Land and Water Boards of the

Mackenzie Valley

Guideline for the Design, Operation, Monitoring, Maintenance and Closure of Petroleum Hydrocarbon-Contaminated Soil Treatment Facilities in the Northwest Territories

January 10, 2020

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Acronyms, Abbreviations, Definitions

CCME – Canadian Council of Ministers of the Environment

Professional Engineer – a Professional Engineer registered to practice in the Northwest Territories in accordance with the Engineering and Geoscience Professions Act, S.N.W.T. 2006, c.16.

FIGQG – Federal Interim Groundwater Quality Guidelines

PHCSTF – Petroleum Hydrocarbon-Contaminated Soil Treatment Facility

PAH – Polycyclic Aromatic Hydrocarbon

PCB – Polychlorinated Biphenyls

PHC – Petroleum Hydrocarbons

Qualified Professional – A Qualified Professional is an applied scientist or technologist who is registered and in good standing with an appropriate professional organization relevant to the specific project task. A Qualified Professional may be, but not be limited to, a Professional Engineer, Professional Geoscientist, Professional Biologist, Professional Chemist, Professional Agrologist, or Technologist.

VOC – Volatile Organic Compounds

1.0 Introduction: Petroleum Hydrocarbon-Contaminated Soil Treatment Facilities

Petroleum hydrocarbon-contaminated soil treatment facilities (PHCSTFs) are used for the remediation of petroleum hydrocarbon-contaminated soils. Soil treatment or remediation in northern PHCSTFs is generally biodegradation of petroleum hydrocarbons via manipulation (e.g., tilling) of contaminated soils. In addition to soil manipulation and aeration, the monitoring and control of moisture, pH, temperature and the addition of nutrients may also assist with the biodegradation process. This Guideline focuses on the remediation of soil via biodegradation and manipulation; however, it is noted that other methods of soil bioremediation can be also used to treat petroleum hydrocarbon-contaminated soil (e.g. biopiles, etc.).

PHCSTFs have been proven to reduce concentrations of various petroleum products in soil including gasoline, diesel (FCSAP, 2013; Chatham, 2003), heating oil, and lubricating oils (FCSAP, 2013; Gowen Environmental Limited, 2002; USEPA, 1994; Poland, et al., 2003). However, their use is generally considered ineffective and unsuitable for very heavy oils or tar contamination (FCSAP, 2013; Poland, et al., 2003).

PHCSTFs are a cost-effective and practical soil remediation technique, and are particularly well-suited to remote regions (FSCAP, 2013). It should be noted that due to the short operational period (i.e., fewer warm temperature months), soil treatment rates are generally slower in northern climates, which can result in longer treatment and operating times.

2.0 Purpose

The *Guideline for the Design, Operation, Monitoring, Maintenance and Closure of Petroleum Hydrocarbon-Contaminated Soil Treatment Facilities in the Northwest Territories* (hereinafter referred to as the Guideline) has been jointly developed by the Government of the Northwest Territories, the Inuvialuit Water Board, and the Mackenzie Valley Land and Water Board.

The Northwest Territories has seen an increase in the number of commercially operated, long-term petroleum hydrocarbon-contaminated soil treatment facilities. The Guideline has been developed to assist owners/operators responsible for petroleum hydrocarbon-contaminated soils remediation in the NWT, in order to effectively and safely design, operate, monitor, maintain, and close PHCSTFs to protect human health and the environment. This Guideline also outlines basic siting and design requirements, key operating and monitoring parameters, and maintenance and closure requirements that can be applied consistently throughout the territory.

The Guideline has been specifically developed with an understanding of the unique challenges often encountered at northern sites (e.g., climate, logistics). The specific design details will be dependent upon a number of factors that will vary from facility to facility. The practices outlined in this document may not be directly applicable to every PHCSTF in the NWT; in most cases the services of a Qualified Professional will be required to ensure that specific design details and operational procedures are in place to protect human health and the environment, i.e. meet the overall intent of the Guideline.

This Guideline has been developed for:

- Third-Party Owners/Operators of commercially operated PHCSTFs (i.e. those that receive contaminated soil from other parties); and/or
- Owners/Operators of PHCSTFs at industrial project sites (mining, oil and gas operations, etc.); and/or
- Owners/Operators of PHCSTFs that operate for longer than 3 years.

All Owners/Operators of PHCSTFs should note the best practices outlined in the Guideline. Also, Owners/Operators who do not fall under the categories listed above may still benefit from following this Guideline, based on the volume and quality of soil to be treated and/or the location in which they intend to operate.

This document has been developed to be a guideline that comprehensively outlines best practices for PHCSTFs; the Guideline is not a regulation. Because the Guideline has not been developed to include all possible methods for the siting, design, operation and closure details for a large-scale commercial PHCSTFs, an owner or operator may propose alternative methods to those proposed in this Guideline. Such a proposal should include a thorough and detailed rationale for why the recommendations set in this Guideline are not feasible and describe how the activities proposed provide an equivalent level of human health and environmental protection.

3.0 Regulation of PHCSTFs

3.1 Water Licences and Land Use Permits

Owners and operators of PHCSTFs in the NWT will require a water licence and may require a land use permit for the construction, operation and closure of their facility if the activities at their facility trigger the requirements under the applicable legislation. A water licence and Land use permit will contain specific conditions under which the owner/operator has to site, design, construct, maintain, monitor, report on and close their PHCSTF.

The regulation of land and water use can vary between jurisdictions in the NWT. These jurisdictions are based on land-claim agreements and are illustrated in Figure 3.1 and Figure 3.2. The Land and Water Boards of the Mackenzie Valley (Figure 3.1) include the Mackenzie Valley Land and Water Board, the Wek'èezhìi Land and Water Board, the Sahtu Land and Water Board, and the Gwich'in Land and Water

Board. The jurisdiction of the Inuvialuit Water Board is within the Inuvialuit Settlement Region (Figure 3.2). Owners and operators should contact the appropriate issuer of water licences and land use permits in their region to determine the regulatory requirements of their PHCSTF.

