.3	2	0.4	**43.0**
2012	21.2	185.0	223.6	27.56	19.69	4.48	6.84	0.76	2.94	0.18	**49.2**
2013	121.2	129.5	197.7	17	20.3	4	3.8	0.5	4.8	1.4	**50.0**
2014	53.9	22.2	133	81.3	13.0	12.1	2.92	1.4	2.81	0.803	**32.3**
2015	7.26	1.62	75.9	19.2	4.66	5.01	4.04	0.565	2.59	0.378	**12.1**
2016	14.8	6.54	80.8	3.4	5.59	2.79	1.73	0.488	1.97	0.745	**11.9**
2017	5.38	8.71	46.8	4.27	3.03	1.99	0.70	0.53	1.94	0.55	**7.4**
2018	10.8	25.9	35.9	3.15	3.16	3.42	1.4	0.79	1.55	0.31	**8.6**
2019	9.86	10.9	33.7	2.54	3.7	2.19	1.39	0.435	3.05	0.65	**6.8**
2020	10.2	4.32	19.0	1.43	2.1	1.39	0.70	0.516	1.65	0.364	**4.2**
2021	4.44	2.43	5.79	1.5	1.65	0.77	1.33	0.461	1.69	0.45	**2.1**
2022	3.03	2.86	12.8	2.19	5.81/0.27[5]	1.04	3.97	0.201	2.04	0.284	**3.4**
2023	8.72	4.28	15.4	1.91	2.02	1.16	1.34	0.557	2.39[6]	0.274	**3.8**
2024	2.22	4.72	8.6	1.78	1.51	1.97	0.84	0.285	2.27	0.698	**2.7**

1 Order of plots indicate increasing distance from SHTC (plot 11 [100 m] to plot 71 [21 km]).
2 No animals were collected for tissue samples.
3 Between 2000 and 2008a, dioxin and furan TEQs calculated based on NATO I-TEFs (1990).
4 From 2008b and onwards, dioxin and furan TEQs calculated based on WHO (2005).

Total TEQs in Relation to Plot Location

Between May 2023 and May 2024, total TEQ levels in red-backed voles decreased at 6 plots and increased at 4 of the 10 monitoring plots, resulting in an average 24% decrease (-5.06 pg/g). Average total TEQ at plots >2 km from the SHTC remained well-below total TEQ concentrations at plots ≤2 km from the SHTC in 2024 (Figure 4-15). The overall trend in total TEQ concentrations for both distance categories in the SHTC study area has continued to decline since 2000 but increased in 2022 because of an anomaly in the data set. In 2023, total TEQ concentrations recorded at plots 114 and 117 were back within historical ranges while total TEQ concentration at plot 70 was the highest recorded since 2000. This was attributed to the occurrence of wildfires that occurred near the Town of Swan Hills and elsewhere in the vicinity of the SHTC study area. Total TEQ continued to decline in 2024 (Figure 4-15).

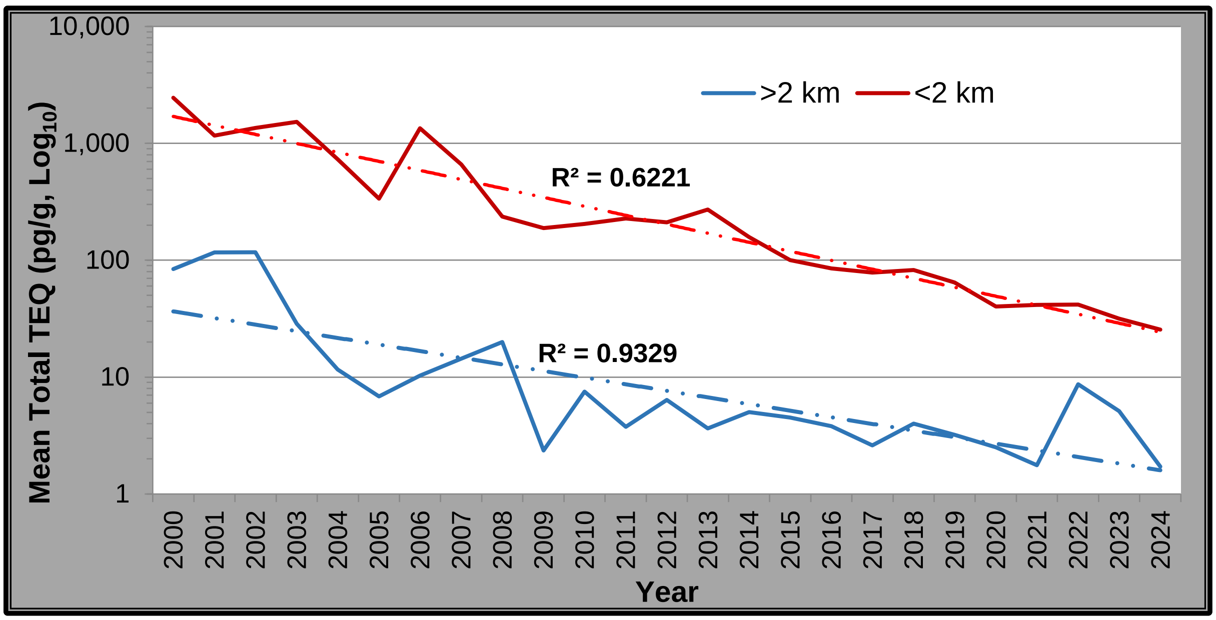

Figure 4-15: Mean total TEQ concentrations at plots ≤2 km and >2 km from SHTC, 2000 - 2024.

Inorganic Elements

Of the 28 heavy metal concentrations measured in vole tissues in 2024, 11 elements were below those recorded during the 1986-1097 baseline period, 10 were similar to baseline concentrations, while 4 exceeded baseline conditions (Table 4-14). Of the 4 heavy metals that exceeded baseline concentrations in 2024 (copper, iron, manganese, and selenium), all were within ranges recorded during previous expanded monitoring years. Overall, 15 of 27 metals measured in 2024 exhibited weak negative correlations, 7 of which were significant ($P<0.05$), indicating that as distance from the SHTC increased, concentrations of heavy metals generally decreased. An additional 10 metals exhibited either significantly ($P<0.05$) weak (5 plots) or moderately (5 plots) positive concentrations suggesting that as distance from the SHTC increased, concentrations of these metals also increased. Eight of the 27 metals that were detected in vole tissues in May 2024 are also generally considered to be elements of concern including arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc (Table 4-14). Of these 8 metals of concern, only copper and selenium exceeded baseline concentrations. Lead and mercury were the only heavy metals that exceeded baseline concentrations in only 3 of the 13 previous monitoring years when analyses of metals were conducted. In contrast, baseline concentrations of zinc, arsenic and copper exceeded baseline concentrations in 7, 7, and 10 years during the same 13 metals monitoring years. Although periodic concentration exceedances for various metals have been detected over the years, any trends in relation to distance from the SHTC were weakly negative and for the most part, non-significant.

Table 4-14: Average May 2024 concentrations (mg/kg dry weight) of inorganic elements in vole tissues compared to historical levels (1986 – 2019) recorded in the SHTC study area

Element	Baseline (1986-87)	1994-98	2004	2009	2010	2011	2012	2014	2019	2024
Aluminum	124.5	64 - 90	129	75	91	76	149	99	76	44
Antimony	<0.2[1]	<0.2	<0.2	<0.4	0.02	0.01	0.01	0.009	0.03	<0.006
Arsenic[3]	**<0.1**	**<0.1 – 0.4**	**n.d.[2]**	**0.2**	**0.08**	**<0.14**	**0.13**	**0.11**	**0.12**	**0.09**
Barium[4]	36.1	18 - 24	26	37	32	***49***	***40***	***42***	***39***	26
Beryllium	<0.2	<0.2	n.d	<0.2	<0.02	<0.17	0.11	n.d.	<0.007	<0.005
Cadmium	**0.37**	**<0.2**	**<0.2**	**<0.4**	**0.15**	**0.19**	**0.19**	**0.18**	**0.18**	**0.16**
Calcium	32,000	25,897–32,487	29,813	***39,615***	***40,248***	***47,660***	***36,256***	30,567	***37,475***	25,910
Chromium	**1.3**	***1.9 – 3.6***	***2.5***	**<0.4**	**0.4**	**0.3**	**1.1**	**0.8**	**0.1**	**0.1**
Cobalt	0.3	<0.2 – 0.3	0.4	***0.8***	0.3	0.3	0.3	0.3	0.3	0.2
Copper	**9.9**	0 - ***21***	***22.1***	***21.1***	***36.2***	***13.2***	***19.5***	***22.2***	***11.6***	***13.8***
Iron	303	291 - ***317***	***425***	***400***	***405***	***468***	***344***	***337***	***350***	***357***
Lead	**1.1**	**1 – 2**	**<1**	**1**	**1**	**1.3**	**0.8**	***1.8***	**1.0**	**0.4**
Magnesium	1,500	1,113 – 1,427	1,512	***1,738***	***1,796***	***2,006***	***1,353***	***1,580***	***1,561***	1,292
Manganese	23	***28 - 41***	***42***	***50***	***57***	***47***	***44***	***44***	***62***	***43***
Mercury	**0.3**	**0.11 – 0.39**	**0.17**	-[4]	**0.29**	***0.54***	**0.28**	**0.31**	**0.21**	**0.26**
Molybdenum	1.1	<1 - 1	<1	0.6	0.6	0.6	0.5	0.6	0.6	0.5
Nickel	**2**	**0.5 – 1.7**	***8.6***	***3.5***	***4.8***	***1.5***	***5.3***	***4.1***	**1.2**	**0.5**
Phosphorus	24,000	19,250–22,447	21,516	***35,944***	***32,695***	***36,073***	23,634	23,079	***27,848***	20,810
Potassium	12,700	10,224–***18,433***	11,423	12,758	***13,340***	***17,702***	12,603	11,095	11,342	11,298
Selenium	0.59	<0.2 – ***0.9***	***1.3***	***1.1***	***0.8***	***<0.4***	***0.9***	***1.0***	***0.8***	***0.8***
Silver	<0.2	<0.2	<0.2	<0.2	0.02	0.37	n.d.	0.004	<0.0353	0.010
Sodium	4,700	3,124 – 4,753	4,704	***5,441***	***5,828***	***5,683***	***4,967***	4,494	4,821	4,692
Strontium	-[5]	-	-	18.4	18	23.1	16	16.6	20.7	13.8
Thallium	-	-	-	<0.04	<0.02	<0.03	<0.02	n.d.	<0.0014	0.003
Tin	<2	<2	<2	0.8	0.5	0.6	0.5	1.0	0.1	0.2
Titanium	***1***	1.1 – ***4.1***	***5.2***	***1.5***	***2.2***	***2***	***3.4***	***3.5***	-	-
Vanadium	2.1	<2 - ***3***	<2	0.4	0.2	0.2	0.3	0.028	0.2	0.11
Zinc	**104**	**94 - *157***	**90**	***123***	***128***	***110***	***113***	**94**	***111***	**91**

[1] < indicates below lowest detection limit. [2] n.d. – Below detection limit. [3] Bold indicates heavy metals of concern. [4] Bold italics indicates monitoring years where metal concentrations exceeded baseline concentrations. [5] - Indicates not analyzed.

PAHs

PAHs in voles collected from the SHTC study area were periodically analyzed on various plots between 2000 and 2003 and then again during the 2019 expanded monitoring programs. During these monitoring years, PAHs in vole tissues were for the most part, below their detection limits although 11 of the analytes were at or near their detection limits. In contrast, 35 (45%) of the 78 analytes present in vole tissues were near or exceeded the detection limits at between 5 and 10 of the plots during the 2024 expanded monitoring program. In comparison to the 2019 monitoring year when the same 78 analytes were analyzed, percentage changes in concentrations increased from a low of 285% at plot 402 to a high of 1,079% at plot 117 representing an overall increase of 613% from the 2019 monitoring year (Table 4-15). As in previous monitoring years, there was no clear trend in the concentrations of PAHs in relation to distance from the SHTC. While anthropogenic sources such as industrial stack emissions can contribute significantly to elevated PAH concentrations in various receptors (including red-backed voles), these results suggest that the higher concentrations recorded during 2024 were more likely related to the recent fire history in the SHTC study area. Forest fires are generally the single most important natural source of PAHs in Canada.

In addition, of the various PAH analytes detected in red-backed vole tissues in 2024 and previous monitoring years, 17 are considered to be priority PAHs because of their toxicity, persistence, and potential to bioaccumulate. Overall, naphthalene and phenanthrene had the highest concentrations over the 6 monitoring years, accounting for 8.5% and 8.2% of the total PAH concentrations present in vole tissues, respectively, while the lowest average concentration was recorded for perylene (1.9%). However, differences among the 17 priority PAHs were small and did not appear to exceed current guidelines nor was there any clear trends in PAH concentrations in relation to distance from the SHTC.

Chemical Concentrations in Relation to Red-backed Vole Demography

Since PCBs and dioxins and furans, can affect reproductive success in mammals, various vole demographic parameters, including density, breeding condition, sex ratios, and weight class structure were examined in relation to chemical concentrations in vole tissues. While results indicate that higher concentrations of PCBs, dioxins/furans, and total TEQ in 2024 were associated with plots 11 and 114 which are closer to the plant site than plot 70, there was no clear indication that the Treatment Centre was affecting vole demography (Table 4-16). With respect to heavy metals and PAHs, the was no apparent relationship between concentrations and distance from the plant site. For example, the highest vole densities were recorded at plot 70 in June but were highest at plot 11 in September. There were also no apparent trends in relation to distance from the plant with respect to other population data such as sex ratios, weights, and breeding voles. Long-term monitoring has not exhibited any obvious population-level changes that would be consistent with the higher body burden levels in voles that were observed between 2000 and 2024. As indicated earlier, this appears to more likely reflect different habitat conditions among the 3 plots and the phase of the population cycle the voles are in.

