BAF-3 LANDFARM DESIGN AND MANAGEMENT PLAN

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CHANGE HISTORY

This sheet is a record of each issue of this document. When the revised document is issued, the previous issue is automatically superseded.

Revision	Date	Author	Pages Changed	Reason for Change
1	18-Oct-2021	A. Leslie	All	New Document

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1.0 INTRODUCTION

1.1 Overview

The Department of National Defence (DND) and/or Raytheon Canada (RC) occasionally has a requirement to remediate hydrocarbon spills on-site through landfarming at North Warning System (NWS) sites. RC is currently responsible for the care, custody and control of the NWS on behalf of DND.

Landfarms are a common method for the ex-situ bioremediation of petroleum hydrocarbon (PHC) impacted soil in northern Canada. Landfarming involves spreading contaminated soil in an even layer (or in windrows) followed by stimulating aerobic microbial activity and allowing time for volatilization. Microbial activity may be stimulated by activities such as tilling, adjusting moisture content, adjusting pH and/or adding nutrients or other amendments. Landfarming is also known as land treatment, land spreading or cell bioremediation (FCSAP, 2013) and will be referred to as landfarming or landfarm in this document.

1.2 History

A landfarm was established at BAF-3 to remediate a fuel spill which occurred in 2007 (prior to RC's care, custody and control of the NWS). Jacques Witford (JW) was contracted by Nasittuq to conduct the design, construction and maintenance of the facility in 2007. Jacques Witford has referred to the area both as "biopiles" and "hydrocarbon-impacted soil storage and landfarm treatment facilities" but in this document it will be referred to simply as the landfarm.

The landfarm was designed and constructed in 2008. An overview of the design and monitoring plan was outlined by Jacques Witford titled "Water License Application – Supplementary Information for Hydrocarbon-Impacted Soil Storage Landfarm Treatment Facilities" and was submitted by Nasittuq (on behalf of DND) to the Nunavut Water Board.

In 2014 Nasittuq's contract for the care and custody of BAF-3 ended and the care and maintenance of the landfarm was transferred to DND.

1.3 Scope

In the event that hydrocarbon remediation at the existing BAF-3 landfarm is required, this document will serve as a general plan. This document ensures compliance with the BAF-3 Nunavut Water Board water licence No. 8BC-BAF1929.

2.0 GENERAL INFORMATION

2.1 Location

Brevoort Island is situated 6 km from the southeastern coast of Baffin Island within the Davis Strait, south of the mouth of Cumberland Sound. The BAF-3 Long Range Radar (LRR) site sits on 2,524 acres of land in the southern portion of the island. See Figure A-1 in Annex A for an overview of the BAF-3 site location.

Accommodations are available at BAF-3, however, the site is not currently attended year-round and is accessed by aircraft from Iqaluit via the Iqaluit Logistics Support Site (LSS-Q) located 150 km to the northwest. The LSS-Q is approximately a one hour flight by helicopter. There is a helipad at the radar site as well as an abandoned gravel airstrip.

Infrastructure on site is located in three main areas connected by a gravel road: the main LRR station at the summit in the north (“Summit Area”), the airstrip located in the central area (“Airstrip Area”), and the beach in the south (“Beach Area”). For a general site plan see Figure A-2 in Annex A.

2.2 Climate

The total mean annual rain and snowfall are 227 mm and 365 cm, respectively. The majority of the precipitation falls from July to September. The nearest weather station with historic climate data is Iqaluit which experiences average daily temperatures ranging from -27.5°C in February to 8.2°C in July (ECCC, 2014).

2.3 Topography

Brevoort Island is 40 km long and 10 km wide and characterized by hilly bedrock outcrops shaped by glacial erosion. Sheer cliffs rising over 200 metres above sea level (masl) surround most of the coastline. Small freshwater lakes are irregularly distributed throughout the island. Vegetation in the area is sparse and limited mostly to lichen.