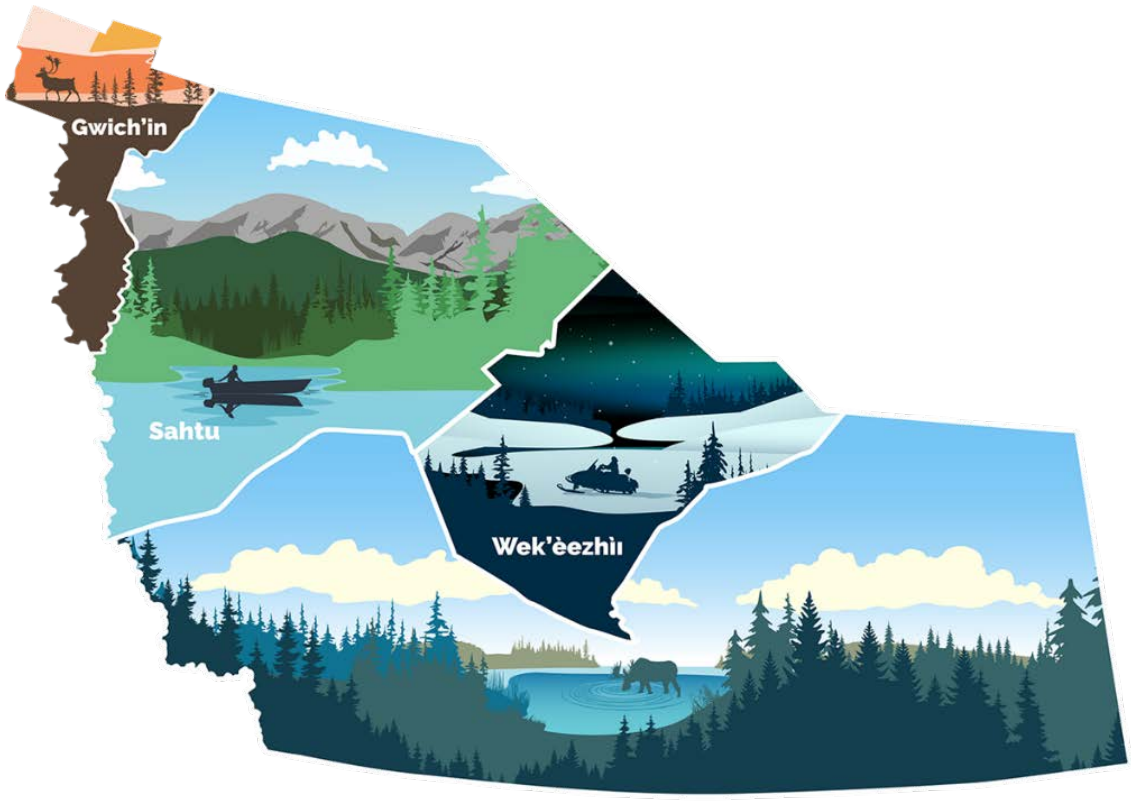

Figure 3.1: The Mackenzie Valley and Regional Land and Water Boards

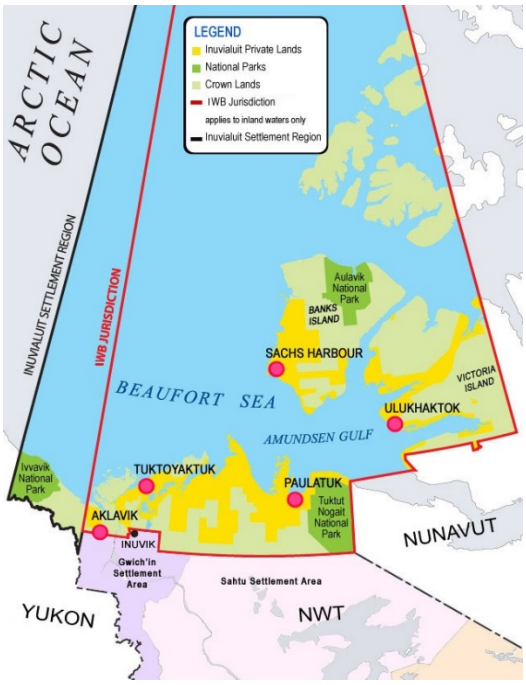

Figure 3.2: The Inuvialuit Settlement Region

Table 3.1 and Table 3.2 outline the triggers for requiring water licences and land use permits, respectively, in the different regulatory jurisdictions of the NWT.

Table 3.1: Triggers for Undertakings Requiring Type A or B Water Licences

Region of the NWT	Land Type	Issuance of Water Licence by:	Legislation that Defines Triggers for Obtaining a Water Licence
Mackenzie Valley	Non-Federal	Gwich'in Land and Water Board Mackenzie Valley Land and Water Board Sahtu Land and Water Board Wek'èezhìi Land and Water Board	Schedules D-H of the Waters Regulations
	Federal		Schedules IV-VIII of the Mackenzie Valley Federal Areas Waters Regulations
Inuvialuit Settlement Region	Federal, Non-Federal and Private Lands	Inuvialuit Water Board	Schedules D-H of the Waters Regulations

Table 3.2: Triggers for Land-Use Operations Requiring Land Use Permits

Region of the NWT	Land Type	Permits Issued By:	Legislation that Defines Triggers for Obtaining a Land Use Permit
Mackenzie Valley	Federal and Non-Federal	Gwich'in Land and Water Board Mackenzie Valley Land and Water Board Sahtu Land and Water Board Wek'èezhìi Land and Water Board	Sections 4 and 5 of the Mackenzie Valley Land Use Regulations
Inuvialuit Settlement Region	Non-Federal	Government of the Northwest Territories - Department of Lands	Sections 8 and 9 of the Northwest Territories Land Use Regulations
	Federal	Government of Canada – Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC)	Sections 8 and 9 of the Northwest Territories Land Use Regulations
	Private	Inuvialuit Land Administration (ILA)	ILA Rules and Procedures

The specific triggers for land use permits and water licences are included in the Regulations listed above. Each PHCSTF will be considered for a land use permit and/or water licence on a site-specific basis, under the jurisdiction of the regulator for the region in which the facility exists. Some triggers may be similar across jurisdictions. For example, triggers for a PHCSTF to obtain a land use permit and/or water licence may be:

Land Use Permits:

- The use of a vehicle the net weight of which equals or exceeds 5 tonnes (Section 5 of the Mackenzie Valley Land Use Regulations and Section 8 of the Northwest Territories Land Use Regulations)

Water Licences:

- The discharge of impacted water from a soil treatment pad to the environment i.e., the deposit of waste (Annex H, Item 3 of the Waters Regulations).

Regulatory processes for application of land use permits and water licences can be found on the respective websites and/or by talking to staff of each regional Land and Water Board or Land Administration in the Northwest Territories.

3.2 Regulatory Inspections of PHCSTFs

If an owner/operator of a PHCSTF holds a land use permit or water licence, the facility will be inspected for compliance with the conditions of the permit and/or licence. Land use permit and water licence inspection responsibilities are designated as follows:

Table 3.3: Land Use Permit and Water Licence Inspectors

Region of the NWT	Permit Type	Land Type	Inspector
Mackenzie Valley	Water Licence	Non-Federal	Government of the Northwest Territories - Department of Environment and Natural Resources
		Federal	Government of Canada - CIRNAC
	Land Use Permit	Non-Federal	Government of the Northwest Territories - Department of Lands
		Federal	Government of Canada - CIRNAC
Inuvialuit Settlement Region	Water Licence	Non-Federal	Government of the Northwest Territories - Department of Environment and Natural Resources
		Federal	Government of Canada - CIRNAC
		Private	Government of the Northwest Territories - Department of Environment and Natural Resources
	Land Use Permit	GNWT	Government of the Northwest Territories - Department of Lands
		Federal	Government of Canada - CIRNAC
		Private	Inuvialuit Land Administration

3.3 PHCSTFs within Larger Facilities/Operations

In some situations, a PHCSTF is not an independent operation; some PHCSTFs exist as one component of a larger undertaking such as a mining operation, a remediation site or a municipality. In these instances, a PHCSTF itself may not trigger the need for a water licence or land use permit; however, if the larger operation requires a land use permit or water licence, that authorization may contain conditions relating to the PHCSTF.

The Guideline has been written when considering an independent PHCSTF operation; therefore, for those PHCSTFs within a larger undertaking, background studies or information may have been gathered for the

site as whole. For example, the information gathering outlined in Section 4.3 (Site Characterization and Field Assessment), may have already been completed for the site as a whole and may not be specifically required again for the PHCSTF. Also, some of the documentation/plans outlined in Section 6.9 may be included in plans that the owner/operator has developed for the site (i.e., within an overall site Waste Management Plan).