Table 4-15: Comparison of average PAH concentrations (mg/kg) between the 2019 and 2024 expanded monitoring years at plots in the SHTC study area

Plot	Average PAH Concentrations (mg/kg)		% Change
	2019	2024	
11	0.01415	0.0998	**605**
109	0.01323	0.0972	**635**
4	0.01431	0.07357	**414**
110	0.01326	0.07246	**447**
114	0.01384	0.10515	**660**
123	0.01507	0.12491	**729**
117	0.0137	0.16145	**1,079**
402	0.01266	0.04876	**285**
70	0.01479	0.09956	**573**
71	0.01308	0.10174	**678**
Totals	**0.13809**	**0.98460**	**613**

Table 4-16: PAH concentrations (mg/kg) recorded in 2024 in comparison to historical concentrations for 17 priority PAHs in the vicinity of the SHTC

Target Analytes	Feb 2000	June 2000	Feb 2002	Feb 2003	May 2019	May 2024	Averages
Acenaphthene	0.005[1]	0.005	0.01	0.01	0.0001	0.0002	**0.0050**
Acenaphthylene	0.006	0.005	0.01	0.01	0.0001	0.0002	**0.0052**
Anthracene	0.005	-[2]	0.01	0.01	0.000194	0.0002	**0.0051**
Benzo(a)anthracene	-	-	0.01	0.01	0.0001	0.0002	**0.0051**
Benzo(a)pyrene	-	-	0.01	0.01	0.0001	0.0002	**0.0051**
Benzo(b)flouranthene	0.01	0.005	0.01	0.01	0.0001	0.0005	**0.0059**
Benzo(ghi)perylene	0.005	0.005	0.01	0.01	0.0001	0.0000	**0.0050**
Benzo(k)fluoranthene	0.005	0.005	0.01	0.01	0.0001	0.0000	**0.0050**
Dibenz(ah)anthracene	0.0146	0.005	0.01	0.01	0.0001	0.0002	**0.0066**
Fluoranthene	0.005	0.005	0.01	0.01	0.0003	0.0017	**0.0053**
Fluorene	0.0146	0.0075	0.01	0.01	0.0001	0.0014	**0.0073**
Indeno(c,d-123)pyrene	0.005	-	0.01	0.01	0.0001	0.0002	**0.0051**
Naphthalene	0.01	0.005	0.01	0.01	0.0009	0.0114	**0.0079**
Phenanthrene	0.012	-	0.01	0.01	0.0005	0.0055	**0.0076**
Pyrene	0.005	-	0.01	0.01	0.0005	0.001	**0.0052**
Retene	-	-	-	-	0.0001	0.00146	**0.0008**
Chrysene	0.005	-	0.01	0.01-	-	-	**0.0083**
Totals	**0.1072**	**0.0525**	**0.15**	**0.15**	**0.0032**	**0.0230**	**-**

5 AQUATIC ENVIRONMENT

Aquatic ecosystem health monitoring includes indicators of water and sediment quality as well as indicators of fish health and contaminant load. Surface water quality (i.e., that of lakes and streams) near the SHTC is important for both human health and the integrity of aquatic ecosystems. Sediment quality in waterbodies near the SHTC is an important indicator of both current environmental conditions affecting aquatic biota and of cumulative pollutant deposition. Fish tissue provides a good indicator of aquatic system contaminant levels and is important to monitor given its direct potential linkage to human health risk through consumption of natural local foods.

The objective of the aquatic monitoring program is to assess changes in the concentration of chemicals of concern in lakes and streams near the SHTC (Figure 5-1) and their potential implications for human health risk.

5.1 Surface Water Monitoring

Surface water quality (i.e., that of lakes and streams) near the SHTC is important for both human health and the integrity of aquatic ecosystems. The surface water monitoring program evaluates spatial and temporal patterns in water quality relative to the SHTC. In 2024, monitoring occurred at one river (Coutts River) and two lakes (Edith Lake and Chrystina Lake) as part of the regulatory environmental monitoring program. The Coutts River and Chrystina Lake monitoring stations are located downgradient and downwind of the SHTC. Specifically, the Coutts River station (S5A) is approximately 5.0 km southeast of the SHTC, while the Chrystina Lake station (S12) is approximately 1.5 km northeast of the SHTC. Edith Lake is the background reference lake for the surface water monitoring program and is situated upwind and up-gradient from the SHTC, approximately 15 km from the facility. 9 additional waterbodies were added to the monitoring program as test sites to capture the impacts of pH decreasing due to the SHTC. These waterbodies had 24 routine water quality parameters lab measured and 7 field measurements taken in July, August, and October.

Over 60 water quality parameters were measured in water samples collected from the Coutts River, S12 and Edith Lake, including routine, nutrient, biological, and metal parameters. Due to low flow, hydrometric measurements were not collected at the time of sampling for any site. For each of the surface water quality parameters measured at each monitoring site, summary statistics were calculated to place the 2024 measurements in historical context (where adequate data were available). Values that were high relative to historic measurements were flagged. Measurements from 2024 were also compared to the Alberta Surface

Water Quality Guidelines for the Protection of Aquatic Life (PAL; where applicable) and exceedances were noted and described. Finally, non-parametric monotonic trend analysis was conducted on parameters with at least 8 years of data and with fewer than 50% of those measurements being censored. The Mann-Kendall test was used to assess whether water quality parameters significantly increased, decreased, or lacked a distinct pattern over time. In 2024, a "moving window" trend analysis approach was implemented, where only the 10 most recent observations were included in the analysis to ensure that any trends detected are representative of current conditions.

A summary of historical range and regulatory guideline exceedances, as well as significant water quality trends, is outlined in Table 5-1. Based on the 2024 monitoring results, surface water quality near the SHTC is largely comparable to historical conditions observed in the Coutts River and Edith Lake. The Coutts River had 2 parameter above historical conditions (Total Kjeldahl Nitrogen [TKN] and dissolved oxygen); Chrystina Lake had 10 parameters above historical conditions (barium, dissolved and total calcium, chlorophyll-a, electrical conductivity, hardness, dissolved and total potassium, strontium, and total suspended solids [TSS]); and Edith Lake had 4 parameters above historical conditions (hardness, dissolved calcium, chlorophyll-a, and TKN). PAL guidelines were met for all parameters, except total alkalinity and pH (below minimum guideline) in Edith Lake and 4 of the extra waterbodies sampled; and dissolved iron in the Coutts River. The low alkalinity value reflects the naturally low buffering capacity in the lakes, and the guidelines only apply if natural conditions are not normally low. Dissolved iron values are consistent with historical results for the Coutts River. There are decreasing trends for pH at Chrystina Lake; total organic carbon for Coutts River; and silicon in Edith Lake. There are increasing trends for TKN, total potassium, copper, and chlorophyll-a in Edith Lake; total silicon in S5A; and increasing barium, sodium, strontium, and chlorophyll-a in Chrystina Lake. There are no guidelines for any of these parameters, except for pH. An examination of pH in 11 lakes across the region showed that pH values in Edith and Chrystina lakes are within the range of other lakes in the region. pH seems to be lower in lakes that have relatively small watersheds, meaning that the relative proportion of water feeding the lakes comes more from rain and snow (which have lower pH).

5.2 Sediment Monitoring

Sediment quality in waterbodies near the SHTC is an important indicator of both current environmental conditions affecting aquatic biota and of cumulative pollutant deposition. The sediment monitoring program evaluates spatial and temporal patterns in water quality relative to the SHTC, with stream stations being monitored annually and lake stations monitored biannually. In 2024, sediment samples were collected from two streambed sites (Coutts River (S5A) and S6) and two lake sites (Edith Lake and Chrystina Lake (S12)) as part of the regulatory environmental monitoring program. Over 300 sediment quality parameters were measured, including nutrient, metal, and organic parameters. S6 (reference stream) is located approximately

700 m southwest of the SHTC and is along an unnamed tributary of the Coutts River. This tributary discharges into the main stem of the Coutts River downstream of S5A (Coutts River); thus, the two stations do not influence each other. The Edith Lake (reference lake), Chrystina Lake (S12) and Coutts River (S5A) monitoring stations are as described above.

Similar to the surface water quality monitoring program, summary statistics were calculated for each sediment parameter at each site to place the 2024 measurements in historical context (where adequate data were available). Values that were high relative to historic measurements were flagged. Measurements from 2024 were also compared to CCME Sediment Quality Guidelines for the Protection of Aquatic Life (PAL; where available) and exceedances were noted and described. Finally, non-parametric monotonic trend analysis was conducted on parameters with at least 8 years of data and with fewer than 50% of those measurements being censored. The Mann-Kendall test was used to assess whether sediment quality parameters significantly increased, decreased, or lacked a distinct pattern over time. As with the surface water quality analysis, in 2024 a 10 year “moving window” trend analysis approach was implemented, highlighting contemporary trends in sediment quality instead of being driven by historically high values.

A summary of historical range and regulatory guideline exceedances, as well as significant sediment quality trends, is outlined in Table 5-2. In 2024, sediment quality near the SHTC in Chrystina Lake, Edith Lake, S6, and the Coutts River had historically high metals, although only a few sites had historical range exceedances that included toxic metals (arsenic, mercury, zinc, and copper). The PCB TEQ was historically high at all sites, but it is based on relatively few samples (8-10) taken in more recent years. Interim Sediment Quality Guideline (ISQG) exceedances were documented for arsenic at all 4 stations; nickel at Chrystina Lake and Edith Lake; mercury at Edith Lake, Cadmium at Edith and S6; and manganese at all 4 stations. Only S5A had a significant increasing trend for PCB TEQ. Total PCBs remained unchanged at both lake sites – likely because the historically high PCB values occurred several decades ago and the moving window trend analysis is now capturing baseline values. However, a large spike was noted at both S6 and S5A. This may be due to historically-high organic carbon in the sediment or scouring of the stream channels during summer rain events. No significant trends in PCDD/F Toxic Equivalents (TEQs) occurred at any sites; however, PCDD/F TEQs exceeded the respective ISQG at Chrystina Lake and Edith Lakes, as has been the case for much of the data record.

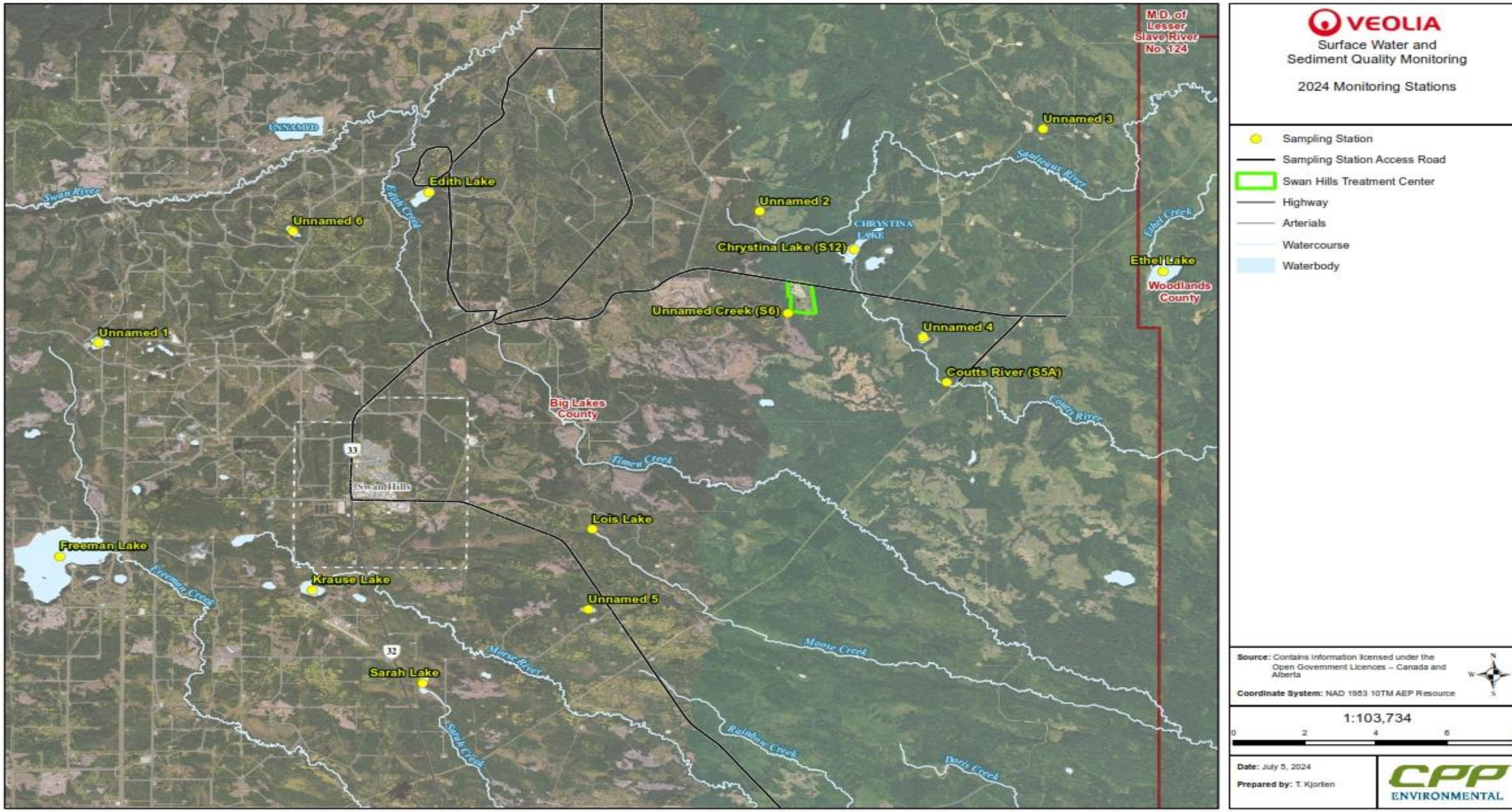

Figure 5-1: Surface Water, Sediment and Fish Tissue Monitoring Locations

Table 5-1: Summary of 2024 Surface Water Quality Monitoring Program

2024 surface water quality summary, including historically high values in 2024, regulatory guideline exceedances (AB chronic surface water quality guidelines, 2018), and significant ($\alpha = 0.1$) water quality trends over 10 years for each of three monitoring sites.

