NIRB File No.: 06DN029
INAC File No.: N2006X0009

July 16, 2010

Honourable Chuck Strahl
Minister of Indian and Northern Affairs Canada
c/o Spencer Dewar
Manager Land Administration
Indian and Northern Affairs Canada
Iqaluit, NU

Via email: spencer.dewar@inac-ainc.gc.ca

Re: Application exempt from Screening pursuant to Section 12.4.3 of the NLCA: Defence Construction Canada's "CAM-1 Jenny Lind Island DEW Line Clean-up" project

Dear Spencer Dewar:

On July 16, 2010 the Nunavut Impact Review Board (NIRB or Board) received an application for an extension to Land Use Permit #N2006X0006 from Indian and Northern Affairs Canada (INAC) for Defence Construction Canada's "CAM-1 Jenny Lind Island DEW [Distant Early Warning] Line Clean-up" project.

Please be advised that the original project proposal (NIRB File No.: 06DN029) was received by the NIRB from INAC on March 31, 2006 and was screened by the Board in accordance with Part 4, Article 12 of the Nunavut Land Claims Agreement (NLCA). On July 31, 2006 the NIRB issued the enclosed NLCA 12.4.4(a) screening decision to the Minister of INAC indicating the proposed project could proceed subject to NIRB's recommended project-specific terms and conditions.

On August 19, 2008 and again on January 13, 2009, the NIRB issued correspondence to INAC advising that an extension to the above-cited land use permit was exempt from the requirement for further screening pursuant to Section 12.4.3 of the NLCA.

The current INAC application, the original NIRB Screening Decision Report (06DN029) and related file information are available from the NIRB's ftp site at the following link: http://ftp.nirb.ca/SCREENINGS/COMPLETED%20SCREENINGS/ARCHIVE/2006_SCREENINGS/06DN029-CAM-1_Jenny_Lind_Island-DCC/1-SCREENING/

PREVIOUSLY-SCREENED PROJECT PROPOSAL

As previously screened by the NIRB under File No. 06DN029, the "CAM-1 Jenny Lind Island DEW Line Clean-up" project was located within the Kitikmeot region, approximately 130 kilometres (km) southeast from Cambridge Bay. The Proponent indicated that it intended to remediate and/or clean-up previous works that occurred as a result of the operation of the former DEW Line site.

The activities/components associated with this proposal included:

- Demolition of existing facilities no longer required;
- Excavation and properly disposal of contaminated soils in on-site engineered landfills and/or off-site facilities if characterized as hazardous;
- Collection and disposal of scattered surface debris and partially buried debris on-site;
- Construction of a new landfill to contain non-hazardous contaminated soil and demolition waste generated during clean-up;
- Remediation of existing landfills as required; and
- Restoration disturbed areas to a stable condition and shaped areas to match the existing terrain.

CURRENT APPLICATION:

Defence Construction Canada has applied with INAC for a further one year extension of INAC Land Use Permit #N2006X0006, to facilitate continued remediation efforts as part of the "CAM-1 Jenny Lind Island DEW Line Clean-up" project.

Please note that Section 12.4.3 of the NLCA states that:

> *"Any application for a component or activity of a project proposal that has been permitted to proceed in accordance with these provisions shall be exempt from the requirement for screening by NIRB unless:*
>
> *(a) such component or activity was not part of the original project proposal; or*
>
> *(b) its inclusion would significantly modify the project."*

After completing a review of the information provided in support of the current application, the NIRB is of the understanding that the proposed extension does not change the general scope of the original project activities, and the exceptions noted in NLCA 12.4.3(a) and (b) do not apply. Therefore, this application is exempt from screening as per Section 12.4.3 of the NLCA and the activities therein remain subject to the terms and conditions recommended in the original July 31, 2006 Screening Decision Report (enclosed).

If you have any questions or concerns, please contact Kelli Gillard, Technical Advisor, at (867) 983-4619 or kgillard@nirb.ca .