3.4 Registration as a Receiver of Hazardous Waste

PHCSTFs that accept contaminated soil from a third party (or parties) will be registered as a receiver according to the *Guideline for Hazardous Waste Management* (GNWT, 2017). The receiver registration is assigned for the purposes of tracking the ultimate disposal of contaminated soil. See Section 6.9 for further details.

4.0 Siting and Development

Petroleum hydrocarbon-contaminated soil may pose an unacceptable risk to human health or the environment. PHCSTFs are constructed to safely contain PHC contaminated soil while the soil is undergoing remediation. This section outlines basic siting and development requirements to mitigate these risks, and limit exposure pathways to sensitive receptors.

PHCSTFs should only be permitted on sites with appropriate setbacks from sensitive areas and restricted zones, and that exhibit appropriate hydrological, hydrogeological, and topographical features (e.g., appropriate site grade). Once it has been determined that a PHCSTF is to be designed and constructed, the following assessments should occur prior to design and construction:

- PHCSTF Size Estimate, to determine the approximate footprint of the facility (Section 4.1);
- Constraint Map Development, to ensure appropriate setbacks (Section 4.2); and,
- Site Characterization and Field Assessment, to ensure appropriate topography, geology, hydrology, and hydrogeology (Section 4.3).

The following sections provide basic site requirements and constraints for siting and developing a PHCSTF.

4.1 PHCSTF Size Estimate

To determine an appropriate location for constructing a PHCSTF, an estimate of the total PHCSTF footprint is required. The total facility footprint needs to consider the footprint of the remediation cell(s) (i.e., the area in which the contaminated soils will be managed, manipulated, or otherwise treated), berms, surface water drainage features (including water management systems), access roads, and ancillary activities.

For the purpose of a preliminary size estimate, the size of the remediation cell can be estimated by approximating the size of the soil treatment area, approximating the berm widths and approximating the surface water management system area. Appendix A provides an example sizing calculation for a PHCSTF that uses a windrow formation to promote soil remediation.

As part of sizing the PHCSTF, the estimated area required for the surface water management system should be approximated based on the catchment area (footprint) of the PHCSTF. As run-on of water is to be controlled via the PHCSTF berms (i.e. no surface water should enter the facility from runoff of the surrounding environment), the amount of precipitation collected within the catchment area will be the estimated volume of water to be collected and managed within the surface water management system. Table 4-1 summarizes input and design requirements that should be used when estimating surface water management volumes:

Table 4.1: Recommendations for Inputs and Design – Water Management Systems

Required Parameter	Recommendation
Rainstorm Event (accumulated precipitation within the PHCSTF)	24-hour, 10-year frequency event
Spring Melt (accumulated snowfall within the PHCSTF)	Average annual accumulation, using a 10:1 (inches of snow: inches of water) ratio[1]
Freeboard	50 cm or as recommended by a Qualified Professional[2]

[1] Environment and Climate Change Canada (2013).

[2] British Columbia Ministry of Environment (2012).

Alternative surface water/leachate management systems/structures may be proposed (e.g., storage tanks); however, all systems should meet the recommendations identified in Table 4.1 unless otherwise recommended by a Qualified Professional. Regardless of the type of containment used for accumulated water, the PHCSTF design should account for the accumulation of water in the remediation cell(s) prior to transferring to a water management system.

Once an estimated total area for the PHCSTF is known, the actual configuration will be determined during design and be based on existing site topography. A single remediation cell or multiple remediation cells may be required.

This is a simple, preliminary footprint estimate to assist with choosing an appropriate site during the constraint map development process (Section 4.2). Once the site has been identified, the facility should be designed based on site conditions, and an anticipated operational schedule. Section 5.0 of this guideline document provides further details for PHCSTF design requirements.

4.2 Constraint Map Development

A constraint map should be developed to determine potential PHCSTF locations within a specified area. Constraint mapping identifies restricted zones that exhibit site features, as listed in Table 4.2 (e.g., sensitive receptors, steep topography), which may pose an unacceptable risk to siting a PHCSTF. The constraint mapping identifies offset distances from these site features and identifies the remaining areas

for potential PHCSTF development. A review of features on adjacent properties that may be impacted by the site (along with appropriate offset distances) should be included on the constraint map. See Figure 4.1 for an example of a constraint map. The potential PHCSTF development sites are then assessed based on the site characteristics (outlined in Section 4.3) and the estimated area requirement (footprint) of the PHCSTF (as calculated pursuant to Section 4.1).

Table 4.2: Recommended Site Constraints for PHCSTF Siting

Site Features	Siting Recommendations
Residential Zoning	>500 m from residential zoning.
Surface Water Body (including high-water mark of 25-year floodplain)	>100 m from the high-water mark of surface water body.
Potable Water Source	>500 m from the extraction point, intake, or wellhead of a potable water source.
Sensitive Area	>500 m and down-wind (prevailing) from regional, territorial, and national park boundaries or areas designated as habitat for sensitive species (such as those identified in the Species at Risk Act, List of Wildlife Species at Risk, and the International Union for Conservation of Nature [IUCN] red list of threatened species); areas identified through stakeholder engagement as culturally important, heritage or archaeological sites.
Site Grade	Natural slope <5%.
Groundwater Hydrology	Seasonal high groundwater level should be >1m below the base of the PHCSTF.