2.4 Soil and Geology

Bedrock geology is described as metamorphic (various compositions) with “mainly metatonalite, granites and amphibolite-facies metasediments” (Tremblay, 2017).

Surficial materials are described as bouldery diamicton till veneer (Tremblay, 2017). The island is located within the zone of continuous permafrost (NRCAN, 1995). The active layer of permafrost extends to 1.5 to 1.8 metres below ground surface (mbgs) (ESG, 2006).

3.0 LOCATION AND CONSTRUCTION OF FACILITIES

3.1 Location

The landfarm is located adjacent to the airstrip at the northeast end. This location was selected as it is relatively flat, easily accessed by road, and over 900 m from any waterbodies. The site has been used historically as a staging area and silty sand and gravel fill has been placed approximately 1.2 m thick. The permafrost active layer at the landfarm location extends to bedrock which was encountered at 1.5 mbgs. Prior to landfarm construction baseline soil samples were collected (Jacques Witford, 2008). The landfarm is over 1 km from any occupied buildings and is not easily accessible to the public.

3.2 Construction

The landfarm was constructed in 2008 following design by Jacques Witford.

Nine cells were constructed and lined with LLDPE-reinforced liner. Each cell was surrounded by a ~1 m high berm. The cells were arranged to be 5 to 10 m wide and 30 m long. For the initial landfarm layout see Figure A-3 in Annex A, and for the landfarm design drawing see Figure B-1 in Annex B.

Fuel-contaminated soil was placed within the facility as windrows, with one or two windrows in each cell. The landfarm was later expanded to include 15 cells. Soils were tilled using an excavator and monitored for moisture, nutrients, and microbial populations (Jacques Witford, 2008). The windrows were tarped over winter. Cells considered to be remediated were returned to the summit site to be used as backfill.

Future design adjustments to the landfarm may include the addition of a geotextile layer to protect the liner, or the use of compacted granular fill in lieu of a liner.

4.0 LANDFARM MANAGEMENT

4.1 General

In the event that the landfarm is actively used, the focus will be safety and environmental responsibility.

Landfarming typically involves the following:

1. Preparation of a engineered landfarm to receive and remediate contaminated soil;
2. Excavation of all contaminated soils;
3. Soil sampling of excavated material to characterize contaminants of concern;
4. Soil sampling of the base and side walls of the excavation to ensure all contamination is removed;
5. Back-fill and grade excavated areas;
6. Till contaminated soil within the landfarm until remediated to the appropriate CCME soil guideline (see Annex C for details);
7. Soil sampling will be conducted to ensure the remediation target is met; and
8. Decommissioning of the landfarm.

4.2 Health and Safety

Employees working in the landfarm will be trained prior to commencement of work so that they are aware of the health and safety risks and mitigation measures. The landfarm is not accessible to the public.

There are four primary exposure pathways to chemicals within the landfarm:

a. Inhalation;
b. Ingestion;
c. Skin contact; and
d. Eye contact.

Because the landfarm is outside in open air, inhalation exposure can be mitigated. Ambient air concentrations of volatile organic compounds (VOCs) will be monitored periodically using a photoionizing detector (PID). In the case that PID readings are elevated respirators with combination filters will be worn.

Incidental ingestion, as well as skin and eye contact, will be prevented through appropriate worker training and personal protective equipment (PPE).

4.3 Operation

Prior to placing new material in the landfarm it will be characterized to ensure any contaminants of concern are appropriate for landfarming. Soil will then be placed into the landfarm cells in an even layer, ideally 30 to 75 cm thick.

After placing contaminated soil granular nutrients may be distributed over the surface. Moisture conditioning may be conducted, as required, by application of water spray to maintain optimum water content within the soil.

After application of nutrients, the full thickness of the soil may be tilled every five to ten days. During periods of heavy precipitation, tilling of the soil will be delayed until the soil is considered damp to a depth of 100 mm.

4.4 Environmental Control

Environmental controls will be put in place in the event that the landfarm is actively used.