Best regards,

Ryan Barry
Director, Technical Services

For:

Stephanie Autut
Executive Director

cc: Eva Schulz, AECOM
Phyllis Beaulieu, NWB

Enclosed: NIRB Screening Decision Report, File No.: 06DN029 (July 31, 2006)

SCREENING DECISION REPORT
Philip Warren, Defence Construction Canada, CAM-1, Site Clean up, Jenny Lind Island, Kitikmeot

NIRB File No.: 06DN029
INAC File No.:N2006X0009

July 31st, 2006

Honorable Jim Prentice
Minister of Indian & Northern Affairs
Ottawa, ON

Via email: Prentice.J@parl.gc.ca

Dear Minister:

Authority:

Section 12.4.4 of the Nunavut Land Claim Agreement states:

Upon receipt of a project proposal, NIRB shall screen the proposal and indicate to the Minister in writing that:

a) the proposal may be processed without a review under Part 5 or 6; NIRB may recommend specific terms and conditions to be attached to any approval, reflecting the primary objectives set out in Section 12.2.5;
b) the proposal requires review under Part 5 or 6; NIRB shall identify particular issues or concerns which should be considered in such a review;
c) the proposal is insufficiently developed to permit proper screening, and should be returned to the proponent for clarification; or
d) the potential adverse impacts of the proposal are so unacceptable that it should be modified or abandoned.

Primary Objectives:

The primary objectives of the Nunavut Land Claims Agreement are set out in section 12.2.5 of the Land Claims Agreement. This section reads:

In carrying out its functions, the primary objectives of NIRB shall be at all times to protect and promote the existing and future well-being of the residents and communities of the Nunavut Settlement Area, and to protect the ecosystemic integrity of the Nunavut Settlement Area. NIRB shall take into account the well-being of the residents of Canada outside the Nunavut Settlement Area.

The decision of the Board in this case is 12.4.4 (a) **the proposal may be processed without a review under Part 5 or 6; NIRB may recommend specific terms and conditions to be attached to any approval, reflecting the primary objectives set out in Section 12.2.5;**

Reason for Decision

NIRB's decision is based on specific considerations that reflect the primary objectives of the Land Claims Agreement. Our considerations in making this decision included:

- the potential impact of further contamination of the ecosystem from PCB's, heavy metals, petroleum products or other materials entering the environment and subsequently into the food chain from failure of the designed storage and containment structures;
- the capability of plans for the clean up, storage and removal of contaminated soils, spills and to prevent the further migration of PCB's and petroleum products;
- the capability of plans to control runoff and drainage control within and around the facility;
- the potential to contaminate marine environment through barge loading and off-loading and marine shipping;
- the potential to contaminate land and surrounding waterbodies from on land transport of contaminated waste;
- the potential to contaminate clean areas from wind blown debris or contaminated machinery;
- the potential to impact fish or fish habitat;
- the impact and disturbance to nesting migratory birds and their habitat along coastal areas due to activities;
- the potential to impact on traditional hunting and fishing activities;
- the potential to impact permafrost;
- the potential impact from disturbance to vegetation;
- the potential impacts to the landscape;
- potential impact of quarrying activities to the ecosystem;
- the potential impact to the ecosystem from accidental spillage of petroleum products;
- the storage and disposal of fuel, garbage, sewage, and grey water, and the impact of these on the ecosystem.

Terms and Conditions:

- That the terms and conditions attached to this screening decision report will apply.

PART A: General

1. The Proponent shall provide NIRB with all permits and authorizations required to undertake the project prior to the commencement of on site activities.
2. The Proponent shall file a comprehensive annual report with the Board no later than March 31 of the year following the calendar year reported, for the duration of the Project, which shall contain the following information:

a. A summary of activities undertaken for the year, including but not limited to the amount contaminated soil removed from the site;
b. A work plan for the following year;
c. An update on the extent of contamination on-site and supporting documentation;
d. Wildlife encounters and actions/mitigation taken;
e. A summary of local hires and initiatives;
f. A summary of community consultations undertaken and the results (if any);
g. A summary of site-visits by inspectors with results and follow-up actions;
h. A summary of site-visits with community members (if conducted);
i. Site photos and updated site maps;
j. The number of barges utilized;
k. Issues related to monitoring including updates to the Plan;
l. Revisions to the Abandonment and Restoration Plan; and
m. A summary of how it has complied with all project Terms and Conditions and how the terms and conditions are achieving their purpose.

3. NIRB shall be notified prior to any changes in operating conditions or plans associated with this land use activity.
4. Any amendment requests deemed by NIRB to be outside the original scope of the project will be considered a new project.