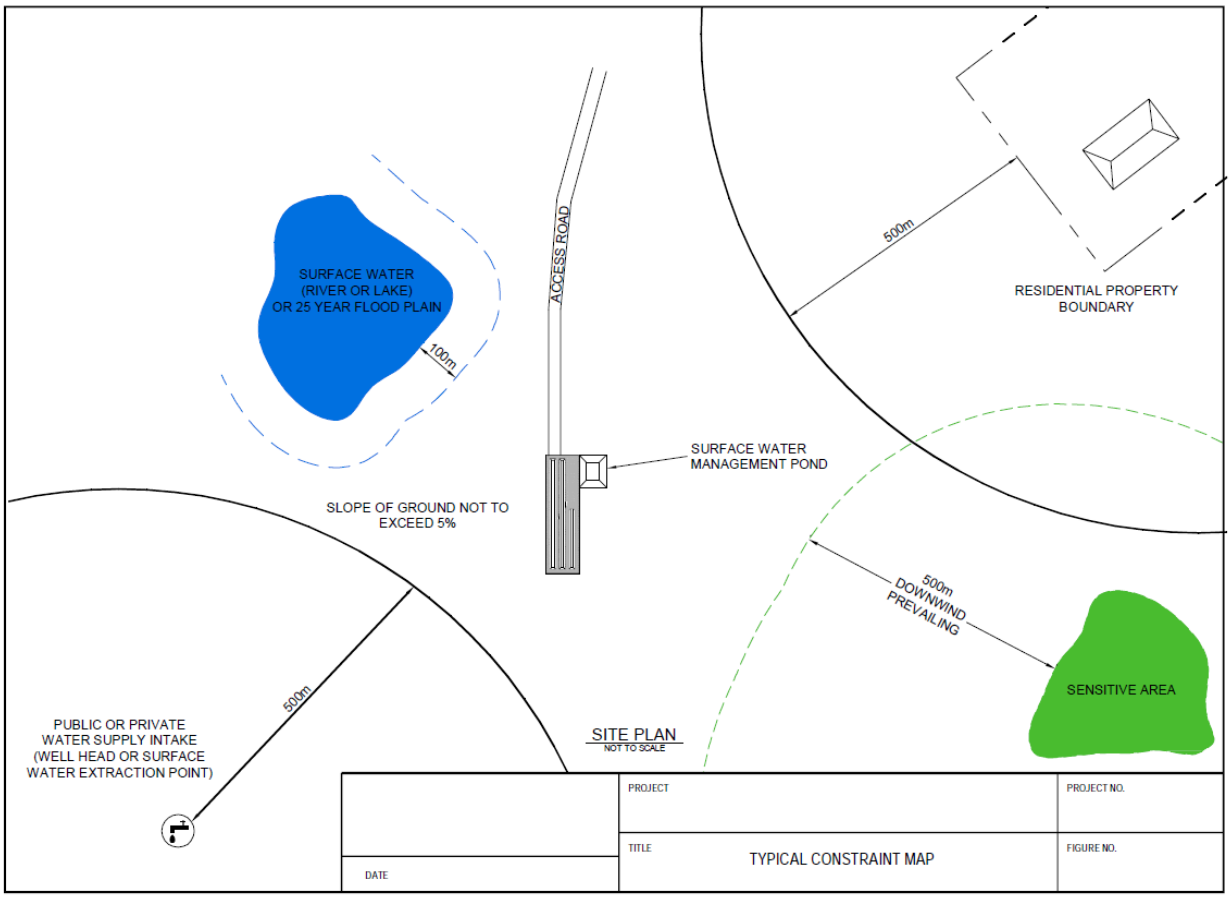

Figure 4.1: Example of Constraint Mapping Assessment

4.3 Site Characterization and Field Assessment

Once a potential site (or sites) is (are) successfully identified based on the constraint mapping assessment, the next step is to determine the suitability of a given site with a baseline field investigation. The baseline field investigation should consist of the following:

- a site topographic survey;
- an assessment of groundwater flow direction and seasonal high groundwater level below ground surface;
- a baseline groundwater chemical analysis; and,
- a native soil hydraulic conductivity determination.

Information collected during the field investigation, in addition to the constraint map, will provide the proper baseline information to complete a detailed PHCSTF design.

4.3.1 Topographic Site Survey

A topographic site survey should be completed during the field investigation to determine the natural grade of the landscape. PHCSTFs should be sited at a location with a natural slope of less than 5% or else the site should be modified to meet the slope requirement of less than 5% (FCSAP, 2013). Features such as surface water drainage channels, surface water ponding areas, depressions, tree line boundaries, and

geological formations should be identified. Contour intervals for the topographic survey should be no greater than one metre.

4.3.2 Underlying Geology/Native Soils

Prior to siting, design and construction of the PHCSTF, a baseline intrusive investigation should be conducted at the site to identify the type of soils and the geology underlying the site, including the depth of overlying soils, permafrost (if applicable), and bedrock (if shallow). Soil samples can be collected by test pit or test hole. Logs for each pit/hole should identify depths, drilling/advancement method, and lithology including a stratigraphic column. Baseline intrusive investigations should be completed by a Qualified Professional.

Baseline soil samples should be collected in a grid pattern across the proposed site footprint. Soil samples should be analyzed and compared to the most current version of *Environmental Guideline for Contaminated Site Remediation in the NWT* (GNWT, 2003). The grid pattern should be determined by a Qualified Professional. These baseline soil samples should be compared to final soil samples collected and analysed prior to closure, as discussed in Section 7.3.

4.3.3 Hydrogeology

The PHCSTF should not be sited:
1) on areas with ponding, springs or groundwater discharge;
2) on sites where the seasonal high groundwater table is less than 1 m below ground surface (including wetlands); or,
3) in any area prone to flooding. The site survey should identify areas of surface water observed during the field investigation.

A baseline groundwater investigation should be completed as part of the field assessment, prior to construction/operation. A minimum of three monitoring wells should be installed to triangulate groundwater flow direction across the site. These wells can be used to monitor groundwater during baseline analysis and can then become part of the groundwater monitoring program during operation and the post-closure monitoring periods. Depending upon the site characteristics, additional groundwater monitoring wells may be required as part of the monitoring program. Baseline groundwater samples should be analyzed for the parameters noted, and compared to guidelines identified, in Table 4.3. Groundwater samples are to be collected in accordance with a standard such as the *Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment* (CCME, 2016), or as recommended by a Qualified Professional.

Table 4.3: Baseline Groundwater Sampling Recommendations

Guidelines	Parameters
Federal Interim Groundwater Quality Guidelines for Federal Contaminated Sites (FIGQG) Tier I [1]	**Petroleum Hydrocarbons**: Benzene Toluene Ethylbenzene Xylenes F1 F2 F3 F4
	Dissolved Metals: Aluminum (Al), Antimony (Sb), Arsenic (As), Boron (B), Barium (Ba), Beryllium (Be), Cadmium (Cd), Chromium (Cr), Cobalt (Co), Copper (Cu), Iron (Fe), Manganese (Mn), Mercury (Hg), Molybdenum (Mo), Nickel (Ni), Phosphorus (P), Lead (Pb), Selenium (Se), Silver (Ag), Thallium (Tl), Uranium (U), Vanadium (V), Zinc (Zn)
	General Chemistry: pH (to be measured in the field) Alkalinity (as $CaCO_3$) Turbidity Conductivity Total Dissolved Solids Chloride Fluoride Sulphate Colour
	Nutrients: Ammonia (as N) Nitrite Nitrate

[1]FCSAP, 2012.

The parameters identified in Table 4.3 represent the recommended minimum analyses for characterizing the groundwater on the site. Additional parameters, such as PAH's, may also be appropriate depending upon the specific history of the proposed location. Additional analyses may be recommended by a Qualified Professional.

5.0 Design and Construction

The design of a PHCSTF is influenced by a number of factors including site characteristics, volume of contaminated soil to be treated, and operational considerations. This section identifies requirements that should be included as part of the detailed PHCSTF design. A conceptual design is presented in Figure 5.1 and Figure 5.2 to provide guidance for the design phase of a simple PHCSTF. Please note that these are conceptual drawings only. Berm dimensions (including slopes), granular fill thickness and specifications, surface water management systems or holding tank design specifications, and liner details are to be approved by a Professional Engineer licensed to practice in the Northwest Territories.