Parameter	Above Historical Range			Exceeding Regulatory Guidelines			Mann-Kendall Trends		
	Chrystina L. (S12)	Edith L.	Coutts R. (S5A)	Chrystina L. (S12)	Edith L.	Coutts R. (S5A)	Chrystina L. (S12)	Edith L.	Coutts R. (S5A)
Alkalinity, total as CaCO3	-	-	-	-	**Above chronic**	-	NT	NT	NT
Barium	**Above**	-	-	-	-	-	**Up**	NT	NT
Calcium	**Above**	-	-	-	-	-	NT	NT	NT
Calcium, dissolved	**Above**	**Above**	-	-	-	-	NT	NT	NT
Chlorophyll-a	**Above**	**Above**	-	-	-	-	**Up**	**Up**	NT
Copper	-	-	-	-	-	-	NT	**Up**	NT
Electrical conductivity	**Above**	-	-	-	-	-	NT	NT	NT
Hardness	**Above**	**Above**	-	-	-	-	NT	NT	NT
Iron, dissolved	-	-	-	-	-	**Above chronic**	ID	NT	NT
Oxygen, dissolved (mg/L)	-	-	**Above**	-	-	-	NT	NT	NT
pH	-	-	-	-	**Below minimum**	-	**Down**	NT	NT
Phosphorous	-	-	-	-	-	-	ID	ID	NT
Potassium	**Above**	-	-	-	-	-	NT	**Up**	NT
Potassium, dissolved	**Above**	-	-	-	-	-	NT	NT	NT
Silicon	-	-	-	-	-	-	NT	**Down**	**Up**
Sodium, total	-	-	-	-	-	-	**Up**	NT	NT
Strontium	**Above**	-	-	-	-	-	**Up**	ID	NT
Total Kjeldahl Nitrogen	-	**Above**	**Above**	-	-	-	NT	**Up**	NT
Total Nitrogen	-	**-**	**Above**				ID	NT	ID
Total Organic Carbon	-	-	-	-	-	-	NT	NT	**Down**
Total Suspended Solids	**Above**	-	-	-	-	-	NT	NT	ID

Note: ID = insufficient data available for trend calculation, NT= Non-significant trend

Table 5-2: Summary of 2024 Sediment Quality Monitoring Program

2024 sediment quality monitoring program summary, including variables that were high in 2024 relative to historical levels, exceedances of regulatory guidelines (ISQG = interim sediment quality guidelines; CCME 2001c), and significant (α = 0.1) trends over 10 years.

Parameter	Above Historical Range				Exceeding Regulatory Guidelines				Mann-Kendall Trends			
	Chrystina L. (S12)	Edith L.	Coutts R. (S5A)	S6	Chrystina L. (S12)	Edith L.	Coutts R. (S5A)	S6	Chrystina L. (S12)	Edith L.	Coutts R. (S5A)	S6
Aluminum	-	-	-	**Above**	-	-	-	-	NT	NT	NT	**Up**
Arsenic	-	**Above**	-	-	**Above** ISQG, Below PEL	**Above** ISQG, Below PEL	-	**Above** ISQG, Below PEL	NT	**Up**	NT	NT
Barium	**Above**	-	**Above**	-	-	-	-	-	NT	NT	NT	NT
Cadmium	-	-	-	**Above**	-	**Above** ISQG, Below PEL	-	**Above** ISQG, Below PEL	NT	**Up**	NT	NT
Calcium	-	-	-	**Above**	-	-	-	-	NT	NT	NT	**Up**
Cobalt	-	**Above**	-	-	-	-	-	-	**Up**	**Up**	NT	NT
Copper	-	-	-	**Above**	-	-	-	-	NT	NT	NT	NT
Iron	**Above**	**Above**	-	**Above**	-	-	-	-	NT	NT	NT	NT
Lead	-	**Above**	-	-	-	-	-	-	NT	**Up**	NT	NT
Magnesium	**Above**	**Above**	-	-	-	-	-	-	NT	NT	NT	NT
Manganese	-	**Above**	**Above**	-	**Above** ISQG	**Above** ISQG	**Above** ISQG	**Above** ISQG	NT	NT	NT	NT
Mercury	-	-	-	**Above**	-	**Above** ISQG Below PEL	-	-	NT	NT	NT	ID
Molybdenum	-	-	ID	**Above**	-	-	-	-	NT	NT	NT	NT
Nickel	-	-	-	-	**Above** ISQG	**Above** ISQG	**Below** ISQG	-	NT	NT	NT	NT
Organic carbon, total	-	**Above**	-	**Above**	-	-	-	-	NT	NT	NT	**Up**
PCB TEQ	**Above**	**Above**	**Above**	**Above**	-	-	-	-	NT	NT	NT	NT
PCB 77	**-**	**-**	**-**	**Above**					-	**Up**	**Up**	NT
PCB 123			**Above**	**Above**							**Up**	-
PCB 156+157	**-**	**Above**	**Above**	**Above**	-	-	-	-	NT	NT	**Up**	**Up**
PCDD/F TEQ	-	-	-	-	**Above** ISQG, Below PEL	**Above** ISQG Below PEL	-	-	NT	NT	NT	NT
Phosphorus	-	-	-	**Above**	-	-	-	-	NT	NT	NT	NT
Strontium	-	ID	**Above**	**Above**	-	-	-	-	NT	NT	NT	**Up**
Sulphur	-	**Above**	-	**Above**	-	-	-	-	NT	NT	NT	**Up**
Thallium	-	**Above**	ID	ID	-	-	-	-	**Up**	NT	NT	ID
Uranium	-	-	-	**Above**	-	-	-	-	**Up**	NT	NT	NT
Vanadium	**Above**	**Above**	-	**Above**	-	-	-	-	**Up**	**Up**	NT	NT
Zinc	-	**Above**	**Above**	**Above**	-	-	-	-	**Up**	**Up**	NT	NT

Note: ID = insufficient data available for trend calculation, NT= Non-significant trend

5.3 Fish Tissue Monitoring

The annual monitoring program includes the collection and chemical analysis of brook trout tissue from Chrystina Lake and Edith Lake to assess potential fish tissue contamination and fish health. Due to its downwind proximity (1.5 kilometres) to the facility, Chrystina Lake is the main study lake, while Edith Lake is farther away, upwind, and acts as a local reference for the FTMP. Both lakes are open year-round to recreational fishing and are stocked each spring with brook trout as part of the Alberta Environment and Protected Areas annual stocking program. In 2024, brook trout were stocked into both lakes from the Raven Brood Trout Station (the hatchery) near Caroline, Alberta. Stocked brook trout have been implanted with coded wire tags (CWTs) each year since 2012 to provide definitive ages. These tags are 1.1 mm long, biologically inert, stainless-steel tags that are imprinted with codes specific to each stocking year and are implanted into the fish snouts before stocking. Tissue samples from both lakes were separated by age and analyzed for contaminants of concern (COC) listed in Table 5-3. Historically, PCBs drive toxicity levels in Chrystina Lake brook trout and are the main COC associated with the facility. There currently is an Alberta Health advisory recommending that consumption of brook trout captured from within 20 km of Swan Hills be kept to only two servings (75 grams/serving) per week.

Table 5-3: Contaminants of Concern Measured During the 2024 FTMP

Metals	Organics
Aluminum, Antimony, Arsenic, Barium, Beryllium, Boron, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Lead, Magnesium, Manganese, Mercury, Molybdenum, Nickel, Phosphorus, Potassium, Selenium, Silver, Sodium, Thallium, Uranium, Vanadium, Zinc	Polychlorinated Biphenyls (PCB) Dioxins Furans

Brook trout were captured from Chrystina and Edith lakes in mid-August. To investigate the potential effects of the facility on fish in nearby waterbodies, chemical concentrations in brook trout from Chrystina Lake were compared with applicable guidelines, historical ranges, and concentrations in the hatchery (control group) and Edith Lake brook trout (reference condition). Objectives of the 2024 monitoring programs include: evaluating brook trout size and condition to detect possible effects of chemical stressors near the facility; comparing PCB concentrations among brook trout age classes in Chrystina and Edith lakes to investigate possible COC accumulation and health impacts; and identifying key recommendations to improve the effectiveness and reliability of the FTMP.

The 2024 monitoring program was also an expanded year; key features of this expansion include:

- Increasing the fish captured in Chrystina Lake, and Edith Lake to 40 instead of 30 fish.

- Completion of a historical analysis of Edith Lake to determine if biannual sampling would be more effective moving forward.
- A fish head community outreach program, which includes signage installed at both lakes encouraging anglers to submit the heads from their catches to increase the number of CWTs submitted for analysis to achieve a greater understanding of age distribution in both lakes.

Tissue Residue Quality Criteria

The toxicity of dioxins, furans, and dioxin-like PCBs occurs through similar physiological processes therefore the toxicity of these compounds can be quantified by combining their respective toxic effects into a single toxic equivalency (TEQ). The TEQ approach uses the toxic equivalence factor (TEF) method, which is based on the concept of dose addition, where the toxicity of individual dioxin and dioxin-like compounds in a mixture is combined into the single TEQ metric that can be used to facilitate risk assessment and regulatory control. The TEQs calculated during the FTMP are based on the 2005 World Health Organization (WHO) TEFs for mammals that express the toxicity of each dioxin, furan, and dioxin-like PCB relative to the most toxic form of dioxin.

Guidelines and toxicological thresholds applicable to the FTMP are summarized in Table 5-4. The Canadian Council of Ministers of the Environment (CCME) guidelines and tissue residue benchmarks (TRB) for dioxins, furans, and dioxin-like PCBs set tissue residue criteria based on TEQ and provide context for concentrations of organic contaminants in Chrystina Lake brook trout. The CCME guidelines provide stringent criteria to protect wildlife consumers of aquatic biota and are protective of the most sensitive wildlife consumers of fish (i.e. mink). The TRBs assist in evaluating the potential of PCBs to cause adverse effects on Chrystina Lake brook trout.

Total PCB concentrations in the edible tissue of brook trout collected during the FTMP are compared with the consumption advisory levels established for the Great Lakes region, while Canada's federal quality criterion for total PCBs remains under review until a provincial guideline is set. The advisory level for unrestricted consumers (0.05 µg/g) is the most stringent consumption limit and is protective of individuals who consume over 225 meals of wild-caught fish per year.

Toxicological thresholds have been developed for eleven metals from the Society of Environmental Toxicology and Chemistry (SETAC) toxicity database based on previously reported no observable effect concentrations (NOEC). The NOEC represents the highest concentration of a contaminant that will not cause an adverse effect. In addition, maximum levels for contaminant concentrations established by Health Canada under the *Food and Drug Regulations* are used to evaluate concentrations of arsenic, lead, and mercury in Chrystina Lake brook trout relative to limits imposed on retail foods.

Table 5-4: Tissue Residue Quality Criteria for the Fish Tissue Monitoring Program

Guideline/ Benchmark	Source	Applicable COC	Protection
Great Lakes Consumption Advisory Levels (2018)	Binational Strategy for Polychlorinated Biphenyl (PCB) Risk Management	Total PCBs	Protection of human fish consumers
CCME (2001)	Canadian Council of Ministers of the Environment (CCME) - Tissue Residue Guidelines	PCBs Dioxins/Furans	Protection of wildlife consumers of aquatic biota
Tissue Residue Benchmarks (TRB)	TRB for Aquatic Biota derived for TCDD and Equivalents (Steevens et al. 2005)	PCBs Dioxins/Furans	Benchmarks derived for protection of: 99% of fish species present 95% of fish species present 90% of fish species present
SETAC (1999)	Society of Toxicology and Chemistry - Linkage of effects to Tissue Residues Database	Aluminum, Antimony, Arsenic, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Selenium, Zinc	No Observable Effect Concentrations (NOEC) for salmonid fish species
Health Canada (2020)	*List of Maximum Levels for Various Chemical Contaminants in Foods* and *List of Contaminants and Other Adulterating Substances in Foods*	Arsenic, Lead, Mercury TCDD	Maximum Levels (ML) for chemical contaminants in retail foods
GOA 2018	Alberta Surface Water Quality Guidelines – Tissue Residue Guideline	Selenium	Fish protection from adverse effects

Fish Characteristics

The fork length between Chrystina and Edith lakes remain similar in 2024. When compared to previous years, the mean fork length for Chrystina Lake has been the lowest since 2012, and Edith Lake has been since 2020. Fish condition for Chrystina Lake brook trout is 1.25 on average, which is considered sufficient for recreational anglers. In addition, this is the highest reported fish condition for Chrystina Lake brook trout since 2004. Condition of Edith Lake brook trout dropped to 1.06 from 1.16 in 2023, which represents poor condition for salmonids and is the lowest result since 2015. The Catch Per Unit Effort (CPUE) was lower in Chrystina Lake in 2024 at 0.85 compared to 1.34 in 2023, while Edith Lake remained comparable (0.29 in 2024, 0.26 in 2023).

Samples analyzed as part of the 2024 FTMP are summarized in Table 5-5. Three fish were captured in Chrystina Lake that did not have a CWT and could not be reliably aged. These fish were analyzed as individuals and were labeled as Unknown A, B, and C. Unknown C had a fork length of 405 mm with a total weight of 955 g, making it one of the largest fish ever captured in the program's history. Fish captured from Chrystina Lake are, on average, larger than their Edith Lake counterparts in each age category.

Table 5-5: Composition of Samples Analyzed during the 2024 Monitoring Program

Age Class	Chrystina Lake (CHBKTR)	Edith Lake (EDBKTR)	Hatchery (HATCH)
1+	*Composite (five fish)*	*Composite (five fish)*	*Composite (six fish)*
2+	*Composite (five fish)*	*Composite (six fish)*	---
3+	*Composite (three fish)*	*Composite (two fish)*	---
4+	---	*Individual*	---
5+	---	*Individual*	---
UNK A	*Individual*	---	---
UNK B	*Individual*	---	---
UNK C	*Individual*	---	---

Polychlorinated Biphenyl (PCB) Levels and Trends

Total PCB concentrations in 2024 for Chrystina Lake and Edith Lake are provided along with historical data in Figure 5-2. Each measurement since 2006 is provided as a single point (concentrations for duplicate samples averaged), with green points representing more recent data and blue representing old PCB concentrations. Total PCB concentrations for 2024 (red) are provided as single points, while mean concentrations for each age class are represented by a horizontal (mean) and vertical (standard error) black line.