PART B: Physical Environment

5. The Proponent shall control all movement of heavy machinery, vehicles and equipment within the hazardous material management area to prevent the dispersion of potentially hazardous dust and materials into the environment.
6. The Proponent shall not move any equipment or vehicles unless the ground surface is in a state capable of fully supporting the equipment or vehicles without rutting. The Proponent shall suspend operation if rutting occurs.
7. The Proponent shall avoid causing soil damage that disturbs natural drainage patterns or exposes permafrost. These areas shall be repaired immediately.
8. The Proponent shall leave a strip of undisturbed vegetation at least thirty (30) metres width between waterbodies and roads and quarries.
9. The Proponent shall remove any obstruction to natural drainage.

PART C: Water

10. The Proponent shall only use the specified volume of water from sources approved by the Nunavut Water Board.
11. The Proponent shall collect all wash water and dispose of it as directed by the Nunavut Water Board.
12. The Proponent shall ensure that all water intake hoses are equipped with a screen with an appropriate mesh size to ensure that there is no entrapment of fish.

PART D: Biological Environment

13. The Proponent shall ensure that there is no damage to wildlife habitat in conducting this land use operation.
14. The Proponent shall ensure that there is minimal disturbance to any nesting birds and wildlife in the area. Harassment of wildlife is prohibited. This includes persistently worrying or chasing animals, or disturbing large groups of animals.
15. Pursuant to the Migratory Bird Convention Act Regulations the Proponent shall not disturb or destroy the nests or eggs of migratory birds. The period from June 1 to August 15 is the general migratory bird breeding season. If nests containing eggs or young are encountered, the Proponent shall avoid these areas until nesting is complete and the young have left the nest.
16. The Proponent shall ensure that aircraft pilots adhere to flight altitudes of greater than 610 m above ground level, unless there is a specific need for low-level-flying which does not to disturb wildlife.
17. The Proponent shall ensure that aircraft maintain a vertical distance of 1000m and a horizontal distance of 1500m from groups/flocks of birds.
18. The Proponent shall not feed wildlife.
19. The Proponent shall follow procedures outlined in the "Safety in Bear Country Manual", and should contact the regional wildlife officer for information and advice on measures which should be taken to minimize the possibility of conflicts/interactions with bears.
20. The Proponent shall not locate any operation so as to block or cause diversion to the migration of caribou.
21. From May 15 to July 15, the Proponent shall cease activities that interfere with caribou migration or calving, such as the movement of equipment and ATV or snowmobile use until the caribou and their calves have vacated the area.
22. The Proponent shall ensure that during the presence of caribou and muskox within sight and sound of a camp that all personnel will remain quietly in camp.
23. The Proponent shall ensure that there is no hunting or fishing by employees or any contractors hired (unless Nunavut authorizations are obtained).
24. The Proponent shall ensure compliance with Section 36 of the Fisheries Act which requires that no person shall deposit or permit the deposit of a deleterious substance of any type in water frequented by fish or in any place under any conditions where the deleterious substance may enter such a water body.
25. The Proponent shall ensure that land use activities avoid environmentally sensitive areas (denning, nesting areas) by a minimum of 250metres.

PART E: Stream Crossings

26. The Proponent shall ensure that culverts are removed upon abandonment.

PART F: Transportation and storage of contaminated waste

27. For the loading of contaminated soil into shipping containers, the Proponent must ensure that:

a. Workers in the storage area wear protective clothing and follow safety protocols for working with contaminated soil;
b. All spills are immediately cleaned up and reloaded into containers; and
c. WHMIS standards are fully adhered to.