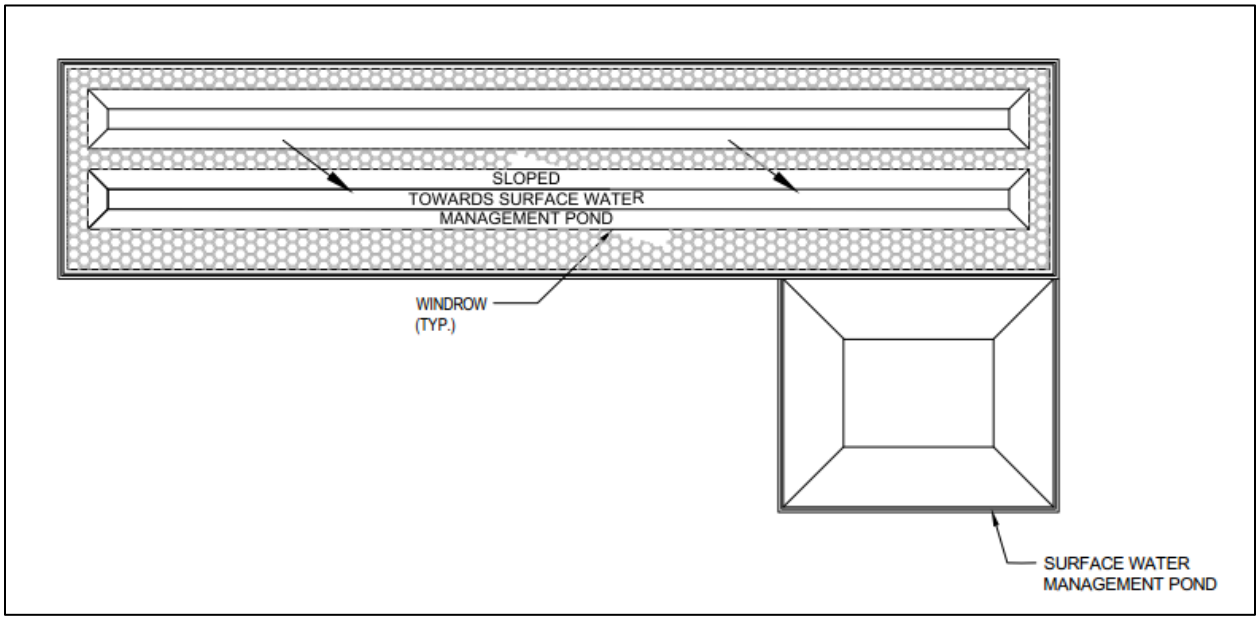

Figure 5.1: Conceptual Design of a PHCSTF– Top View

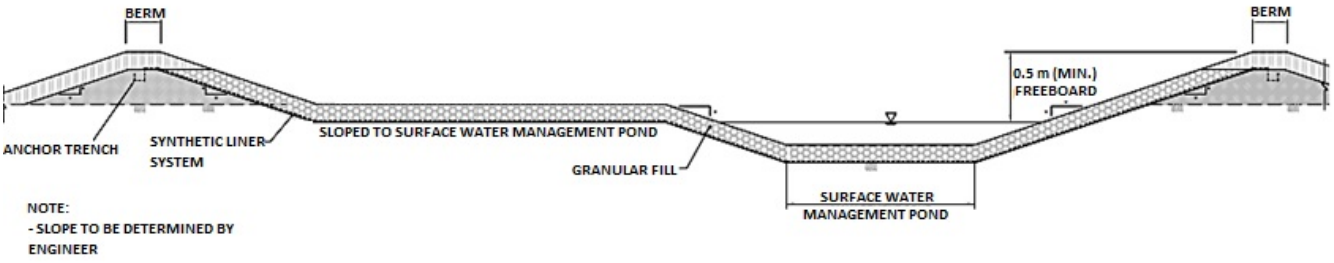

Figure 5.2: Conceptual Design of a PHCSTF - Cross-Section

5.1 Scale of Operations

The scale of operations and timeframe for soil remediation should be considered. The design should consider the volume of contaminated soil to be remediated and the operational treatment period (i.e., the amount of treatment time that will be required for a specific volume of soil to reach target remedial soil levels). Soil may be remediated within a remediation cell or multiple remediation cells, as required by land availability and equipment.

5.2 Berm Design

Petroleum hydrocarbon-contaminated soils should be placed into a contained system built to control surface water run-on and runoff from within and around the PHCSTF. Engineered berms should be constructed to a sufficient height as to contain the total volume of contaminated soil to be placed within the PHCSTF cell, prevent precipitation and associated surface water from escaping the PHCSTF, allow for a minimum of 50 cm of freeboard (British Columbia Ministry of Environment, 2012), or as approved by a Professional Engineer, within the surface water retention system (Yukon CSR, 2018), and prevent freshet runoff from entering the facility. Berms should be constructed around the entire perimeter of the treatment area to fully contain surface water runoff and petroleum hydrocarbon-contaminated soils (FCSAP, 2013).

Access ramps should be constructed over the berms to allow equipment access to the windrowed soils. No portion of the berm should be removed to allow for equipment to pass in and out of the PHCSTF (Yukon CSR, 2018).

5.3 Barriers and Liners

A liner system (e.g., geosynthetic membrane or clay liner) is generally required to prevent downward migration of contaminants into the underlying and surrounding environment. The liner system should be approved by a Professional Engineer licensed to practice in the Northwest Territories.

The liner system should be resistant to deterioration by sunlight and petroleum hydrocarbon compounds, should be properly temperature rated for the north, and should be manufactured and installed to avoid puncture or tearing from soil spreading and tilling operations. The liner system should have a hydraulic conductivity of less than 1×10^{-7} cm/s (FCSAP, 2013).

An indicator layer (such as snow fencing or other highly visible material) should be installed on top of the completed liner system. The purpose of this indicator layer is to assist operators with identifying when equipment has excavated too deep into the base of the PHCSTF and is in danger of damaging the liner.

In some instances, a PHCSTF may be base lined with non-synthetic materials that provide a sufficiently protective barrier with appropriate hydraulic conductivity, as recommended by a Qualified Professional.

5.4 Surface Water Management Structure Design

Soil treatment cells should contain surface water runoff (and any associated contaminated sediment) within the treatment area. The design should make provisions to contain internal rainwater runoff and freshet to prevent seepage through the berm into the surrounding environment. The PHCSTF should be graded towards a connected surface water management system to collect and contain surface water runoff. The surface water management system should be capable of accommodating runoff volumes as a result of a 24-hour, 10-year frequency storm (at a minimum) with additional capacity for regional spring freshet, or as recommended by a Qualified Professional. See Table 4.1 for surface water management system sizing requirements. Facility-specific considerations may influence selection of an appropriate minimum runoff design volume, and alternative volumes may be recommended by a Qualified Professional.

5.5 Qualifications for Design and Construction Contractors

The design and construction of a PHCSTF should be completed by a qualified contractor with the support of a Professional Engineer licensed to practice in the Northwest Territories. Engineered structures should be constructed and maintained in accordance with the stamped engineered design and recommendations of the Professional Engineer responsible, including, but not limited to, recommendations regarding field supervision and inspection requirements. Construction records of materials should be maintained and readily available upon request. An as-built report should include record drawings, documentation of field decisions that deviate from the final detailed design and any data used to support these decisions.

5.6 Site Security

To limit public and wildlife access to the site, fencing (or other appropriate barriers) should be installed around the perimeter of the site with a lockable access gate, most notably for PHCSTFs within, or in close proximity to, municipalities. Signage should be posted at the entrance to the site which identifies the responsible authority, states that a potential hazard is present (e.g., petroleum hydrocarbon-contaminated soil), and states that trespassing is prohibited. Consideration of local languages or universal symbols should be made when developing signage.

6.0 Operation and Maintenance

As a best practice, a PHCSTF should have an Operation and Maintenance Plan and a Spill Contingency Plan. This type of documentation is typically required as part of the water licensing process in the Northwest Territories. This section provides guidance on the operation and maintenance of the PHCSTF, including requirements for incoming soils, tilling, monitoring, surface water management, system maintenance, and documentation.

6.1 Contaminant Type and Concentration Restrictions on Incoming Soils

As previously stated in Section 1, this Guideline is written for petroleum hydrocarbon-contaminated soil remediation only and are recommended for treatment of light and mid-range petroleum hydrocarbon-contaminated soils. PHCSTFs are not suitable or effective for the remediation of elevated metals, very heavy oils or tar contamination. These types of contaminants usually require alternative treatment or risk management measures.