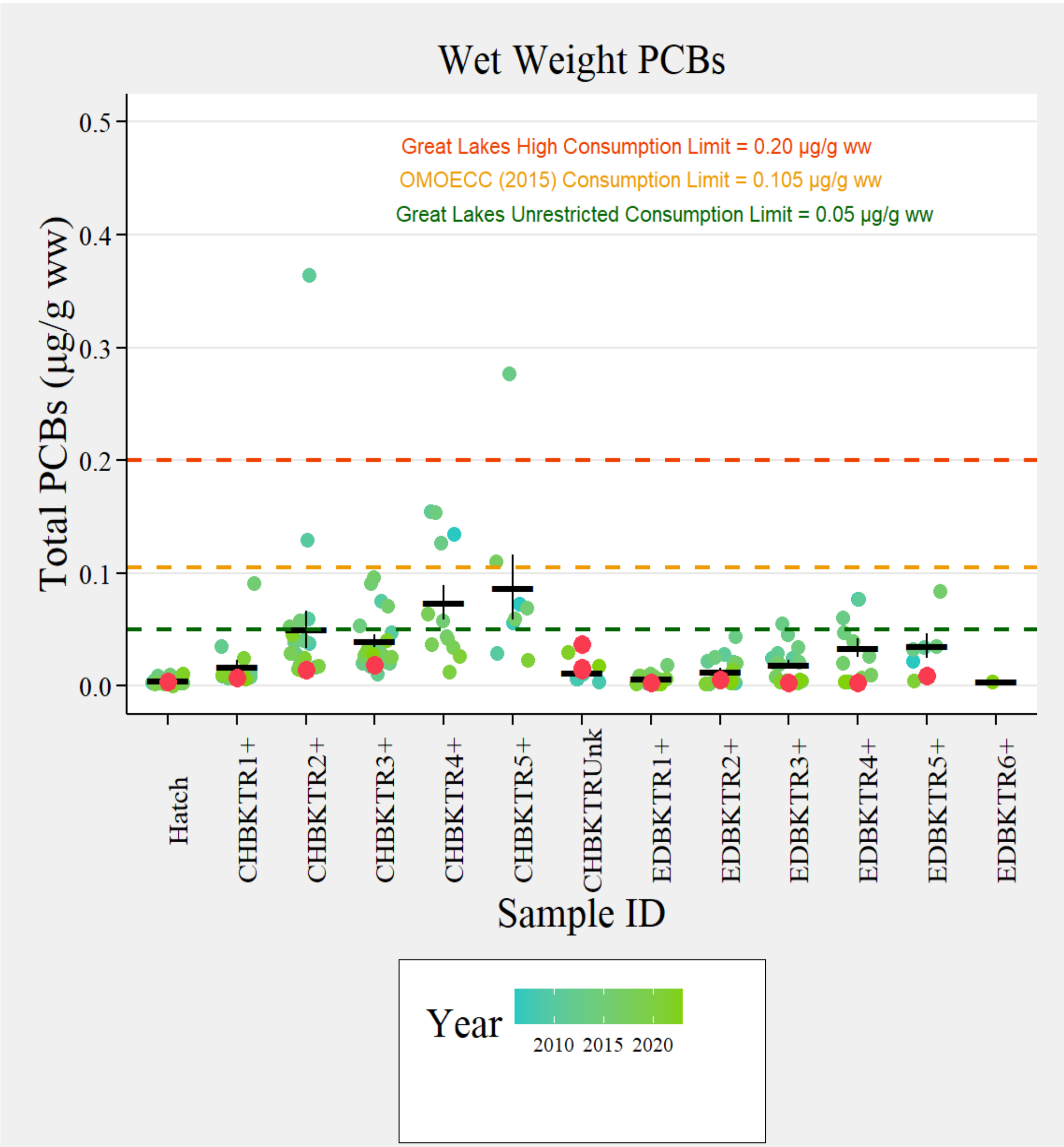

Figure 5-2: Ave Total PCB Concentrations in Chrystina & Edith Lake Brook Trout (2006 to 2024)

Total PCB concentrations in Chrystina Lake brook trout remained consistent in 2024 when compared to previous year's results, apart from CHBKTR3+ which decreased since 2023. Total PCB concentrations in Edith Lake brook trout also remained consistent with 2023 results. All age classes for both lakes were below the unrestricted consumption guideline for the Great Lakes.

Since PCBs are lipophilic and preferentially accumulate in fatty tissue, the total PCB concentrations were normalized according to the lipid content in each sample to provide a lipid normalized PCB (PCB_{lipid}) concentration. The PCB_{lipid} concentrations of Chrystina Lake brook trout continued to decrease from the previous year in 2024. Edith Lake total PCB_{lipid} concentrations decreased in all age classes except the 1+ and 2+ year olds, which showed slight increases from 2023. Overall linear regression trends for both lakes suggest a statistically significant decreasing trend in total PCBs (Figure 5-3).

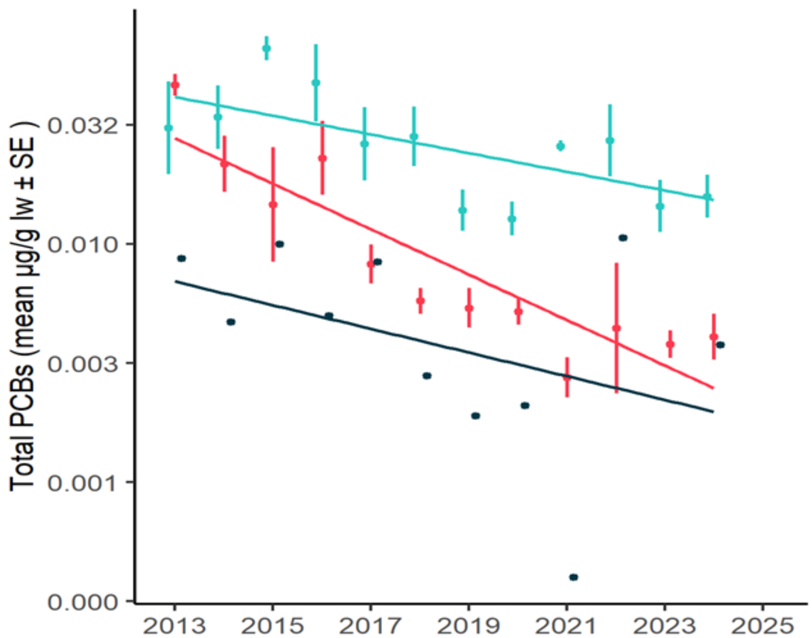

Figure 5-3: Ave (± standard error) Lipid Normalized Total PCB in Chrystina & Edith Lake Brook Trout (2012 to 2024)

Reconstruction of the life history of a single fish is used to estimate PCB accumulation rates in Chrystina Lake and Edith Lake brook trout. Reconstructed life-history results based on PCB 118 are summarized for cohorts stocked into Chrystina Lake and Edith Lake from 2010 to 2021 in Figure 5-4 plots A and B.

This figure provides the exponential relationships plotted on a log-transformed axis; therefore, they appear linear for each successive cohort in Chrystina Lake (Plot A) and Edith Lake (Plot B). Plots C and D provide the slope parameter for each cohort from 2010 to 2021. Within Chrystina Lake, the accumulation rates for PCB 118 had been decreasing prior to 2021; however, estimated accumulation rates suggest an increasing trend since the 2016 cohort. Edith Lake accumulation rates have been increasing as well. As a result, there is no longer a significantly decreasing trend for the rate of PCB accumulation in Edith Lake. Despite the potential increase in PCB accumulation rates, the PCB tissue concentrations in both lakes remain relatively low compared with historical data.

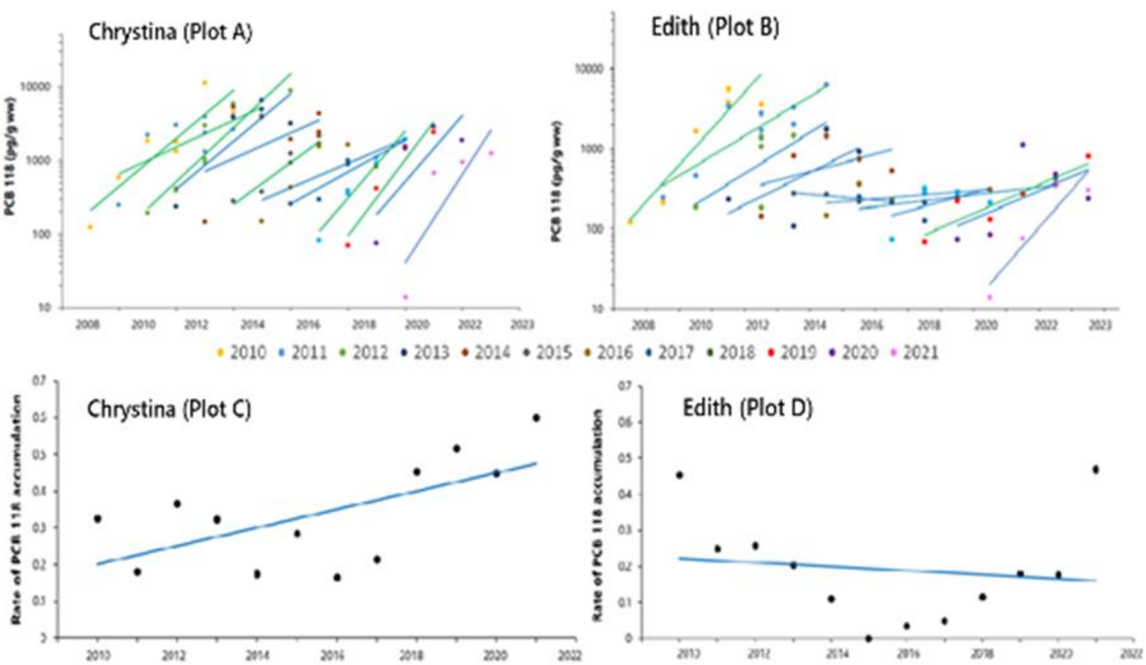

Figure 5-4: PCB 118-Based Reconstructed Life-Histories of Brook Trout Stocked into Chrystina Lake and Edith Lake for Cohorts stocked from 2010 to 2021

Overall Toxicity Levels and Trends

Dioxin/furan based TEQ ($TEQ_{Dx/F}$) concentrations for both lakes continue to be below historical maxima, although all age classes within Chrystina Lake and Edith Lake show slightly increased concentrations compared to 2023. Despite the increases, all $TEQ_{Dx/F}$ concentrations in 2024 remain below the CCME (2001b) guideline.

The 2024 TEQ_{PCB} content in Chrystina Lake brook trout are consistent with the 2023 data, with all age classes below the CCME (2001a) guidelines. Similarly to 2023, the 3+ year-old age class remains above this guideline but continues to decrease. The TEQ_{PCB} concentrations for Edith Lake brook trout remain under the CCME (2001a) guideline and decreased in the 3+ and 4+ year-old age classes, while increasing in the 1+, 2+, and 5+ year-old age classes. New historical minima for total PCBs were set for the Edith Lake 3+ and 4+ year-old age classes.

The total TEQs of brook trout sampled in 2024 are compared with the CCME guideline, historical ranges, and Edith Lake brook trout in Figure 5-5. Additionally, the total TEQ was normalized according to lipid content and the average TEQ of Chrystina Lake, Edith Lake, and hatchery brook trout since 2012 were fit to a logarithmic regression to assess for trends over time (Figure 5-6). From these results, the 1+ year-old age class in Chrystina Lake had TEQs below the CCME guideline, with older fish (2+, 3+, and unknowns) exceeding the CCME guideline. Unlike 2023, where all TEQ concentrations in Edith Lake brook trout were below the CCME guideline, two age classes (2+ and 5+ year-olds) were above guidelines. The average lipid normalized TEQ decreased in both lakes between 2012 and 2024 (Figure 5-6). In more recent years (2022-2024), average total TEQs in Chrystina Lake continue decreasing, while average total TEQs in Edith Lake are elevated compared with the decreasing trend. Lastly, the lipid normalized TEQs in both lakes are below the most conservative TRB, which is protective of 99% of fish species, including brook trout. According to the linear regression results, average TEQ in both lakes continues to decrease and this decrease is statistically significant for both lakes.