Water runoff is captured within each cell of the landfarm due to the impervious liner and berms. In the event that water discharge is necessary water will be sampled and analyzed, prior to discharge, to ensure it meets the wastewater discharge criteria (see Table D-1 in Annex D).

The landfarm will be monitored weekly during summer months by the contractor to ensure proper operating conditions of soil moisture and aeration (i.e., moisture content around 5%, uncompacted soil). Soil samples will be routinely collected and analyzed at a CALA-accredited laboratory to ensure that concentrations of hydrocarbons are decreasing. Headspace vapour readings using a PID may aid in determining frequency of laboratory analysis.

Corrective maintenance to the landfarm facility will be noted during weekly inspections, and any repairs will be carried out promptly. The nature of the repairs required and when repairs were completed will be recorded in the weekly report.

Prior to exiting the landfarm, equipment will be cleaned off to ensure that contaminated soil is not spread outside the landfarm.

4.5 Landfarm Closure

Once the soil in the landfarm facility has been remediated to the CCME Canadian Soil Quality Standards (CCME, 1999 r. 2018), (CCME, 2001 r. 2008) (see Annex C, Table C-1), and confirmatory testing of the soils verifies that the remediation objectives have been reached, the landfarm may be decommissioned.

It should be noted that in the past, consultants have used the Abandoned Military Sites Remediation Protocol as a remediation target (INAC, 2008) (see Annex C, Table C-2).

Any wastewater will be sampled and analyzed to ensure that prior to discharge all wastewater conforms to Wastewater Discharge Criteria. Wastewater above the criteria will either be treated on site, or containerized for off-site disposal.

Remediated soil will be used as backfill in an area that is compatible with the selected guideline and land use type (eg. Commercial or industrial). The Nunavut Guideline for Contaminated Site Remediation (GN, 1999 r. 2009) defines commercial land use as “land on which the primary activity is the commercial buying, selling or trading of goods and services. Members of the public, including children, normally have free access to these lands”. Industrial land use is defined as “land on which the primary activity is the production, manufacture, construction or storage of goods. Public access is restricted and children are not permitted continuous access or occupancy” (GN, 1999 r. 2009).

If the landfarm is no longer required, the perimeter berms will be regraded to prevent ponding within the former landfarm. Final grading will promote drainage away from the site and will match the surrounding terrain.

5.0 REFERENCES

CCME. (1999 r. 2018). *Canadian Environmental Quality Guidelines*. Retrieved February 1st, 2021, from Canadian Council of Ministers of the Environment (CCME): http://st-ts.ccme.ca/

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GN. (1999 r. 2009). *Environmental Guideline for Contaminated Site Remediation.* Department of Environment, Government of Nunavut (GN).

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INAC. (2008). *Abandoned Military Site Remediation Protocol: Volume I - Main Report.* Indian and Northern Affairs Canada (INAC), Northern Affairs Organization, Contaminated Sites Program.

Jacques Witford. (2008). *Final Report Water License Application - Supplementary Information for Hydrocarbon-Impacted Soil Storage and Landfarm Treatment Facilities.*

NRCAN. (1995). Canada Permafrost (MCR 4177). In *The National Atlas of Canada 5th Edition.* Natural Resources Canada (NRCAN).

Tremblay, T. (2017). *Surficial Geology: Beekman Peninsula, Baffin Island, Nunavut, NTS 25P and NTS 15M (part), Open File Map 2017-03, Scale 1:125 000.* Canada-Nunavut Geoscience Office.