28. The Proponent shall install an impermeable membrane on the ground/floor of the contaminated soil storage site/facility before storing contaminated soil on site.
29. The Proponent shall rest containers on a wooden platform that will be used solely for this purpose each season. Containers will not rest directly on the beach.
30. The Proponent shall ensure that the loading of containers onto barges and ships is only conducted in good weather. Specific factors to consider are wind, ice concentrations, fog, waves, and icebergs.
31. When transferring hazardous or contaminated cargo, the Proponent shall ensure that conditions are such that the barges can be pulled up immediately adjacent to the second vessel, leaving no space large enough for a container to fall through between the two vessels.
32. The Proponent shall ensure that contaminated waste containers are strong enough to easily withstand dropping events without any breakage of the seal.
33. The Proponent shall secure containers on the barge.
34. The Proponent shall use waterproof containers that withstand corrosion in seawater for a minimum of 15 years.
35. The Proponent shall use containers that comply with the *International Maritime Organization Dangerous Goods Code* and the *Transportation of Dangerous Goods Act*.
36. The Proponent shall physically connect containers by chains or safety lines to the barge or vessel at all times during transfer to other vessels.
37. If the containers are reused in subsequent years, the Proponent shall ensure that the containers are decontaminated, and washing effectiveness measured and compared to a minimum standard (i.e. <1.0 mg/m^2 PCBs by swab test).
38. The Proponent shall, for all handling operations beginning at Jenny Island and ending at the licensed disposal facility, follow not only the requirements of the *Transportation of Dangerous Goods* legislation in Canada, but also the following legislative requirements:

    a. The *Arctic Waters Pollution Prevention Act*;
    b. The Guidelines for the Operation of Tankers and Barges in Canadian Arctic Waters;
    c. The Arctic Ice Regime Shipping System Standards;
    d. The *International Maritime Organization Dangerous Goods Code*; and
    e. All other environmental and regulatory laws in Canada, including but not limited to: the *Fisheries Act; Canada Shipping Act; Safe Containers Convention Act; Nunavut Public Health Act; Nunavut Safety Act;* Nunavut Spill Contingency Planning and Reporting Regulation; and the *Canada Labour Act.*

39. The Proponent shall ensure that the following requirements are met for transportation at sea:

    a. The designated carrier will have seaworthy certifications and Ice Class certification;

b. The designated carrier will follow all applicable environmental regulations;
c. The containers will be secured to prevent movement during sea transport;
d. The vessel will be on a direct route and will not approach any communities, thereby reducing the possibility of a vessel wreck occurring in proximity to community food chains;
e. The designated carrier obtains shipping insurance sufficient to enable an environmentally proper salvage in the event of a shipwreck;
f. The shipping facilities will have a retrieval process in place for retrieving containers if they should sink;
g. All containers will be double sealed; and
h. The pick-up will be scheduled during the ice-free period.

40. The Proponent shall ensure that the following is adhered to for the transportation of containers on land:
    a. The designated carrier will follow approved Transportation of Dangerous Goods Regulations;
    b. Containers will be secured to prevent movement during land transport;
    c. The designated carrier will have a spill contingency plan in place that will immediately and effectively remove all spilled PCB-contaminated soil in the event of a spill;
    d. The carrier will have insurance to cover public liability and property damage, and pollution liability;
    e. Trained personnel will perform the handling, loading and driving operations; and
    f. The carrier will have a waste-tracking system in place.

41. The Proponent shall ensure that all contractors, including those handling the soils on-site, the shipping company, and the company responsible for transporting the soils in the final deposition site, are fully licensed and have all the permits necessary to operate such facilities.

PART G: Storage and Management of Hazardous Waste and other Hazardous Materials

42. The Proponent shall ensure that all waste and hazardous material management areas are located a minimum distance of one hundred (100) metres from the nearest water body.
43. The Proponent shall have an Emergency Response and Spill Contingency Plan approved by the Nunavut Water Board prior to the commencement of on-site activities.
44. The Proponent shall have emergency response equipment appropriate for the hazardous waste stored on site.
45. The Proponent shall ensure that any chemicals or wastes associated with the project do not spread to the surrounding lands or enter into any water body.
46. The Proponent shall not mix or dilute any hazardous materials with any substance or divide into smaller quantities to avoid meeting the definition of hazardous waste.
47. The Proponent shall store hazardous material in their original containers, where possible, or in containers manufactured for the purpose of storing hazardous waste. The containers must be sealable and not damaged or leaking.
48. The Proponent shall place containers such that each container can be inspected for signs of leaks and deterioration.