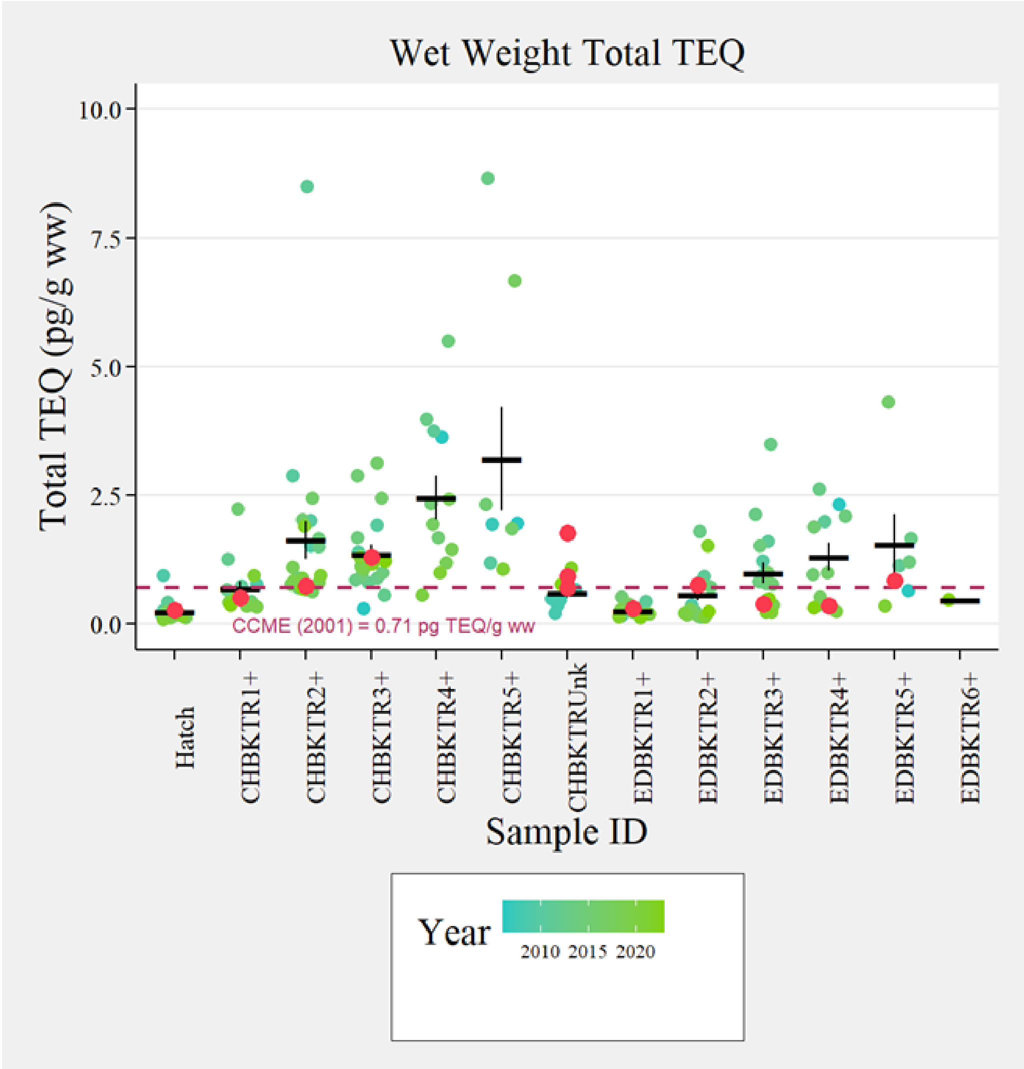

Figure 5-5: Historical and 2024 Wet Weight Total TEQs in Brook Trout (2006 to 2024)

Figure 5-6: Average Lipid Normalized Total TEQs in Brook Trout (2012 to 2024)

Other Contaminants and Guidelines

Inorganic and organic concentrations that exceed tissue residue criteria in 2024 are summarized alongside historical range comparisons in Table 5-6. No metals other than zinc exceeded guidelines in Chrystina Lake, while chromium, iron, and barium had historical minima. Christina Lake also exceeded guidelines for total TEQ and PCB-based TEQ across multiple age classes. A new historical maximum for chromium and lead was recorded in Edith Lake brook trout, which are the first metal concentrations exceeding a historical maximum in this lake since 2016. Apart from this, guideline exceedances were consistent with those previously documented in Chrystina and Edith lakes.

Table 5-6: Guideline Exceedances & Historical Comparisons of 2024 Tissue Concentrations

Location/Age Class	Guideline Exceedances	Contaminants Outside Historical Range
Chrystina Lake 1+	Zinc	*Chromium, Iron*
Chrystina Lake 2+	Total TEQ, Zinc	*Coplanar PCB 105, 114*
Chrystina Lake 3+	PCB-based TEQ, Total TEQ, Zinc	*Barium*
Chrystina Lake (Unk A)	Total TEQ, Zinc	N/A
Chrystina Lake (Unk B)	PCB-based TEQ, Total TEQ, Zinc	N/A
Chrystina Lake (Unk C)	Zinc	N/A
Edith Lake 1+	Chromium, Selenium, Zinc	***Chromium***
Edith Lake 2+	Total TEQ, Zinc	*Copper, Coplanar PCB 123*
Edith Lake 3+	Zinc	*Coplanar PCB 114,* ***Lead,*** *Total PCB*
Edith Lake 4+	Aluminum, Zinc	*Coplanar PCB 114, 118, 123, 156, 167, 189, Total PCB*
Edith Lake 5+	Zinc	*Arsenic*

Notes:
Guideline exceedances indicate tissue concentrations above SETAC thresholds for metal contaminants and CCME tissue residue guidelines for organic contaminants.
Contaminants listed in *italics* indicate that the tissue concentration is below the historical minimum for the corresponding age class.
Contaminants listed in ***BOLD*** indicate that the tissue concentration is above the historical maximum for the corresponding age class

Expanded Program Objectives Summary

A summary of the 2024 expanded program objectives are below:

- Due to the success of gill netting in Chrystina Lake and the overall health of the brook trout from this lake, increasing the fish captured in both lakes to 40 instead of 30 did not result in captured fish older than 3+ years. Moving forward, it is recommended that less emphasis be put into gill netting with more time being devoted to angling and the use of set lines will be incorporated into fishing methods.
- Completion of a historical analysis of Edith Lake has determined concentrations have been similar to hatchery fish since 2017 and it is recommended that biannual sampling of Edith Lake would be more effective moving forward. The off years would be used to devote more resources to determining PCB concentration variability in Chrystina Lake brook trout.
- After conversations with Alberta Parks, Alberta Environment and Protected Areas (AEPA), the fish head community outreach program was approved. Signage and brochures have been created outlining the intent to use data collected from donated fish heads to increase the

understanding of age distribution in both lakes. Brochures were provided to community stakeholders in 2024 and signage is ready to be posted in the recreational areas of both lakes.

Figure 5-7: Examples of signage and brochure created for Fish Head Outreach Program in 2024

5.4 Toxicological Assessment of Fish Tissue Monitoring Results

Brook trout are collected annually from Chrystina Lake (study lake) and Edith Lake (reference lake) as part of the EMP to measure concentrations of contaminants of concern in edible tissue. Polychlorinated biphenyl (PCB) concentrations are measured given that these compounds are the main contaminants of concern based on historical monitoring data. Polychlorinated dibenzo-ρ-dioxin (dioxin) and polychlorinated dibenzofuran (furan) concentrations are also measured in edible brook trout tissue given that these contaminants can be produced when PCBs are heated. Historically, dioxin and furan concentrations in fish tissue have been below analytical detection limits in both lakes but they continue to be monitored to ensure the monitoring program captures these potential effects on the surrounding environment.

Tissue concentrations measured in brook trout from Chrystina Lake and Edith Lake are used to inform the annual human health risk assessment (HHRA) component of the EMP. The objectives of the HHRA in 2024 include:

- Comparing measured Contaminant of Concern (COC) concentrations in edible brook trout tissue from Chrystina Lake and Edith Lake in 2024 with historical concentrations; and
- Determining potential risk to human health posed by consumption of brook trout captured from Chrystina Lake and Edith Lake based on Health Canada's current exposure limits.

The scope of the EMP is expanded for all monitoring components every five years to identify potential data gaps and ensure the level of effort and methods used are appropriate to fulfill program objectives. The 2024 monitoring program represents an expanded monitoring year and additional scope for the HHRA includes:

- A review of currently used exposure factors (e.g. background exposure estimates, consumption rates, and body weights) and their reliability to assure the accuracy of risk estimates calculated during the HHRA.
- A review of current tolerable daily intakes (TDIs) for COCs and their supporting derivation information, including consultation with Alberta Health to investigate the most appropriate TDIs for the HHRA.
- Review historical trends associated with maximum tissue concentrations to investigate maximum worst-case risk estimates over time.
- Assessment of current program triggers and development of new triggers if required following review of exposure factors (e.g. consumption rates, body weights, background exposure estimates), and TDIs used for the HHRA in 2024 and beyond.

Refinement of the HHRA since its inception has identified consumption of wild-caught fish as the main exposure pathway to PCBs and this is the only exposure pathway assessed as part of the HHRA. The current version of the HHRA characterizes risk to adult, adolescent, child, and toddlers through the fish consumption pathway and associated risk factors for these groups are also considered.

Contaminant Concentration Analysis

The HHRA is based on analysis of fish tissue samples using congener-specific PCB analysis (based on EPA method 1668C), which includes concentrations of all 209 PCB congeners. Brook trout tissue concentrations for each dioxin, furan, and dioxin-like PCBs including PCB 77, 81, 126, and 169 are also measured using EPA method 1613B.

Tissue concentrations measured in brook trout from each lake are divided into three categories for the HHRA including the maximum concentration, weighted average, and average of ‘keeper’ fish. Maximum concentrations provide an overly conservative estimate of risk but is included to provide a worst-case scenario for comparison with exposure limits. Since 2019, the weighted average of brook trout 2+ years old and up has been included in the HHRA given that these fish are generally targeted by recreational fishers based on size. These brook trout are generally referred to as ‘keeper’ fish. Notably, large brook trout with unknown ages have been incorporated into the ‘keeper’ category since 2022 given that they would be targeted by recreational fishers.

Exposure estimates calculated for the 2024 HHRA are based on contaminant concentrations including:

- the annual weighted average of all brook trout sampled from each lake since 2002;
- the weighted average of ‘keeper’ brook trout from each lake since 2019;
- the maximum concentration measured in brook trout from each lake in 2024; and
- the maximum concentration measured in brook trout from each lake since 2006 (as part of the expanded program).

Risk Characterization

In the context of HHRA, risk characterization is the final step in the risk assessment process that combines information from the toxicity and exposure assessments to determine estimated risk to consumers. The toxicity assessment includes a scientific evaluation of the potential harm from COCs to human health and involves the development of exposure limits for various exposure routes. The Swan Hills HHRA assesses risks from the consumption of wild-caught fish, therefore exposure limits are based on tolerable daily intakes (TDIs) established by Health Canada. These TDIs set the safe consumption limits for COCs based on available toxicological data. The exposure assessment is the process of quantifying the following:

1. Magnitude, frequency and duration aims to quantify how much, how often and how long humans (e.g. daily intake or dose) are exposed to a COC.

2. Population characteristics - Adults, adolescents, children, and toddlers were identified as receptors exposed to PCBs through ingestion of fish tissue collected near the SHTC.

3. Routes and pathways – This HHRA is aimed only at the fish consumption pathway in this instance (see Section 3).

Population characteristics are a key component of the exposure assessment given that exposure estimates are based on assumed exposure factors including consumption rates, body weights, and background exposures based on available information. Consumption rates, body weights, and background exposures are based on food consumption surveys, ideally within the region of the specific HHRA. Health Canada and Alberta Health have developed guidance documents to help determine the most reliable exposure factor values based on meta-analysis of previous food consumption surveys throughout Alberta/Canada. Exposure factors traditionally used for the SHTC HHRA are adopted from the 1997 diet and activity study by Alberta Health. These exposure factors, along with COC concentrations, are used to calculate daily intakes (exposure estimates) for each consumer group (Equation 1). Exposure factors currently used for each consumer group assessed during the SHTC HHRA are summarized in Table 5-7.

Equation 1

$$Estimated\ Exposure = \frac{COC\ Concentration\ *\ Consumption\ Rate}{body\ weight} + Background\ Exposure$$

Table 5-7: Exposure Factors used to Quantify Exposure for the SHTC HHRA

Life Stage	Age Group	Average Consumption Rate (grams/day)	Average Body Weight (kg)	Background Exposure
Adult	>19 years	High consumer = 167 **Medium consumer = 47** Low consumer = 13 Very low consumer = 2 Advisory level = 22	73 (propose change to 80 kg following 2024)	Total PCBs = 0.002 µg/kg/day Total TEQ = 0.5 pg TEQ/kg/day
Adolescent	12 – 19 years	40	65.2	Total PCBs = 0.002 µg/kg/day Total TEQ = 0.63 pg TEQ/kg/day
Child	5 – 11 years	33	35.2	Total PCBs = 0.0035 µg/kg/day Total TEQ = 0.99 pg TEQ/kg/day
Toddler	7 month – 4 years	20	15.3	Total PCBs = 0.0068 µg/kg/day Total TEQ = 1.89 pg TEQ/kg/day
Notes: **Bold** text denotes that the medium consumer group more accurately reflects current maximum consumption rates of traditional foods in the Swan Hills region based on literature review and discussions with Alberta Health				

Risk is characterized for each consumer group by comparing the estimated exposure from the exposure assessment with Health Canada TDIs from the toxicity assessment to calculate an exposure ratio (ER) using Equation 2.

Equation 2

$$Exposure\ Ratio\ (ER) = \frac{Estimated\ exposure}{Exposure\ Limit\ (TDI)}$$

The toxicity and exposure assessments maintain a conservative approach to ensure that potential risks to human consumers are not underestimated. The SHTC HHRA maintains this conservatism by incorporating the following:

1. Dioxin, furan, and PCB concentrations below the detection limit are replaced with half the detection limit value to account for potential exposure to these COCs.

2. Risk estimates are based on the highest consumption rate from the 1997 Swan Hills survey to ensure ERs are protective of people consuming the highest tissue quantities.
3. Risks are characterized based on maximum concentrations reported in fish tissue to account for a worst-case scenario for human consumers of wild-caught fish.
4. The lowest regional background exposure rates available have not been incorporated into the HHRA given that some other available diet surveys report higher background exposure rates.
5. Risks are characterized based on tissue concentrations of edible tissue with the skin on to account for higher COC concentrations of lipophilic COCs such as PCBs, dioxins, and furans.
6. Risks reported do not account for cooking prior to eating, which can remove up to 50% of the tissue residues present in edible tissue.

Given the steps to ensure the HHRA maintains a conservative approach, the risks associated with ERs below 1 are considered negligible to be acceptable by Health Canada where background exposure is considered (Health Canada 2021). In this Project, the ER's relevance to levels of risk used during the HHRA include:

- **ER ≤ 1.0 –** estimated exposure from fish consumption are below the respective exposure limit and **no risk** of adverse health effects are expected**.**
- **1 < ER ≤ 10** – estimated exposure from fish consumption presents a **low risk** of potential adverse human health effects given the conservatism built into the HHRA.
- **10 < ER – medium risk** of potential adverse health effects, indicating that risk management and/or adaptive monitoring measures should be considered.