ANNEX A. BAF-3 SITE PLANS AND LANDFARM LOCATION

Figure A-1: BAF-3 Site Location

Figure A-2: BAF-3 Site Plan

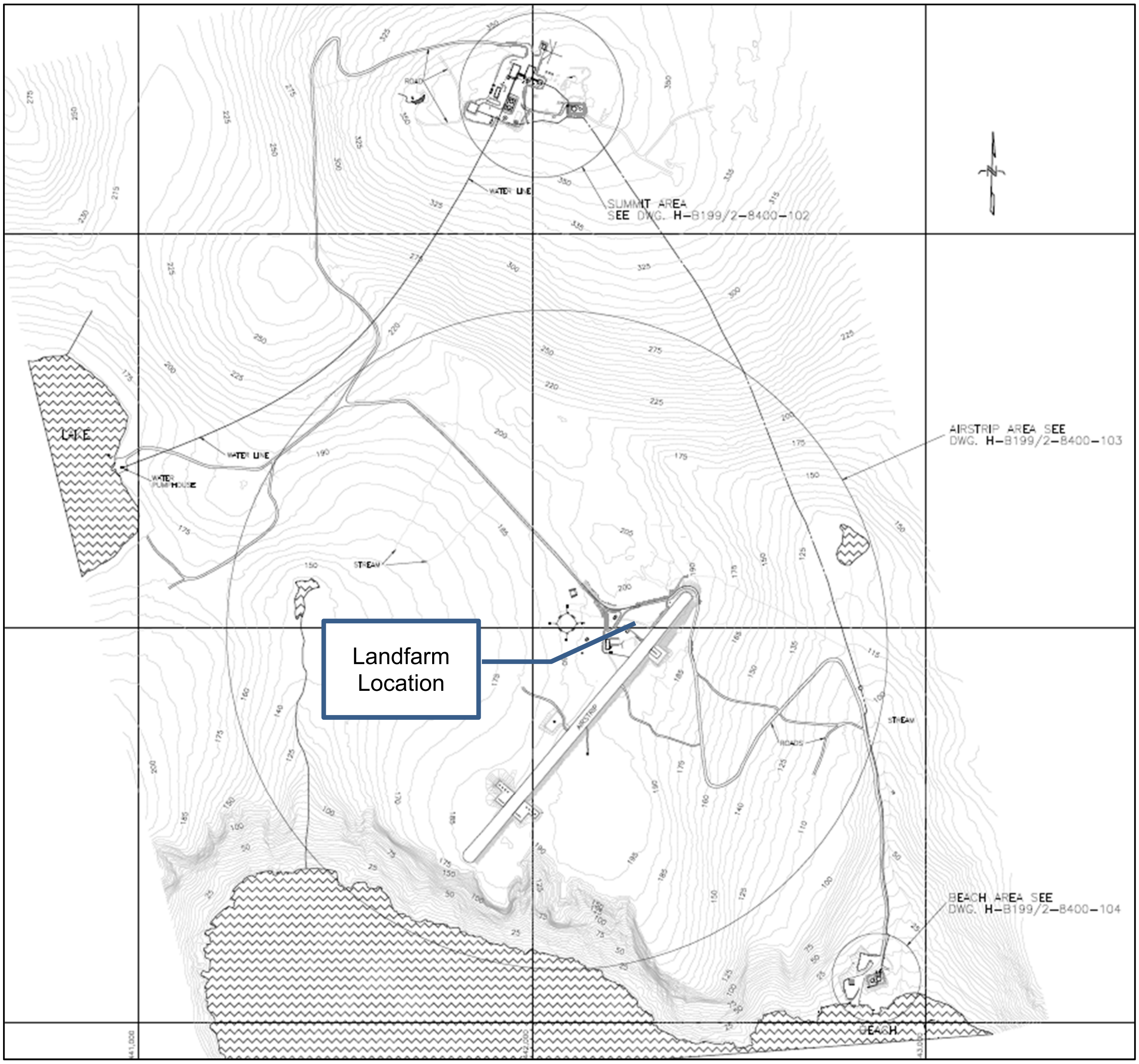