Owners or operators need to know what type of contaminated material is entering their facility. If the owner or operator of a PHCSTF facility knowingly accepts soils contaminated with heavy metals or other untreatable contaminants, with concentrations above the most current version of *Environmental Guideline for Contaminated Site Remediation in the NWT* (GNWT, 2003), they will become responsible for the proper treatment and/or ultimate disposal of these contaminants in the soil. Liability falls on the operator or property owner if soils with untreatable materials or contaminant concentrations are accepted into the PHCSTF facility.

If a PHCSTF operator accepts soil from more than one site (i.e., on a commercial basis), it is the responsibility of the PHCSTF operator to ensure they communicate the acceptance criteria and review the analysis of the soil prior to accepting it into their facility. See Section 6.9 for further details related to documentation of incoming soils.

The *Guideline for Hazardous Waste Management* (GNWT, 2017) states that hazardous waste must not be mixed or diluted with any substance or divided into smaller quantities to avoid meeting the definition of hazardous waste. Owners and operators should understand that blending soils to reduce the concentration of unacceptable contaminants in PHCSTFs is not an acceptable practice (British Columbia Ministry of Environment, 1999).

Soils contaminated with total extractable hydrocarbon concentrations exceeding 30,000 ppm are considered highly contaminated (Yukon CSR, 2018). If soils are accepted with concentrations exceeding 30,000 ppm, or if the soils are saturated to the point where free product is visible, the owner should ensure that their facility is capable of treating this soil, is built to properly contain and treat liquids that may contain free product, and has sufficient health and safety protocols in place.

It is the responsibility of the owner of the soil to ensure adequate analysis is completed and reviewed to meet the acceptance criteria of the receiving facility. Before contaminated soil is transported to the PHCSTF, the soil should be confirmatory sampled and analyzed as follows, or as recommended by a Qualified Professional:

- Sampling parameters should be chosen based on suspected contaminants, as per Table 6.1. Representative samples of the contaminated soil should be collected and analyzed at a rate of one composite sample per 50 m^3 of soil.
- Representative samples should be analyzed, at a minimum, for the same parameters identified in the most current version of *Environmental Guideline for Contaminated Site Remediation in the NWT*

(GNWT, 2003). Analysis of other contaminants of potential concern, if suspected, should be conducted as appropriate.

- If field observations, field measurements, knowledge of the site, or spill conditions suggest other contaminants besides treatable petroleum hydrocarbons are present on site, the recommended sample density is one sample per 10 m^3 of material.

Table 6.1: Recommended Parameters for Confirmatory Soil Analyses

Contaminant Source	Parameters Analyzed[1]						
	Hydrocarbon Fractions (F1-F4)	BTEX	Lead	Metals	PCBs	Phenols	PAHs
Unleaded gasoline	✔	✔		✔			
Leaded gasoline, aviation gasoline	✔	✔	✔	✔			
Fuel oil, diesel, kerosene, jet fuel, mineral oil/spirits, motor oil	✔	✔					✔
Petroleum solvents	✔	✔			✔		
Crude oils, hydraulic fluids	✔		✔	✔			✔
Waste petroleum products	✔	✔	✔	✔	✔	✔	✔

[1]FCSAP, 2013

6.2 Operational Period

Petroleum hydrocarbons in soil are most effectively treated and remediated in PHCSTFs through physical and biological processes in the warmer months when the soil is not frozen or covered with snow. Generally, contaminated soil should not be placed or manipulated (e.g., tilled) when the ground surface is saturated with water, or covered with ice or snow (Yukon CSR, 2018).

6.3 Soil Manipulation

Soil manipulation is a physical process of aerating the soils to enhance remediation. Soil can be manipulated in various ways. For example, by tilling, by turning it over with a backhoe, or by using other mechanical means to move the soil.

The frequency of soil manipulation will depend on several factors including the petroleum hydrocarbon concentrations in the soil, the remediation schedule, and the target PHC concentrations. Generally, the more frequent the manipulation, the faster PHC concentrations will decrease. Manipulation of the soil

when it is excessively dry may erode the soil and cause wind-blown dust problems (FCSAP, 2013). If the soil is dry (i.e., moisture content less than 5 percent), wetting the soil should be considered prior to and during manipulation to prevent erosion and dust. Soil manipulation should be carried out by an experienced operator, as it is possible to damage the liner under the soils with heavy equipment.

Owners and operators should note that blending or diluting soils is not an acceptable method of treating petroleum hydrocarbon-contaminated soils, as described in Section 6.1.

6.4 Soil Treatment Monitoring

During remediation, PHC concentrations in the soil should be analyzed to evaluate the extent to which the soil has been remediated and to assist the operator in evaluating and optimizing the soil manipulation approach (e.g., increasing the frequency of soil manipulation). The frequency at which the soil is sampled during the operational period is at the discretion of the PHCSTF operator; however, it is recommended that the operator complete one round of soil sampling per year prior to freeze-up of the site. Soil samples are to be collected in accordance with a Quality Assurance/Quality Control (QA/QC) Plan (Section 6.9.2).

6.5 Removal of Treated Soil

Prior to removal, the PHCSTF soils must be tested for the parameters listed in the current version of the *Environmental Guideline for Contaminated Site Remediation* (GNWT, 2003) for the intended future land use of the soils.

Before soil is released from the PHCSTF, the soil should be sampled and analyzed as per the QA/QC Plan (Section 6.9.2), which should incorporate the following:

- Sampling of soils prior to release from the PHCSTF should follow a standard procedure, such as *the Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment* (CCME, 2016), or as recommended by a Qualified Professional.
- Samples should be collected by, or under the direction of, a Qualified Professional.
- Representative samples of the contaminated soil should be collected and analyzed at a minimum rate of one composite sample per 50 m^3 of soil, or as recommended by a Qualified Professional.
- Composite samples should be collected by combining discrete soil samples taken of equivalent volume, from three different locations: 10 cm below the top of the soil surface in the windrow; at the base of the windrow; and one sample from the middle of the windrow, or as recommended by a Qualified Professional.
- If regulated under a water licence, a PHCSTF may have to send sampling results to an Inspector prior to removal of soil, should their authorization require.

A stockpile of soil that is not in a windrow, and greater than 100 m^3, cannot be readily characterized by this method; therefore, consultation with Qualified Professionals are required to design and conduct a thorough sampling and analysis plan.

6.6 Surface Water Monitoring and Management

6.6.1 Surface Water Management at PHCSTFs

Some PHCSTFs will accumulate contact water. Generally, this water can be used to water the soil in a facility; however, larger operations will have to remove excess water from the facility. Excess water may be stored in a pond, sump or holding tank with proper containment, as discussed in Section 4. Some PHCSTFs may have to treat water prior to discharging to the receiving environment. PHCSTFs of this scale will have a water licence to authorize the discharge of waste to the receiving environment.

As water holding tanks approach full volume, water within the retention pond or holding tank should be analysed as outlined in Table 6.2; a water licence will typically require that results are provided to the Inspector and/or Regional Land and Water Board for review and approval prior to decant. Discharge criteria may be specifically developed in a water licence for a particular PHCSTF on a site-specific basis; however, general criteria for the discharge of water from the PHCSTF are provided from the guidelines referenced in Table 6.2, depending on the location of the discharge point or ultimate receiving environment. The PHCSTF operator should be present during decant operations. Emergency/buffer containment should be available to store water during times when capacity is being approached and the PHCSTF is awaiting laboratory results prior to discharge approval.