The Health Canada TDI for non-dioxin-like PCBs before 2021 was 0.13 µg/kg/day but was lowered in 2021, causing the ERs calculated during the HHRA to increase substantially. This increase in risk estimates did not reflect a change in tissue concentrations in brook trout captured from Chrystina Lake or Edith Lake. Rather the increased risk estimates caused by the more stringent TDI prompted a review of available TDIs for PCBs in recent years. Currently the Health Canada TDIs for organic COCs, including total PCBs and dioxins/dioxin-like compounds, near the SHTC are:

- Total (non-dioxin-like) PCBs = 0.01 µg/kg/day; and
- Total TEQ (dioxin-like PCBs, dioxins and furans) = 2.3 pg TEQ/kg/day.

The derivation of the 2021 non-dioxin-like PCB TDI was reviewed in detail as part of the expanded program in 2024. A key finding of this review was that the current TDI used in the HHRA has to be corrected (reduced) to account for the proportion of the total PCB concentration that consist of a subset of seven marker PCBs. Comparison with total PCB concentrations from Chrystina Lake and Edith Lake potentially overestimate risk given that the tissue concentrations are based on the sum of all 209 PCB congeners rather than being limited to the seven marker PCBs discussed in the report.

Current versus Proposed Exposure Factors for Risk Characterization

In 2024, risk was characterized based on the exposure factors and PCB concentrations currently used for the HHRA to provide consistency with previous reports and comparison with newly proposed methods. Risk estimates using these methods are referred to as the current HHRA case throughout the report. Risk estimates calculated using the proposed changes to the exposure estimation methods are presented as part of the proposed HHRA case. The current HHRA case overestimates risk based on the findings of the review of exposure factors and limits in 2024. The proposed HHRA case recommends changes including the following:

- Increasing the assumed adult body weight from 73 kg to 80 kg.
- High consumption rate from the 1997 Swan Hills diet and activity study potentially overestimates current consumption rates based on more recent survey data in the Swan Hills region and the medium consumption rate from the 1997 survey aligns more closely with these more recent consumption rates for determining risk.
- Total PCB concentrations (for non-dioxin-like PCBs) currently overestimates risk by comparing tissue concentrations based on the sum of all 209 PCB congeners with the current Health Canada TDI that accounts for only seven marker PCBs.

Health Risks Associated with Consuming Brook Trout from the Swan Hills Area

Tissue concentrations measured in brook trout from Chrystina Lake and Edith Lake in 2024 are summarized in Table 5-8. The weighted average concentrations measured in 2024 are compared with historical concentrations since 2002 in Figure 5-8.

Table 5-8: Weighted Averages for Total PCB Concentrations and TEQs Measured in Brook Trout Sampled for the 2024 HHRA

Age Group	Station	Total PCB (µg/g)	PCB TEQ (pg/g)	Dioxin/Furan TEQ (pg/g)	Total TEQ (pg/g)
2024 Maximum	Chrystina Lake	0.0366	1.56	0.22	1.78
	Edith Lake	0.0086	0.64	0.21	0.85
All ages (weighted average)	Chrystina Lake	0.0143	0.68	0.17	0.84
	Edith Lake	0.0042	0.36	0.17	0.53
>2+ years old ("Keeper")	Chrystina Lake	0.0174	0.83	0.16	1.00
	Edith Lake	0.0048	0.50	0.15	0.65

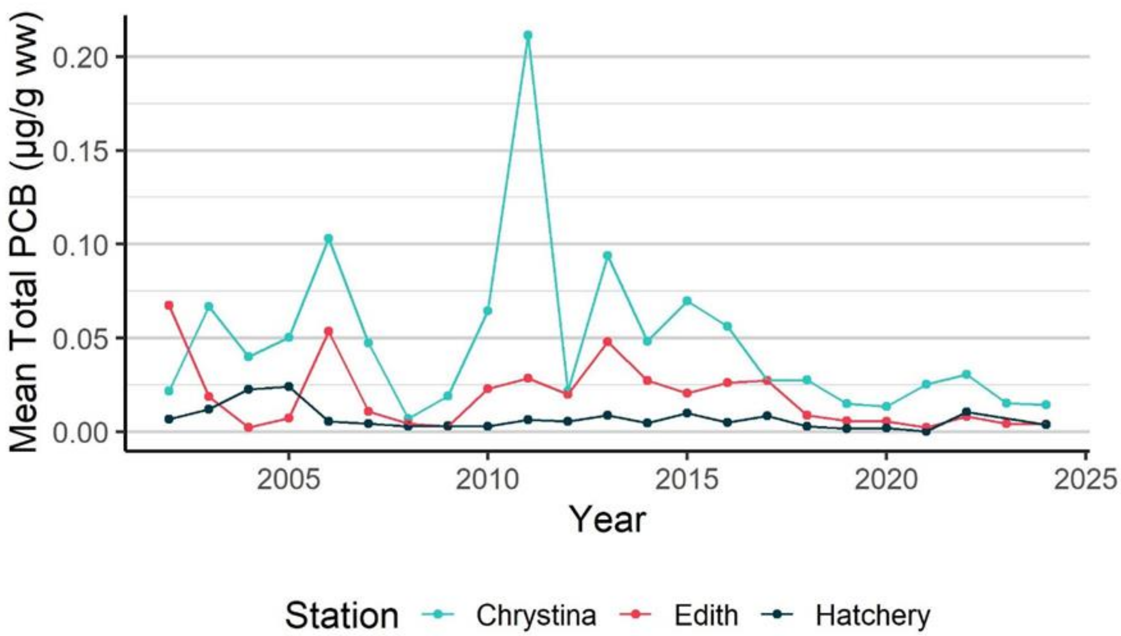

Figure 5-8: Weighted Average of Total PCBs in Brook Tout Sampled from Chrystina Lake, Edith Lake and the Hatchery (2002 to 2024)

Adult Fish Consumers

The ERs calculated for adult consumer groups based on the maximum, weighted average, and 'keeper' average PCB concentrations in Chrystina Lake, Edith Lake, and hatchery brook trout in 2024 (Table 5-9). The ERs for low and very low consumer groups were all below 1, therefore these groups are not included in Table 5-9. There are no ERs exceeding 10 in 2024. High consumers have ERs over one suggesting there is a low potential risk to high consumers of Chrystina lake brook trout. Three of the five tissue samples from Edith Lake reported total PCB concentrations equal to or below concentrations in trout taken directly from the hatchery, leading to similar ERs between Edith Lake (based on weighted average) and hatchery brook trout in 2024 (Table 5-9).

Table 5-9: Exposure Ratios Based on Total PCBs for Consumption of Brook Trout near Swan Hills in 2024

Station	Consumer Class	Maximum	Weighted Average	>2+ years old ("Keeper")
Chrystina Lake	High (167 g/day)	8.57	3.48	4.17
	Medium (47 g/day)	2.56	1.12	1.32
	Advisory (22 g/day)	1.30	0.63	0.72
Edith Lake	High (167 g/day)	2.17	1.17	1.31
	Medium (47 g/day)	0.76	0.47	0.51
	Advisory (22 g/day)	0.46	0.33	0.35
Hatchery	High (167 g/day)	1.06		
	Medium (47 g/day)	0.44		
	Advisory (22 g/day)	0.31		

Notes:
Yellow highlighting indicates ER is between 1 and 10 and has a low risk of potential adverse effects on human fish consumers.

The ERs calculated for potential exposure to dioxin-like PCBs, dioxins, and furans (as total TEQ) from adult consumption of brook trout from Chrystina Lake, Edith Lake, and the hatchery in 2024 are presented in Table 5-10. All the ERs for low and very low consumers were well below 1 and indicate no risk to these consumer groups. The ERs for consumers of Chrystina Lake brook trout were slightly above 1 based on the highest consumption rate. Based on the total TEQ concentrations reported in 2024, there is no risk to most adult consumer groups eating brook trout from both lakes. The low potential risk to high consumers of Chrystina Lake brook trout may overestimate risk based on more recent consumption rate estimates.

Table 5-10: Exposure Ratios for Consumption of Brook Trout near Swan Hills in 2024

Station	Consumer Class	Maximum	Weighted Average	>2+ years old ("Keeper")
Chrystina Lake	High (167 g/day)	1.98	1.05	1.21
	Medium (47 g/day)	0.71	0.45	0.50
	Advisory (22 g/day)	0.45	0.33	0.35
Edith Lake	High (167 g/day)	1.06	0.74	0.86
	Medium (47 g/day)	0.46	0.37	0.40
	Advisory (22 g/day)	0.33	0.29	0.30
Hatchery	High (167 g/day)	0.49		
	Medium (47 g/day)	0.29		
	Advisory (22 g/day)	0.25		

Notes:
Yellow highlighting indicates ER is between 1 and 10 and has a low risk of potential adverse effects on human fish consumers.

The ERs for high consumers based on concentrations of dioxin-like PCBs, dioxins, and furans from 2002 to 2024 are presented in Figure 5-9. These ERs suggest there is no risk to consumers of Edith Lake brook trout and low potential risk to adult consumers of Chrystina Lake brook trout since 2017. In addition, Edith Lake brook trout pose a similar risk to brook trout taken directly from the hatchery since 2017.

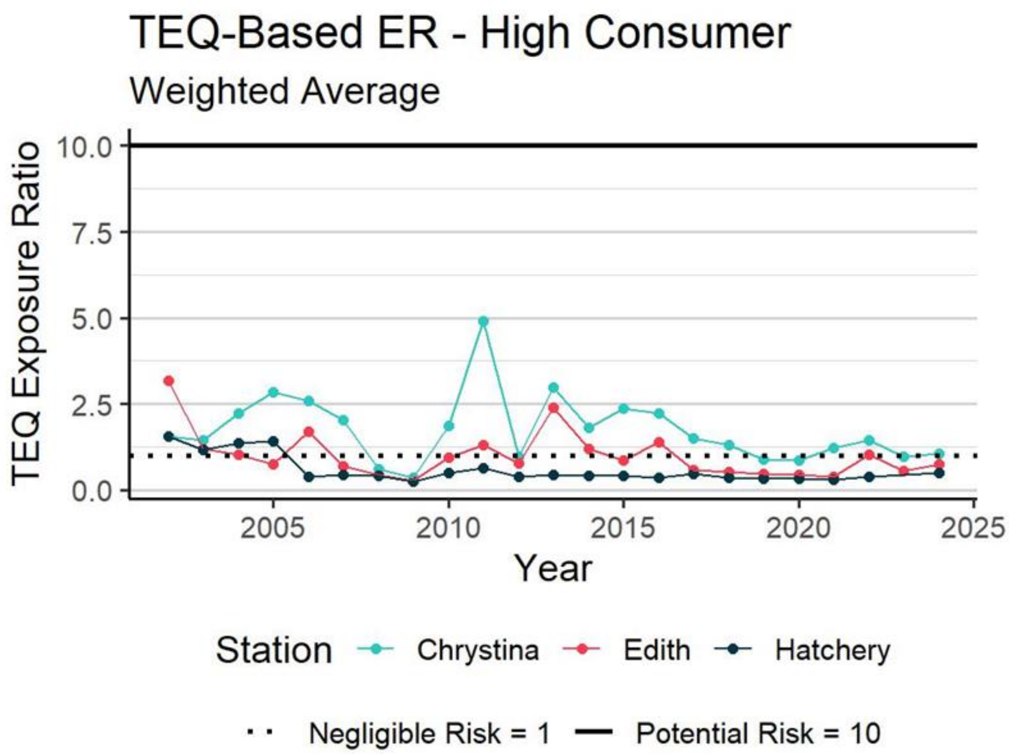

Figure 5-9: Exposure Rations for Adult High Consumers of Chrystina Lake, Edith Lake, and Hatchery Brook Trout Based on the Weighted Average TEQ for Dioxin-like PCBs, Dioxins, and Furans

Adolescent/Juvenile Fish Consumers

The ERs for adolescent, child, and toddler consumers of brook trout from Chrystina Lake, Edith Lake, and the hatchery based on the current HHRA case methods are provided in Table 5-11. Based on the concentrations measured in 2024 in Chrystina Lake there is a low potential risk to toddler, child, and adolescent consumers. Alternatively, there is no risk to child and adolescent consumers, and low potential risk for toddler consumers of Edith Lake brook trout based on concentrations measured in 2024. Similarly to adult consumers, the ERs calculated for Edith Lake brook trout consumers (based on weighted average) were comparable to those calculated for the hatchery brook trout.

Table 5-11: Adolescent/Juvenile Exposure Ratios for Total PCBs for Consumption for Brook Trout Near Swan Hills in 2024

Station	Consumer Class	Maximum	Weighted Average	>2+ years old ("Keeper")
Chrystina Lake	Adolescent	2.45	1.08	1.27
	Child	3.78	1.69	1.98
	Toddler	5.46	2.55	2.95
Edith Lake	Adolescent	0.73	0.46	0.50
	Child	1.16	0.75	0.80
	Toddler	1.81	1.23	1.31
Hatchery	Adolescent	0.43		
	Child	0.70		
	Toddler	1.17		

Notes:

Yellow highlighting indicates ER is between 1 and 10 and has a low risk of potential adverse effects on human fish consumers.

The ERs for adolescent, child and toddler consumers of 'keeper' brook trout from Chrystina Lake and Edith Lake for dioxin-like PCBs, dioxins, and furans (as total TEQ) from 2019 to 2024 are provided in Figure 5-10. These ERs suggest that there is no risk to adolescent and child consumers of brook trout from either lake since 2019, however toddler consumers may have low potential risk from brook trout consumption. Notably, the ERs for toddler consumers is highly conservative given that the background exposure estimate for this consumer group represents 82% of the TDI. Consequently, the ER for brook trout taken directly from the hatchery is nearly 1 (ER=0.98).