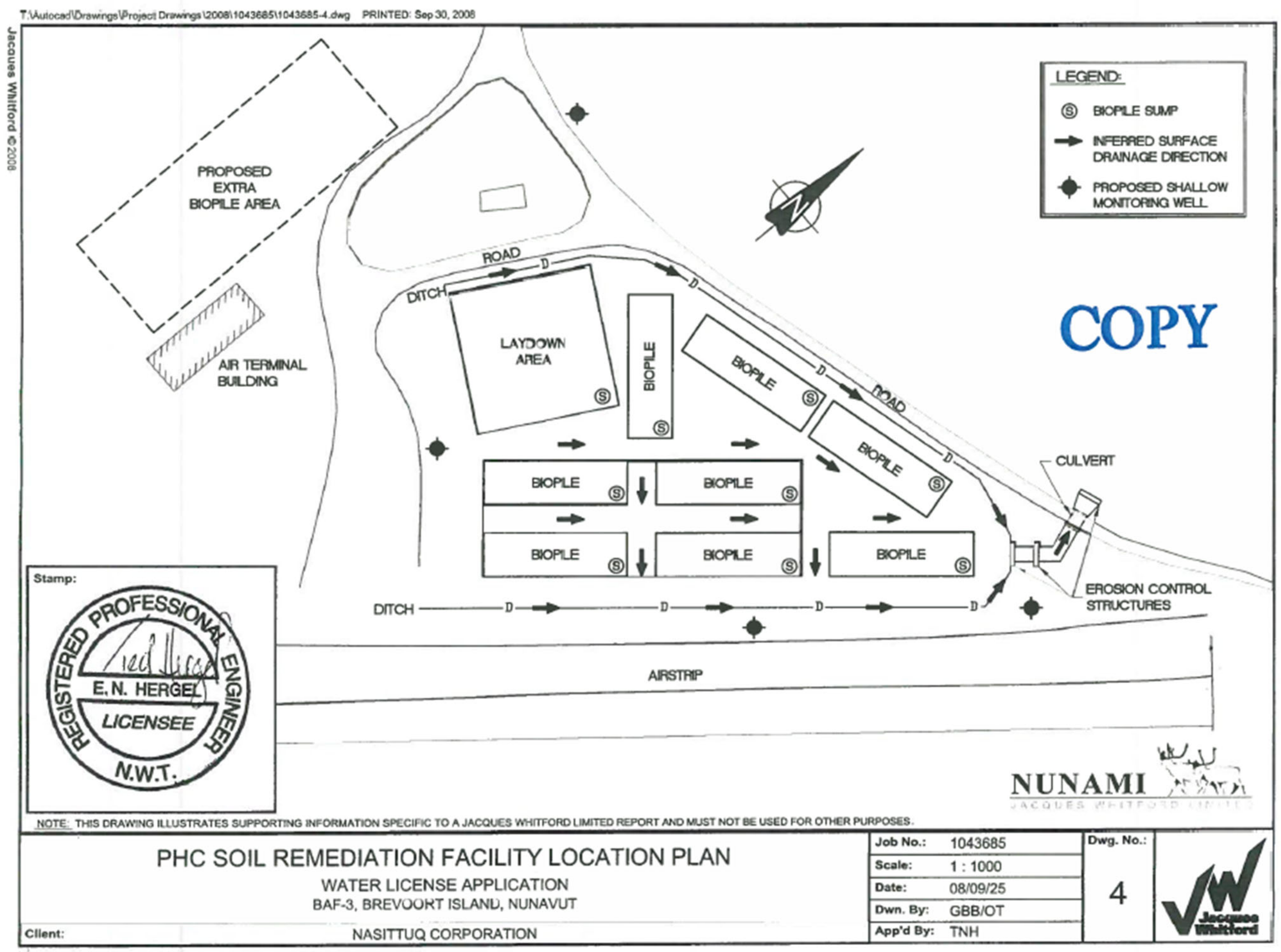
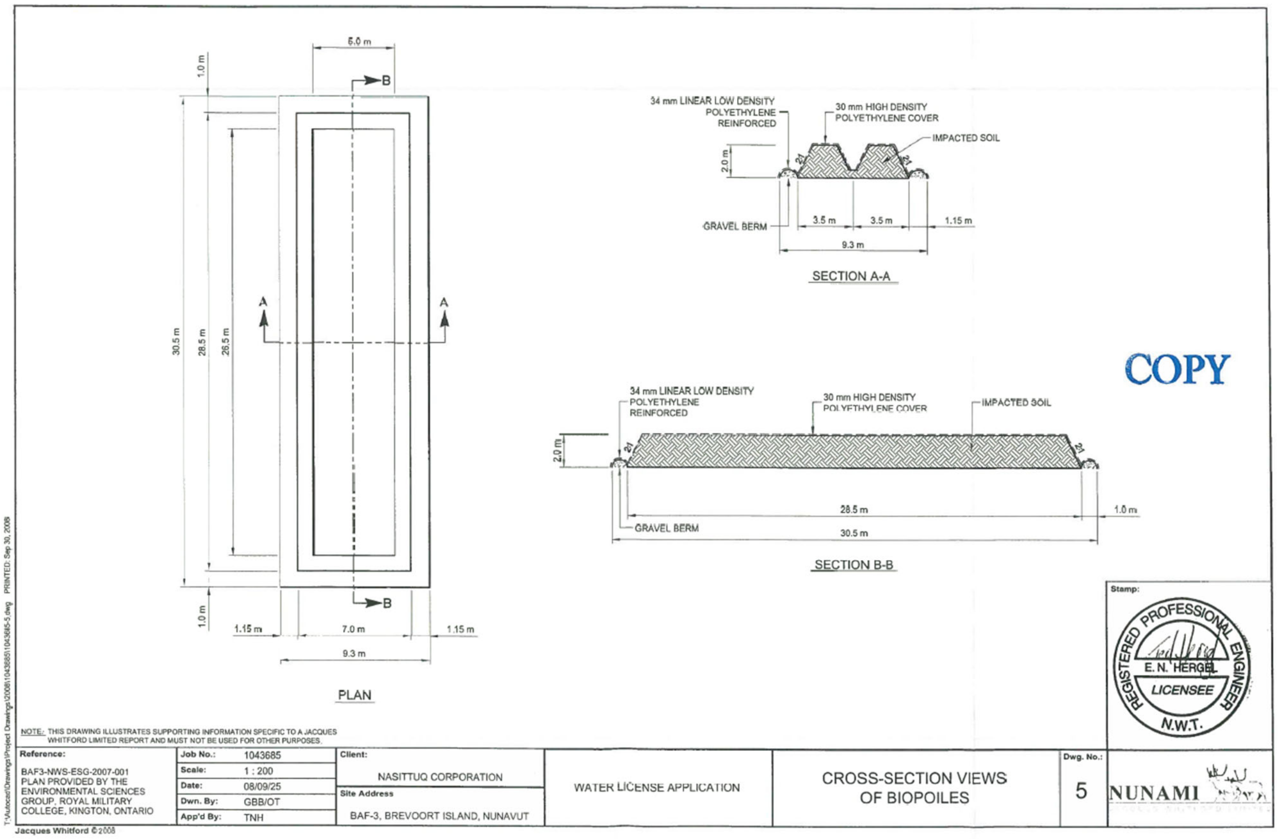