49. The Proponent shall maintain a record of the type and amount of waste in storage.
50. The Proponent shall label all containers according to the requirements of the Work Site Hazardous Materials Information System (WHMIS) of the Safety Act or the relevant Transportation Authority.
51. The Proponent shall ensure that residual waste, petroleum or other chemicals, from barrels are not released into the environment.
52. The Proponent shall assess the contents of barrels which still contain product and shall not bury those found to contain hazardous waste.
53. The Proponent shall segregate wastes by chemical compatibility to ensure safety of the public and workers.
54. The Proponent shall remove any leaking and deteriorated containers and transfer their contents to an impermeable container.
55. The Proponent shall ensure that all ethylene glycol (antifreeze) is managed in accordance with the *Environmental Protection Act (EPA)* due to its potential to attract wildlife.

PART H: Fuel

56. The Proponent shall ensure that the transportation of fuel shall be done in compliance with the *Transportation of Dangerous Goods Act and Regulation*s requirements.
57. The Proponent shall ensure that fuel storage containers are not located within thirty-one (31) metres of the ordinary high water mark of any body of water.
58. The Proponent shall use self-supporting insta-berms for the storage of barreled fuel on location.
59. The Proponent shall ensure that all valves on fuel tanks have receptacles placed beneath them to catch any leaked fuel.
60. The Proponent shall inspect all fuel containers for leaks daily and shall report and repair all leaks immediately.
61. Fuel storage containers in excess of 4,000 litres capacity shall either be double-walled, self bermed construction, or diked with adequate storage capacity. An impermeable liner shall be used to ensure that no fuel escapes. The Proponent is encouraged to consult Environment Canada on the implementation of the 2003 CCME Guidance Document PN 1326 entitled: *Environmental Code of Practice for Above Ground and Underground Storage Tank Systems containing Petroleum Product and Allied Petroleum Products.*
62. The Proponent shall immediately report **all** spills of petroleum and hazardous chemicals to the Twenty-four (24) hour spill report line (867) 920-8130. Spills shall also be reported to Environment Canada at (867) 920-5131.
63. The Proponent shall ensure that vehicle and equipment maintenance and servicing shall be conducted only in designated areas and shall implement special procedures to manage fluids, waste and contain potential spills.

PART I: Waste Disposal

64. The Proponent shall construct, operate, maintain, reclaim and monitor the landfarm and per the direction of the Nunavut Water Board.

65. The Proponent shall use a CCMA compliant incinerator for non-hazardous combustible waste. Food wastes shall be incinerated daily to eliminate potential for wildlife problems created by the attraction of wildlife to garbage.
66. The Proponent shall ensure that non-combustible non-hazardous wastes are buried in landfills.
67. The Proponent shall construct, operate, maintain, reclaim and monitor the landfills and per the direction of the Nunavut Water Board.
68. The Proponent shall construct, operate, maintain, reclaim and monitor all containment areas to ensure that there is no seepage of leachate. Any seepage that occurs shall be collected and treated as hazardous material.
69. The Proponent shall ensure that any areas designated for waste disposal shall not be located within thirty (30) metres of the ordinary high water mark of any body of water, unless otherwise authorized.
70. The Proponent shall ensure that all waste management sites are mapped and inventoried. Updated maps shall be provided to NIRB.
71. The Proponent shall recover and recycle material wherever practical.
72. The Proponent shall treat and dispose of all lead and PCB contaminated paints and painted materials as hazardous materials.
73. The Proponent shall deposit all sewage and greywater discharged in a sump and ensure that no drainage enters any waterbody.

PART J: Quarries

74. The Proponent shall locate quarries at least thirty (30) meters above the high water mark of any waterbody.
75. The Proponent shall slope the sides of the excavations and embankments except in solid rock to 2:1 (two horizontal, one vertical).
76. The Proponent shall perform tests to ensure that construction material is not acid generating and/or metal leaching.

PART K: Camp

77. The Proponent shall not erect camps or store material on the surface ice of lakes or streams.
78. The Proponent shall locate all infrastructure facilities on gravel, or other durable land.
79. The Proponent shall keep the land use area clean and tidy at all times.