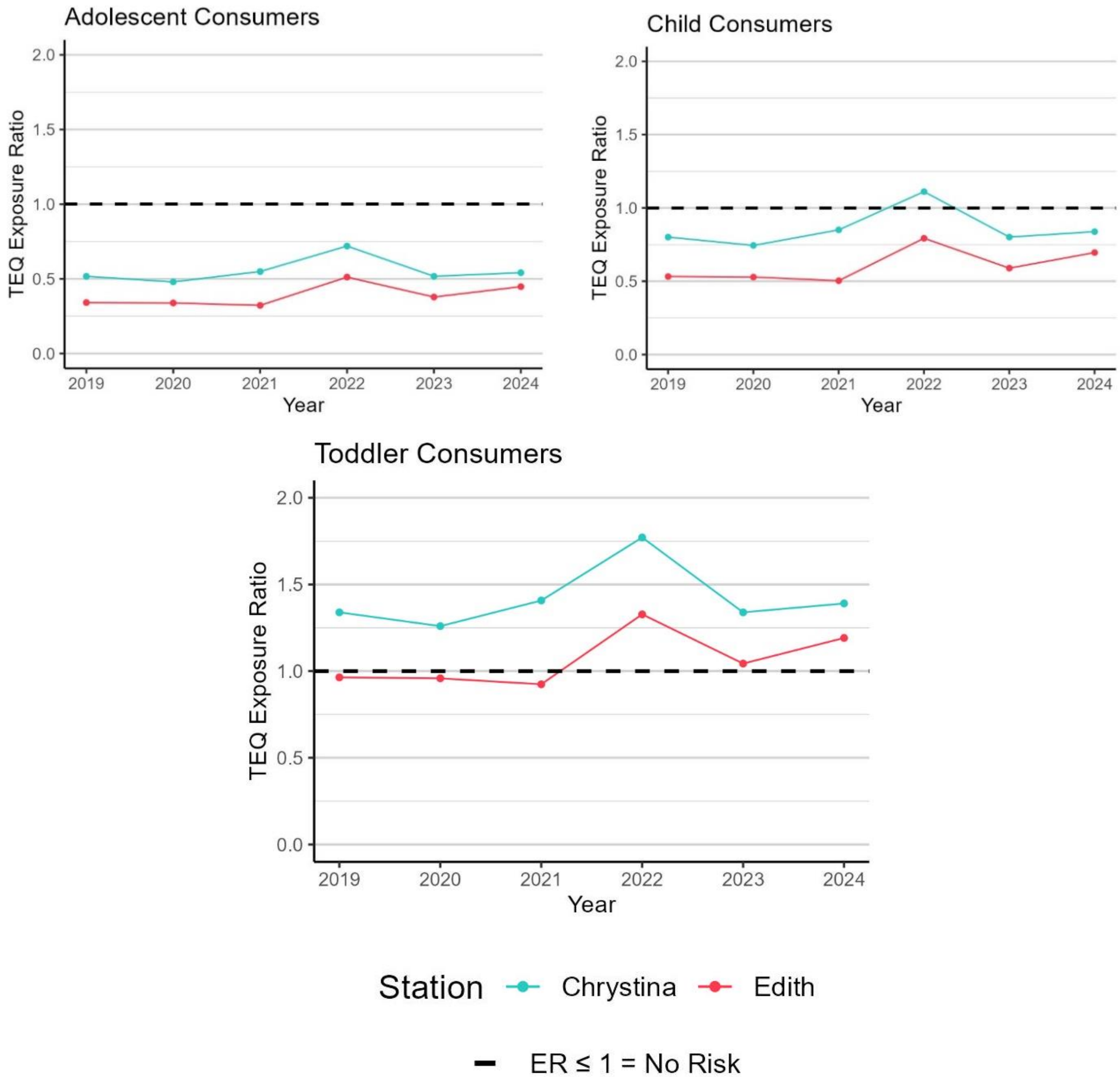

Figure 5-10: Exposure Rations for Adolescent (top left), Child (top right), and Toddler (bottom) Consumers of Brook Trout from Chrystina Lake and Edith Lake from 2019 to 2024, Based on Average Concentrations of Dioxin-like PCBs, Dioxins, and Furans in 'Keeper' Fish

A common theme observed throughout the HHRA in 2024 is that risk estimates for consumers of Edith Lake brook trout based on weighted averages are similar to risk estimates for brook trout taken directly from the hatchery. This is in part a reflection of the conservatism built into the HHRA and similar PCB concentrations in Edith Lake brook trout and control brook trout from the hatchery. Although risk potential is elevated for consumers of Chrystina Lake brook trout compared with Edith Lake brook trout consumers, the potential for risk remains low for Chrystina Lake.

6 STATE OF THE ENVIRONMENT SURROUNDING THE SWAN HILLS TREATMENT CENTRE

6.1 On-Site Monitoring

The SHTC operated within its Approval requirements, except for the continuous monitoring of mercury emissions, in 2024 and no excursions resulting in significant emissions occurred. Incinerator performance during the compliance tests met emission requirements for total PCDD/DF TEQ and mercury. Fugitive emissions remained well controlled and the activated carbon in the air management units was replaced as required. No leaks were identified in the annual tank farm survey. The success in fugitive emission control measures was demonstrated in the ambient air monitoring results. The annual average PCB levels in ambient air recorded at all fence line sites and the off-site monitoring location remain among the lowest reported to date. VOC and TOC levels measured at the OTF remained low and consistent with recent monitoring results. All Total Suspended Particulate (TSP) samples were well below the ambient air quality objective of 100 $\mu g/m^3$, and the fine particulate ($PM_{2.5}$) samples were low at all monitoring locations and mostly met the Alberta ambient air quality objective of 29 $\mu g/m^3$. There were exceedances of the 24-hour $PM_{2.5}$ ambient air quality objective measured at Site 1 (31.8 $\mu g/m^3$), Site 5A (30.4 $\mu g/m^3$), or Site 9 (34.9 $\mu g/m^3$) on August 13. There was heavy wildfire smoke in the area. Samples collected August 29 were below 29 $\mu g/m^3$.

There were no activities required in 2024 for the on-site soil monitoring and management programs. The Soil Monitoring Program Proposal that is due May 30, 2025 was started.

Groundwater monitoring was completed in September and results in 2024 confirmed that water quality in the till (shallow and intermediate depths) and the sandstone aquifer remains good and consistent with previous results.

6.2 Terrestrial Environment

The 2024 soil, vegetation and wildlife monitoring results were consistent with previous monitoring program results. The primary contaminants of concern (PCBs, dioxins and furans) were detected in all three receptors and show a similar distribution. Although levels are declining, they remain elevated above background at sites nearest to the SHTC and decrease significantly with distance. The area of influence is relatively small as concentrations return to near background levels beyond approximately 2 km from the facility. In 2023, the forest fires caused an increase in PCBs and PCB TEQ at the plots near the SHTC as well as the background and more peripheral plots for Labrador tea and live moss. In 2024, TEQ concentrations in the Labrador tea decreased to pre-fire (pre-2023) levels and concentrations in the live moss did not increase substantially between 2022 and 2024; the monitoring data reported in 2024 indicates that the effect of the 2023 wildfires on metallic and polychlorinated compounds was transient. The reduced activity at the SHTC also may be further reducing emissions to the surrounding terrestrial environment.

Significant variation is often seen in the organic results year to year. This likely reflects the variability inherent in environmental monitoring programs and the highly sensitive analytical methods being employed. To summarize potential contaminant risk and show trends over the past 20 years, the mean total TEQ results for Labrador tea, live moss and red-backed vole tissue are presented in Figures 6-1 to 6-3. The results from 10 monitoring plots were segregated according to their proximity to the SHTC. Six of the 10 sites are situated near the SHTC and are all within 2 kilometers. The remaining four plots are located at distances of 2.4 to 21 kilometers and include the two reference sites. The magnitude of concentrations varies by receptor with the lowest levels observed in Labrador tea and the highest in red-backed vole tissue. This reflects the nature of the receptor and its exposure to the contaminants of concern. Despite these differences, consistency is seen in the results. Levels are highest at plots located closest to the facility (plots <2 km) and show a decreasing trend over time. Although the trends are not significant in all cases, a consistent decrease in average total TEQ is evident in Labrador tea, live moss and voles at plots near the facility. The Labrador tea mean total TEQ levels for plots >2 km has remained at a low level since 2000.

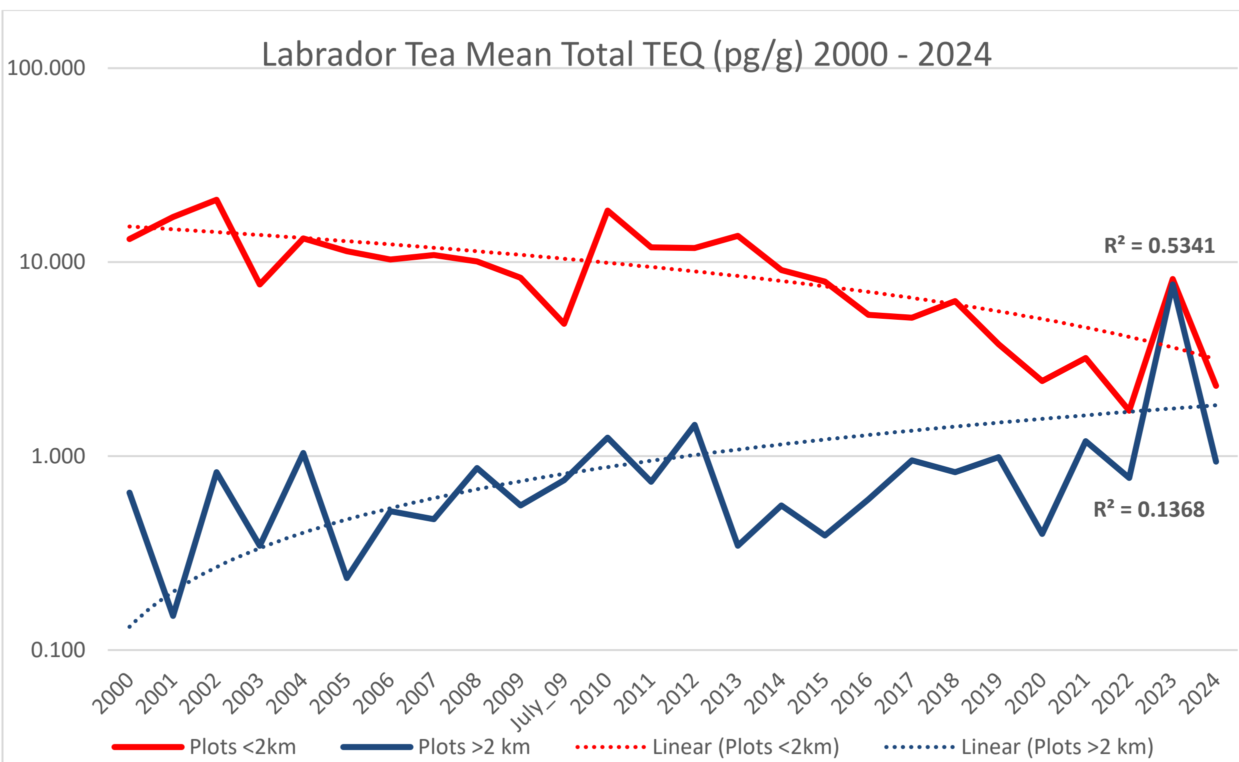

Figure 6-1: Labrador tea Mean Total TEQ at plots ≤2 km and >2 km from the SHTC (2000-2024)

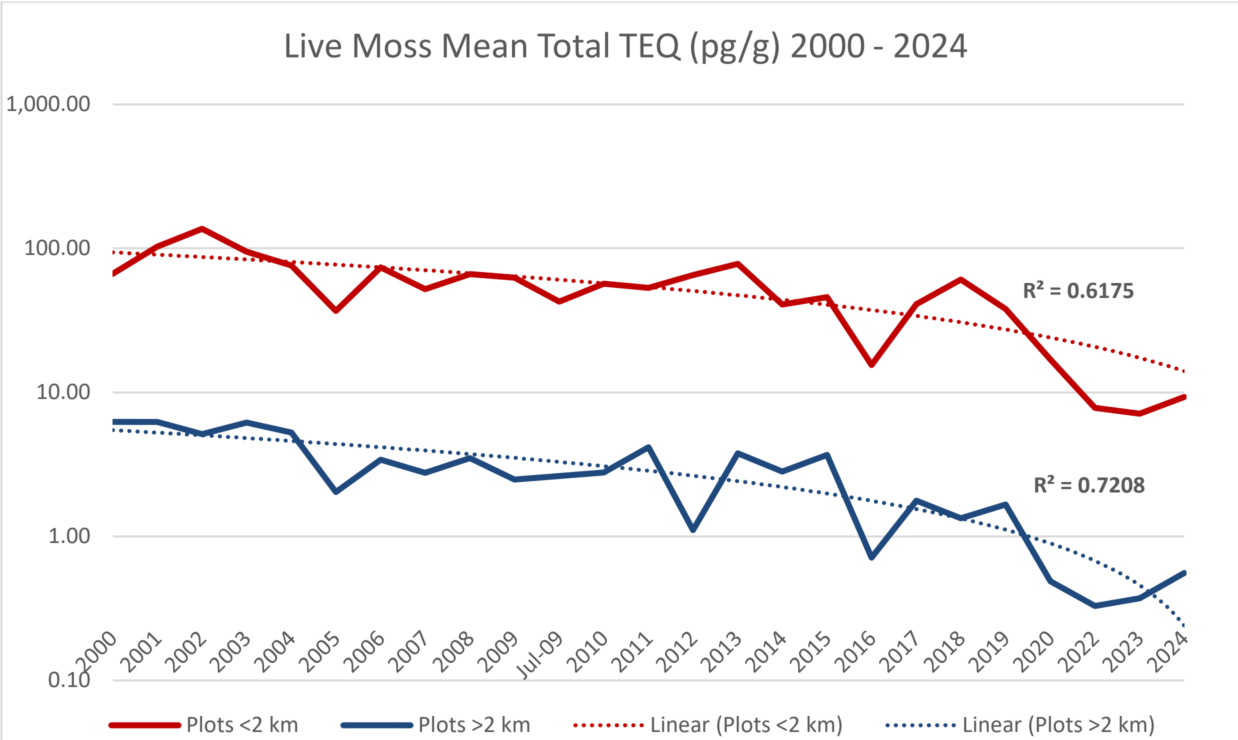

Figure 6-2: Live moss Mean Total TEQ at plots ≤2 km and >2 km from the SHTC (2000-2024)