Figure A-3: Initial Landfarm Layout Plan (Jacques Witford, 2008).



ANNEX B. BAF-3 LANDFARM DESIGN DRAWING

Figure B-1: Design Drawing (Jacques Witford, 2008)



ANNEX C. SOIL GUIDELINES

Table C-1: CCME guidelines for coarse-grained soil (Canadian Soil Quality Guidelines (CCME, 1999 r. 2018) and Canada-Wide Standards for PHC in Soil (CCME, 2001 r. 2008)

Grouping	Parameter	Land Use: Commercial	Land Use: Industrial
Metals and Inorganics	Arsenic	*12*	*12*
	Barium	*2000*	*2000*
	Cadmium	*22*	*22*
	Chromium (total)	*87*	*87*
	Copper	*91*	*91*
	Cobalt	*300*	*300*
	Lead	260	600
	Mercury	24	50
	Nickel	*89*	*89*
	Zinc	*410*	*410*
PHCs	PHCs F1 (C6 to C10)	320	320
	PHCs F2 (C>10 to C16)	260	260
	PHCs F3 (C>16 to C34)	1700	2500
	PHCs F4 (C>34 to C50+)	3300	6600
VOCs	Benzene	*0.03*	*0.03*
	Toluene	*0.37*	*0.37*
	Ethylbenzene	*0.082*	*0.082*
	Xylene	*11*	*11*
Other	Phenol	*3.8*	*3.8*
	PCBs	*33*	*33*

Grey Italic – Indicates the industrial and commercial guidelines are the same
Units: mg/kg

Notes:

Guideline values for PHCs are in reference to the Canada-Wide Standards for PHC in Soil (CCME, 2001 r. 2008). The other values are in reference to the Canadian Soil Quality Guidelines (CCME, 1999 r. 2018).

Guideline values for PHCs refer to surface soils (between 0 and 3 mbgs) (CCME, 2008).

Parameter groups recommended by FCSAP (2013) for spills of unleaded gasoline, leaded gasoline and/or aviation gasoline include: metals and inorganics, PHCs and VOCs. These parameters may be used for the initial screening to establish contaminants of concern. Additional parameters, such as the ones listed as "Other", may be used if other contaminants are suspected.

Table C-2: Abandoned Military Sites Remediation Protocol, DEW Line Cleanup Criteria for Metals and PCBs in Soil (INAC, 2008)

Parameter	Tier I Guideline	Tier II Guideline
Arsenic		30
Barium		NA
Cadmium		5.0
Chromium (total)		250
Copper		100
Cobalt		50
Lead	200	500
Mercury		2.0
Nickel		100
Zinc		500
PCBs	1.0	5.0

Notes: Tier I and Tier II criteria are used to determine disposal requirements.

Table C-3: Abandoned Military Sites Remediation Protocol, DEW Line Cleanup Criteria for PHCs in Soil (INAC, 2008)

Parameter	ECO-FAL	ECO-T	HH	ML	Most Conservative
PHCs F1 (C6 to C10)	1290				1290
PHCs F2 (C>10 to C16)	330		11,000		330
PHCs F3 (C>16 to C34)			20,000		20000
PHCs F4 (C>34 to C50+)					N/A
Type B (F1 to F3)	330	2500		5000	330
Type A (F4)			20,000		20,000
Free Product				No free phase liquid	No free phase liquid

Notes:

Type B may be used when light PHC fractions are dominant. Type B is approximately equal to the sum of F1 through F3 fractions.

Type A may be used when the sum of F3 plus F4 is greater than 70% of the total TPH and the F2 is less than F4. Type A is approximately equal to the sum of F3 and F4 fractions.

ECO-FAL: Protection of freshwater life (for soils within 30 m of a waterbody)

ECO-T: Protection of terrestrial life (for surface soils to a 0.5 m depth)

HH: Protection of human health

ML: Management Limit (below 0.5 m depth this value may be applied based on professional judgement)

ANNEX D. WASTEWATER DISCHARGE CRITERIA

Table D-1: Wastewater discharge criteria as listed in Nunavut Water Board licence No. 8BC-BAF1929, Part D.

Parameter	Wastewater Discharge Criteria (µg/L)
pH	6 to 9 (pH units)
Oil and Grease	5000
Arsenic (total)	100
Cadmium (dissolved)	10
Chromium (dissolved)	100
Cobalt (dissolved)	50
Copper (dissolved)	200
Lead (dissolved)	50
Mercury (total)	0.6
Nickel (dissolved)	200
PCB (total)	1000
Phenols	20
Zinc (total)	500
Benzene	370
Toluene	2
Ethylbenzene	90