PART L: Archaeological & Palaeontological Sites

80. ***The Proponent shall conduct an archaeological assessment of the site paying special attention to the location of quarries as the Government of Nunavut Department of Culture, Language, Elders and Youth (GN-CLEY) has noted known sites, including a grave site, in the vicinity. The Proponent shall contact GN-CLEY regarding the status of the sites once the investigation is complete and before quarrying commences. These sites are to be avoided.***
81. ***The Proponent shall follow all protocols for the protection and restoration of archaeological and palaeontological resources as outlined by the Government of Nunavut Department of Culture, Language, Elders and Youth.***

PART M: Monitoring

82. The Proponent shall monitor all waste containment facilities during operation and closure to ensure that there is no seepage of leachate. Parameters shall include but not be limited to PCBs.
83. The Proponent shall monitor the landfarm during operation and closure to ensure its effectiveness.
84. The Proponent shall monitor quarry sites for potential acid generation and metal leaching.
85. The Proponent shall monitor water quality during operation and closure to ensure that water quality meets levels approved by the Nunavut Water Board.
86. The Proponent shall monitor soil quality for metals and other contaminants during operation to determine and verify the extent of clean-up required.
87. The Proponent shall monitor soil quality during operation to ensure clean-up objectives are met and maintained.
88. Where permafrost is required for containment, the Proponent shall monitor permafrost aggradation and propose contingency plans if this fails to occur or becomes ineffective due to global warming.

PART N: Socio-economics

89. The Proponent shall ensure that workers wear protective clothing and follow established protocols for working with contaminated soil and conducting all on site works.
90. The Proponent shall record all injuries and incidents and have reporting procedures included in an approved Emergency Response Plan.
91. The Proponent shall ensure that all personnel are trained and that the requirements of the Workplace Hazardous Materials Information System (WHMIS) are followed.
92. NIRB would like to encourage the proponent to hire local people where possible.
93. The Proponent shall keep local communities and residents informed regarding its activities in the region.

PART O: Closure

94. The Proponent shall advise NIRB and the Land Use Inspector in writing at least 15 days prior to the completion of activities.

95. The Proponent shall remove all equipment, scrap metal and discarded machinery upon abandonment.
96. The Proponent shall commence and foster revegetation where possible. Methods should include scarification and transplanting native vegetation from other areas.
97. The Proponent shall regrade the landfills to match the contours of the land.
98. The Proponent shall backfill and recontour all sumps to match the natural environment prior to the expiry date of the permit.

Validity of Land Claims Agreement

Section 2.12.2
Where there is any inconsistency or conflict between any federal, territorial and local government laws, and the Agreement, the Agreement shall prevail to the extent of the inconsistency or conflict.

Dated July 31, 2006 at Cambridge Bay, NU

_____
Elizabeth Copland, A/Chairperson

APPENDIX A: LANDFARMING INFORMATION

Many of the recommendations relative to design, siting, operation, monitoring, sampling and analytical methods, decommissioning and closure as well as record keeping and reporting in this letter reference the following guidance documents:

- ***Federal Guidelines for Landfarming Petroleum Hydrocarbon Contaminated Soils.*** **SAIC Canada (Science Applications International Corporation*),* December 2005**

- ***Bioremediation of Petroleum Hydrocarbons in Soil and Groundwater Under Cold Climate Conditions: A Review, Implications for Applications in Canada*** **, Dale Van Stempvoort and Pamela Grande, National Water Research Institute in Burlington, December 2005**

- ***Cold Climate Bioremediation: A Review of Field Case Histories.*** **Pamela Rogers, Research Assistant, Department of Civil & Environmental Engineering, University of Alberta, July 2005**

Environment Canada urges the proponent to follow environmental site assessment steps as established by the following standards:

- **Canadian Council of Ministers of the Environment (CCME) *Canada-Wide Standard for Petroleum Hydrocarbons in Soil* (CWS-PHC) (CCME, 2001);**
- **Canadian Standards Association (CSA) Environmental Site Assessment Standards Z768-01 (2001) and Z769-00 (2000), for Phase 1 and Phase 2; and,**
- ***Subsurface Assessment Handbook for Contaminated Sites*** **(CCME, 1994).**

As these documents are updated periodically, please consult the CCME and CSA for the most recent versions.

Please find below technical comments and advice that Environment Canada suggests for landfarming facilities in Canada's north.