Table 6.2 will inform subsequent water management actions with respect to on-site discharge, the need for treatment, or transportation to an off-site approved disposal facility.

Table 6.2: Recommended Guidelines for the Development of Discharge Criteria for Managed Water at PHCSTFs

Discharge Environment	Recommended Guidelines/Criteria	Parameters
Surface Water	*CCME Environmental Quality Guidelines* (EQGs) *for the Protection of Aquatic Life* (Freshwater, Marine) [2] *Environmental Quality Guidelines for Alberta Surface Waters*[3]	**Petroleum Hydrocarbons**: Benzene Toluene Ethylbenzene Xylene **Petroleum Hydrocarbons:** F1, F2, F3, F4[1]
	CCME Environmental Quality Guidelines (EQGs) *for the Protection of Aquatic Life* (Freshwater, Marine)[2] *CCME Environmental Quality Guidelines* (EQGs) *for the*	**Total Metals:** Aluminum (Al), Arsenic (As), Boron (B), Cadmium (Cd), (Hexavalent) Chromium (CrVI), Copper (Cu), Iron (Fe), Mercury (Hg), Molybdenum (Mo), Nickel (Ni), Phosphorus (P), Lead (Pb), Selenium (Se), Uranium (U), Vanadium (V), Zinc (Zn)

[1] The guidelines do not have criteria for F3 and F4; however, they should still be sampled and reported.
[2] CCME, 2019.
[3] Alberta Government, 2018.
[4] FCSAP, 2012.

Discharge Environment	Recommended Guidelines/Criteria	Parameters
Surface Water (Continued)	*Protection of Aquatic Life* (Freshwater, Marine)[2]	**General Chemistry:** pH (measured in the field) Alkalinity (as $CaCO_3$) Chloride Sulfate Turbidity Conductivity Total Suspended Solids
		Nutrients: Ammonia (as N) Nitrite Nitrate
		Petroleum Hydrocarbons: Benzene Toluene Ethylbenzene Xylene F1, F2, F3, F4[1]
Land/Groundwater	*Federal Interim Groundwater Quality Guidelines for Federal Contaminated Sites (FIGQG)*[4]	**Dissolved Metals:** Aluminum (Al), Antimony (Sb), Arsenic (As), Boron (B), Barium (Ba), Beryllium (Be), Cadmium (Cd), Chromium (Cr), Cobalt (Co), Copper (Cu), Iron (Fe), Manganese (Mn), Mercury (Hg), Molybdenum (Mo), Nickel (Ni), Phosphorus (P), Lead (Pb), Selenium (Se), Silver (Ag), Thallium (Tl), Uranium (U), Vanadium (V), Zinc (Zn)
		General Chemistry: pH (measured in the field) Alkalinity (as $CaCO_3$) Chloride Sulphate Turbidity Conductivity Total Dissolved Solids
		Nutrients: Ammonia (as N) Nitrite Nitrate

6.6.2 *Inspections Relating to Water Management*

Monthly inspections are recommended on the:

- Drainage control systems (e.g., ditches, berms and liners) to assess evidence of deterioration, malfunction, leaks or improper operation; and
- Retention pond or surface water collection systems to ensure proper functioning and to determine if leachate is being generated or accumulating (FCSAP, 2013).

If a PHCSTF does not operate during certain periods of the year, a reduced inspection frequency may be considered. Regardless, inspections should always take place during periods of heavy rainfall precipitation or spring freshet to record when the facility is approaching capacity and to ensure control measures are taken as needed.

6.7 Groundwater Monitoring

Groundwater monitoring wells installed during the site characterization phase should be monitored during operation of the PHCSTF. The criteria and parameters outlined for groundwater in Table 6.2 should be used as a guide when assessing groundwater quality; however, the baseline groundwater quality determined prior to operations (see Section 4.3.3) and the type of contaminated soil accepted at the PHCSTF will help inform the groundwater quality monitoring program. Groundwater should be sampled and analyzed at a minimum of twice per year: at the beginning of open-water season; and at the end of open water season. Additional sampling and analysis might be required under a water licence.

Under a water licence, a Groundwater Monitoring Plan, or a sub-section of the Operation and Maintenance Plan will include action levels for groundwater quality. Action levels are established to identify when contaminants may have entered the groundwater from the facility and require possible mitigative actions. Actions levels are typically determined on a site-specific basis using a combination of information that may include the background groundwater quality data gathered during the site characterization (see Section 4.3.3 and the applicable guidelines outlined in Table 6.2. For example, if background groundwater monitoring shows that concentrations of certain constituents are naturally elevated in the vicinity of the PHCSTF, guidelines may not provide an appropriate action level. The Groundwater Monitoring Plan should also stipulate the corrective actions that will take place should groundwater results reach or exceed action levels.

6.8 System Maintenance

Inspection of the PHCSTF should be conducted annually by the owner/operator to ensure infrastructure integrity to prevent contamination from the PHCSTF from leaching into the surrounding environment. This annual inspection should include visual observations of the berms to identify areas of erosion, sloughing, animal intrusion or other areas of damage. As well, areas of liner exposure, including exposure of the liner indicator layer, should be noted. If any damage, malfunctions or defects are detected, immediate repair is required to maintain the integrity of the infrastructure.

As stated in Section 6.6.2, the drainage control system and retention ponds/surface water management structures should be inspected monthly during the operational period and more frequently during periods of precipitation or spring thaw to ensure that control measures are taken if the system is approaching capacity (FCSAP, 2013).

6.9 Documentation

When a PHCSTF operates under a water licence, an Operation and Maintenance Plan, a Spill Contingency Plan, and Annual Reports are generally required once authorization to construct the PHCSTF has been obtained. Sections 6.9.1 to 6.9.4 outline further details with respect to these requirements.

PHCSTFs that accept contaminated soil from a third party, or parties, should be registered as a receiver by the Department of Environment and Natural Resources, GNWT according to the *Guideline for Hazardous Waste Management* (GNWT, 2017) for the purpose of tracking the type and amount of soil entering the facility. The waste generator is required to characterize the soil according to the PHCSTF's acceptance procedures. The six-part movement document is used to track the ultimate disposal of contaminated soil from the generating site to the registered receiving facilities. The document provides a means of recourse for the owners of the receiving facility if the soils are found to be unacceptable and also serves as a form of recordkeeping to ensure treatment facilities do not accept quantities beyond their capacity.

6.9.1 Operation and Maintenance Plan

An Operation and Maintenance Plan should detail the operations and maintenance procedures to be followed during the operational lifespan of the facility. Typically, an Operation and Maintenance Plan is required as part of the water licencing process. Requirements of the Operation and Maintenance Plan for an PHCSTF may include, but are not limited to, the following:

- Project Description
- Facility Design
- Facility Personnel and Training
- Soil Intake Procedures
- Soil Management Procedures
- Soil Removal Procedures
- Surface and Groundwater Monitoring Plan
    - Action Levels for Surface and Groundwater Monitoring (including rationale/explanation of how action levels were derived)
    - Corrective Actions to be taken by Owner/Operator should Action Levels be exceeded
- Soil and Water Monitoring QA/QC (Section 6.9.2)
- Effluent Discharge Location and Procedures
- Maintenance Schedule
- Inspection Schedule
- Documentation and Reporting

6.9.2 Soil and Water Monitoring Quality Assurance/Quality Control

Soil and water analysis involve identifying or verifying the chemical and physical characteristics of the soil and water at the PHCSTF, as well as verifying the amount or mobility of the contaminants. A Quality Assurance/Quality Control (QA/QC) Plan for soil and water monitoring should be sufficient to ensure that the testing will provide all information necessary to confirm soil and water monitoring requirements are met. The QA/QC Plan should encompass the following:

- Sampling requirements specified as a condition in a land use permit or water licence;
- Procedures used to obtain representative samples of soil or water;
- Procedures for QA/QC; and
- Reference to an applicable soil and water sampling standard or procedure such as the *Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment (CCME, 2016)*, or as recommended by a Qualified Professional.