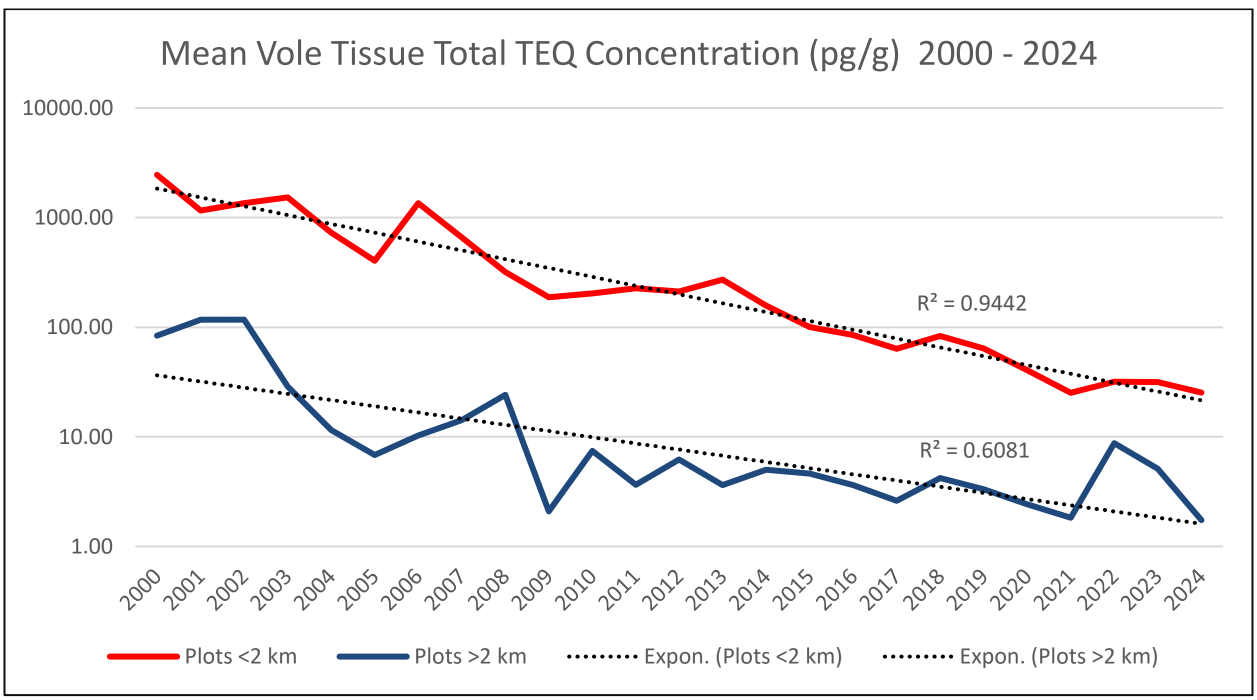

Figure 6-3: Wildlife Mean Total TEQ at plots ≤2 km and >2 km from the SHTC (2000-2024)

Collectively, these results suggest that the area influenced by trace organic contaminant emissions (total TEQ) from the SHTC is localized and that contaminant levels are either decreasing or stable. Furthermore, the Labrador tea results suggest that annual emissions of organic contaminants, reported as total TEQ, are very low and have not shown any significant change at sites beyond 2 km since 2000.

Organic contaminant results are lower than what has been observed historically in all media and appear to be stable and/or decreasing. Currently, results are below relevant guidelines and have not resulted in any observable impacts on the indicator receptors used in the monitoring program (lichen, live moss or Labrador tea). In addition, contaminant levels in small mammals (red-backed voles) are well below the lowest observed adverse effect level (LOAEL) and decreased from levels observed in 2024. The results for Total TEQ are among the lowest results at most sites. Demographic studies continue to show that vole populations are healthy, and no impacts have been observed.

Metals are also monitored in Labrador tea, live moss, moss bags and vole tissue (expanded years only). Metal results are generally low and consistent with background and historic levels at most sites. However, several metals including antimony, arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, silver, tin and zinc have been observed at higher concentrations at monitoring plots closest to the SHTC from 2019-2024. This may be partially due to improved sample extraction methods, analytical procedures and lower detection limits implemented in recent years. All results are below levels of concern however it was noted that Cadmium is increasing at Plot 114 but it still within its historical range and similar fluctuations in cadmium levels have occurred in the past and zinc concentrations have increased at plots near the SHTC (Plots 4, 109, 114, 117, and 123), although concentrations have stabilized in recent years. However, recent results suggest that the SHTC may be a minor source of metals and additional monitoring effort is currently being implemented to better define and understand potential issues related to these findings.

6.3 Aquatic Environment

Based on the 2024 monitoring results, surface water quality near the SHTC is largely comparable to historical conditions observed in the Coutts River, Chrystina Lake, and Edith Lake. The Coutts River had 2 parameters above historical conditions (Total Kjeldahl Nitrogen [TKN] and dissolved oxygen); Chrystina Lake had 10 parameters above historical conditions (barium, dissolved and total calcium, chlorophyll-a, electrical conductivity, hardness, dissolved and total potassium, strontium, and total suspended solids [TSS]); and Edith Lake and 4 of the extra waterbodies sampled; and dissolved iron in the Coutts River. PAL guidelines were met for all parameters, except total alkalinity and pH (below minimum guideline) in Edith Lake and 4 of the extra waterbodies sampled; and dissolved iron in the Coutts River.

Examining results from the 11 lakes sampled for routine analysis across the region, it is evident that pH varies broadly across sites (average summer pH from 5.45 to 8.02) pH at these sites seems to be consistent with those of Edith Lake and Christina Lake. There appears to be a relationship between pH and the size of the watershed (see adjacent figure). Lakes with smaller watersheds would have a water balance that is more driven by atmospheric input of water (rain, snow), which has lower pH, than lakes with larger contributing areas.

Generally, sediment quality near the SHTC has not significantly changed, and is comparable to historical conditions observed in Chrystina Lake, Edith Lake, and the Coutts River (metals were only historically high at the reference site S6). Interim Sediment Quality Guideline (ISQG) exceedances were documented for arsenic at all 4 stations; nickel at Chrystina Lake and Edith Lake; mercury at Edith Lake, Cadmium at Edith and S6; and manganese at all 4 stations. Only S5A had a significant increasing trend for PCB TEQ. Total PCBs remained unchanged at both lake sites. However, a large spike in total PCBs was noted at both S6 and S5A. This may be due to historically high organic carbon in the sediment or scouring of the stream channels during summer rain events. No significant trends in PCDD/F Toxic Equivalents (TEQs) occurred at any sites; however, PCDD/FTEQs exceeded the respective ISQG at Chrystina Lake and Edith Lakes, as has been the case for much of the data record.

Fish remain in a healthy condition and contaminant levels in brook trout in both Chrystina and Edith lakes were low in 2024. No exceedances of Health Canada Maximum Levels for metals (Hg, Pb, As) were observed in Chrystina, or Edith Lake fish. Organic contaminants (PCBs, dioxins/furans) were higher in fish from Chrystina Lake in comparison to fish in the reference lake (Edith Lake). However, results were very low and at or near minimum levels observed in previous studies.

The human health risk assessment conducted using the 2024 fish tissue levels concluded that the predicted total PCB ERs were elevated compared with those historically reported due to a more conservative exposure limit introduced by Health Canada in 2021. The risk assessment results suggest that there is little to no risk to consumers of Edith Lake brook trout, whereas non-dioxin-like PCBs pose a potential risk to people consuming brook trout from Chrystina Lake at a high and medium consumption rate. It is recommended that consumers remain aware of the current Alberta fish consumption advisory of 150 g/week (22 g/day) of fish from lakes within 20 km of Swan Hills (including Chrystina Lake and Edith Lake) and consumers should remove fish skin from edible tissue and cook tissue before eating.

Overall, environmental quality surrounding the SHTC is good and contaminant levels associated primarily with historic operations (PCBs, dioxins and furans) continue to decrease and/or have stabilized at low concentrations near background levels.

7 2025 MONITORING PROGRAM

7.1 Existing Program and Changes for 2025

The results of the 2024 monitoring program were reviewed at the technical meeting which was held virtually on February 19, 2025. Participants included members of the Veolia staff, external consultants, representatives from Alberta Infrastructure, Alberta Health, and Alberta Environment and Protected Areas. There was limited scope change recommended for the 2025 monitoring program based on the results of the 2024 data, these recommendations were discussed during the technical review meeting.

Overall objectives for the 2025 monitoring program include:

1. Continue with the overall monitoring programs, reducing or expanding where necessary based on objectives and effectiveness.
2. Continue to review and monitor triggers to optimize the effectiveness of the current scope for sampling and analysis.

Table 7-1: Overview of 2025 standard monitoring year and proposed changes.

Monitoring Program	Existing	Recommended Changes
Air	• Program as specified in EPEA Approval No. 1744-03-00	• No changes proposed for 2025
Groundwater	• Routine water, PCB's, metals and Organic Carbon on all wells • BTEX, F1, AOX, Dioxin and Furan also analyzed on shallow wells	• Sampling of new well sites • Monitoring of road salt runoff around treatment center
Soils and Vegetation	• Labrador Tea at 10 sites • Moss Bags at 15 sites	• Continue to monitor TSP through fly ash emission study • Continue to deploy Moss Bags along fence line at sites 1, 5 and 9 • Move SV117 to expanded monitoring program • Shift MB22 to SV114
Wildlife	• 3 live trapping plots • 6 snap trapping plots	• Plots 110, 117, 123 and 402 be moved to expanded monitoring program
Surface Water, Sediments and Fish	• Annual surface water sampling at 3 locations • Annual fish tissue collection at 2 locations	• Next sediment sampling scheduled to occur in 2026 • Edith Lake: Transition to biannual sampling. • Increase efforts to capture older fish in Chrystina by reducing gill netting and expanding with other methods. • ICES7 subset recommended for future PCB analysis • Community outreach for additional fish head collection
Toxicology	• Based on fish tissue and vole results	• Alberta Health: Consider revising fish consumption advisories (e.g., 150 g/week) for lakes near Swan Hills. • Biannual sampling at Edith Lake due to similar contamination levels to hatchery fish. • Adjust analysis methods to focus on dioxin-like PCBs and ICES7 Marker PCBs

7.2 Triggers

Triggers provide specific levels and actions that expand the Environmental Monitoring Program to address potential issues that may be identified through the initial review of monitoring results and/or to respond quickly to a potential off-site release. Recommended 2025 program triggers for all monitoring components have been reviewed and are presented in Table 7-1.

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Table 7-2: Environmental Monitoring Triggers for 2025

Component	**Trigger**	**Response - Additional Monitoring Work**
Operations	A facility upset resulting in off-site emissions of significant magnitude to warrant immediate assessment	Implement Emergency Response Plan and compile relevant data regarding the incident to facilitate development of an effective Environmental Monitoring Program response
Ambient Air	PCB concentration exceeds 150 ng/m^3 at fenceline monitoring locations	Verify result and investigate potential sources of fugitive emissions. Increase frequency of PCB air monitoring to NAPS cycle – once every 6 days if warranted.
	VOC exceeds a level of 3 ppm or THC exceeds 5 ppm	Report individual VOC compounds and compare with appropriate air quality and occupational health and safety guidelines and review trends over the period of record. If deemed significant, the OTF fugitive emission survey would be triggered if not already conducted
	A facility upset resulting in an off-site release of significant magnitude to warrant immediate assessment	Review meteorological data and conduct dispersion modelling (if appropriate) to support initial assessment and guidance for environmental monitoring response. Conduct additional air monitoring as recommended
Groundwater	Statistically significant increase in key parameter (e.g. PCBs).	Implement Response Plan and conduct follow up sampling to verify and assess results
	A significant facility upset resulting in on-site spill of significant magnitude to warrant immediate assessment	Incorporate additional monitoring as recommended by the Response Plan
Soil & Vegetation	Total TEQ increases above 75th percentile (last 10 years data) in the Labrador tea at plots (4, 11, 109, 114)	Analyze archived live moss samples If levels are elevated in both Labrador tea and live moss, expand monitoring scope in following year to include both Labrador tea and live moss from 10 Plots
	A facility upset resulting in off-site emissions of significant magnitude to warrant immediate assessment	Soil and vegetation monitoring to proceed at selected sites immediately following incident. The number/location of sites and analytical scope would be based on meteorological conditions and the nature of the release.

Component	Trigger	Response - Additional Monitoring Work
Wildlife	Statistically significant change in June vole population levels correlated with the April/May tissue contaminant levels	Collect and analyze September vole tissue from population monitoring plots (11, 114 and 70) for PCBs, dioxins and furans
	Elevated Total TEQ in live moss and Labrador tea is observed	Expand vole tissue collection to 10 plots consistent with the Soil and Vegetation program
	A facility upset resulting in off-site emissions of significant magnitude to warrant immediate assessment	Additional sampling of vole tissue. Timing, sample locations and analytical scope would be determined based on meteorological conditions and the nature of the release.
Aquatic	Contaminant levels exceed the 95th percentile value in Chrystina Lake sediments	Verify result and include sediment sampling in both Chrystina and Edith lakes during the next annual program if warranted
	Contaminant levels exceed 95th percentile value and/or the Interim Sediment Quality Guidelines (ISQG) in stream sediment samples	Verify results and initiate additional downstream sampling in following sampling period if warranted
	Organic contaminant levels in Chrystina Lake brook trout exceed the recommended toxicity trigger	Analyze any archived samples to verify results Sample Edith Lake brook trout in the following year
	A facility upset resulting in off-site emissions of significant magnitude to warrant immediate assessment	Initiate immediate water quality, sediment and fish tissue sampling as recommended.
Toxicology	New toxicity information becomes available (i.e. significant change in end-point toxicity of the compounds of interest – PCBs, PCDD/F)	Conduct full HHRA on fish tissue results Re-evaluate vole toxicity assessment
	Chrystina Lake fish tissue level exceeds Toxicity Trigger	Conduct full HHRA and assess fish tissue levels in Edith Lake
	Any new compounds are identified at elevated levels (e.g. heavy metals) in animal or fish tissue.	Assess vole toxicity Expand HHRA to incorporate new compounds of interest