  Using a standard sampling protocol is particularly important when characterizing soils to be removed from the facility and used as prescribed in the *Environmental Guideline for Contaminated Site Remediation (GNWT, 2003).*

6.9.3 Spill Contingency Plan

A Spill Contingency Plan should be prepared to alleviate the potential environmental effects should petroleum hydrocarbons be spilled and released into the environment. Owners and operators should refer to the *Guidelines for Spill Contingency Planning* (2007) developed by Indian and Northern Affairs Canada for further guidance.

6.9.4 Annual Reports

If the facility has a water licence, owners/operators will have to submit a report to the applicable regulator each year. An annual report may include, but not be limited to, the following information specific to the PHCSTF's operation and maintenance activities in the previous calendar year:

- Summary of any revisions made to existing plans;
- Summary of any construction, modification and/or maintenance activities;
- Origin of contaminated soil being treated, the volume of soil accepted from each source, the total volume being treated and the intended final destination for the remediated soils;
- Laboratory analytical results for soils brought to or removed from the facility;
- Laboratory analytical results for groundwater, surface water, and any additional sampling conducted, and a comparison of results to all appropriate guidelines, water licence criteria and/or action levels identified in the Operation and Maintenance Plan;
- The volume of soil removed from the facility, the locations of the receiving sites and the land use activity occurring at each receiving site location;
- Contravention reports, if applicable;
- Volume of water used, and volume of wastewater discharged; and
- Inspection reports of the containment structure(s).

This information will be summarized in the annual report; however, the original records should be retained and readily available and produced at facility inspections, or upon request by the applicable regulator.

7.0 Closure

7.1 Closure Plan

Upon receiving authorization from the applicable regulator to construct the PHCSTF, the operator should present a Closure Plan for the PHCSTF site. Once the Closure Plan is approved, it should be updated annually to make any necessary revisions to reflect changes in operations.

The Closure Plan should address the following:

- Target PHC concentrations;
- Final removal and disposal of treated soil;
- Removal of synthetic liner system, surface water management retention pond/structures and PHCSTF berms;
- Restoration of natural drainage at the site(s);
- Potential for groundwater contamination;
- Areas that may have been affected by development such that potential residual pollution problems exist;
- A phased approach and schedule;
- Maps delineating disturbed areas, borrow material locations, and site facilities;
- Proposed disposition of remaining soils; and,
- Future land use of the site.

Typically, the Closure Plan is to be submitted and approved by the applicable regulator prior to closure of the site. Soils must meet reuse criteria for remediation before being removed from the PHCSTF facility and transported to the final soil location.

7.2 Removal of Liner System and Surface Water Management Structures

After the remediated soils have been reused or disposed off-site, the PHCSTF should be decommissioned, surface water decanted, liner extracted, and a field assessment of the underlying soils completed. As described in **Section 6.6**, surface water should only be decanted from the PHCSTF following sampling and analysis to ensure the water meets appropriate surface water criteria.

Once the surface water is decanted, the synthetic liner system can be removed. Next, inspect the liner for damage that may have led to environmental contamination. Should damage to the liner system be identified, record where the damaged area of liner was located and inspect for potential areas of soil contamination beneath the liner. Additional sampling of soil may be required in this area.

Dispose of the synthetic liner system at an appropriate landfill facility.

7.3 Underlying Soil Testing

Once the liner is removed, the underlying native soil should be sampled and analysed for potential contaminants. Soil samples are to be tested against the most recent version of the *Environmental Guideline for Contaminated Site Remediation (GNWT, 2003).*

Samples should be collected from across the site, but specifically from any areas of suspected contamination (e.g., locations where liner damage was noted). The site, including the berms, should be divided into a grid with squares no larger than 26 x 26 m. These squares represent an approximate soil volume of 100 m^3 per square (assuming a depth of 0.15 m). In each grid square, a composite sample comprised of 5 grab samples taken from each corner (including soil from the berms) and from the centre should be collected. Each sample should be taken from a depth of no more than 15 cm and combined to create a single representative sample. Underlying soils must meet the criteria outlined in the most recent version of *the Environmental Guideline for Contaminated Site Remediation* (GNWT, 2003) for the future land use of the site. Any contaminated soil generated during remedial activities will be transported to another permitted facility (Protocol 11, Yukon CSR, 2018).

If contamination is discovered in the underlying soils, then the site will be considered a contaminated site for the purpose of applying the *Environmental Guideline for Contaminated Site Remediation* (GNWT, 2003).

7.4 Groundwater Monitoring Well Decommissioning

Groundwater wells should be monitored throughout the lifetime of the PHCSTF and through closure. If the results of the groundwater monitoring program at decommissioning exceed the applicable criteria outlined in Table 6.2, then the site will be considered a contaminated site for the purpose of applying the *Environmental Guideline for Contaminated Site Remediation* (GNWT, 2003).

Monitoring wells should not be decommissioned until the results meet the applicable criteria and the site is decommissioned. Once the PHCSTF has been decommissioned then proper standards for decommissioning a groundwater monitoring well, as recommended by a Qualified Professional, are to be followed.

7.5 Site Reclamation

Once the liner is removed, the underlying soil meets applicable land use criteria as per the *Environmental Guideline for Contaminated Site Remediation* (GNWT, 2003), and the monitoring wells have been appropriately decommissioned, then the land surface should be contoured to its original grade and re-vegetated where appropriate for erosion control, consistent with the future land use outlined in the Closure Plan. Borrow material may be required to re-grade the site.

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9.0 Appendix A: Sizing a PHCSTF

The following is a simple example of estimating the size of a PHCSTF. This example assumes the use of windrows, which is a common method of soil remediation in the North.

The approximate size of the soil treatment area can be calculated by determining the volume of soil to be treated and using the windrow sizing recommendations in Table A-1. Recommendations are based on a maximum windrow slope of 1:1. A windrow height of 1 m is recommended as a conservative estimate, which will allow for aeration with one pass of equipment expected to be available in most communities; however, windrow sizes can be adjusted to accommodate the capacity of the available equipment. These dimensions will need to be verified by a Qualified Professional once the site has been selected and a topographical survey has been completed. Proposed alternate windrow sizing dimensions could be proposed.

Table A.1: Windrow Sizing Recommendations

Feature	Recommended Dimensions[1]
Windrow Slope	Maximum 1:1
Windrow Height	1 m
Windrow Base	2 m
Windrow Spacing[2]	1 m

[1]Recommended windrow dimensions allow equipment anticipated to be readily available to aerate the soil in one pass through the windrow.

[2]Windrow spacing recommendations are to allow for a piece of aeration equipment to pass between windrows. Windrow spacing requirements should be adjusted based on the size of the equipment available.