Assuming that the soils to be admitted to the bio-treatment facility are known to contain primarily petroleum hydrocarbon contamination, following the procedure in the CWS-PHC is recommended. The CWS-PHC allow for a risk-assessment approach. This could take the form of the CWS-PHC Tier 2 or 3 or, other tools to ensure equal or better protection, for example, the Risk-Based Corrective Action (RBCA) process. For information on the CWS-PHC and related documentation, consult with the on-line information available from CCME at **http://www.ccme.ca/ourwork/standards.html.**

The characterization of the contaminants and contaminant levels in the soil determined during the environmental site assessment may be used to determine landfarming applicability. An evaluation of the type and degree of contamination helps to exclude soil material that might be toxic to certain species of microorganisms and also helps to determine if landfarming would be the appropriate remediation technology to be employed for the contaminants of concern. Although landfarming is recommended for petroleum hydrocarbon contaminated soils only, it is understood that other contaminants may also be present. **Table** 1 indicates, through shaded selections, the type of analyses recommended for contaminated soil characterization.

Table 1 Recommended Analyses Based on Suspected Soil Contamination[1]

Contaminant Source	Parameters Analyzed								
	CWS – PHC fractions	BTEX	TPH	Lead	Total Heavy Metals[2]	Chromium/ Cadmium	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	■	■	■	■	■	■	■	■	■

Please note that if any of the levels detected exceed these maximums, the contaminated soil should be considered hazardous waste and handled accordingly. Landfarming is not recommended for such contaminated soils.

- Total petroleum hydrocarbon (TPH) or total extractable hydrocarbons (TEH) < 3% (Yukon, 2004a and 2004b);
- total heavy metal concentrations < 2500 mg/L (USEPA, 1994);
- electrical conductivity (EC) < 4 dS/m; and
- sodium adsorption ratio (SAR) < 6 (Alberta EUB, 1996).

Site Characterization

Prior to landfarm design, a characterization of the site where the landfarm is to be placed should be conducted such that the following parameters are identified and respected:

- groundwater flow, direction and baseline chemical analysis;
- native soil hydraulic conductivity determination;
- Microbial identification determination and population.
- A landfarm should be sited greater than 500 m from a permanent surface water body. This restriction applies to both potable and non-potable surface waters.
- A landfarm should be sited greater than 500 m from a potable groundwater well.

[1] Modified from: Environment Canada. 1993. "Appendix 3: Guidelines on the Ex-Situ Bioremediation of Petroleum Hydrocarbon Contaminated Soils on Federal Crown Land" in the *Study on the Use of Landfarming and Surface Impoundments in the Management of Hazardous and Non-Hazardous Waste*. Conservation and Protection. June 23, 1993.

[2] Heavy metal analyses required to determine if constituents are not present at levels toxic to micro-organisms (>2500 mg/L) (USEPA. 1994). (Soils with heavy metal concentrations below this level but above remediation criteria, will have to undergo further treatment following landfarming to reduce heavy metal concentrations.)

- The geology of the site needs to be considered (e.g. thickness of underlying soil, the presence of bedrock, degree of fracturing) to determine the need for a liner/barrier. It is recommended that at landfarm sites with less than 5 m of low hydraulic conductivity ($<10^{-6}$ cm/s) native underlying soil, a liner/barrier be used.
- The landfarm should be sited at a location with a natural slope of less than 5%; otherwise the site will require grading.
- The landfarm should be sited where the groundwater table is greater than 3 m from the surface. When there is a need to excavate during landfarm construction, cultivation no closer than 3 m above the groundwater table must be ensured. Using groundwater flow direction and rate data, the landfarm should be sited such that groundwater contamination is avoided (otherwise, a barrier to groundwater flow is necessary).
- A landfarm should not be sited on land within a 50 year floodplain.
- Please note that there should be adequate volumes of topsoil at the site that may be required to effectively manage and operate a soil treatment facility.

Prior to landfarm design, an evaluation of the soil characteristics provided in **Table 2** will ensure that the contaminated soil is well-suited to landfarming.

Table 2: Optimal Soil Characteristics for Landfarming

Landfarming Parameter	Optimal Characteristics
Microbial population density:	For landfarming to be effective, the minimum heterotrophic plate count should be 10^3 CFU/g (colony forming units/gram). Below this minimum, landfarming may still be effective provided the existing bacteria are stimulated using nutrients or the soil is amended to increase the bacteria population (USEPA. 1994) In the latter case, adding non-indigenous bacteria to a site has had limited success in enhancing degradation of petroleum hydrocarbons. There are also regulatory restrictions associated with the addition of bacteria to sites.
Soil pH:	To support bacterial growth, soil pH should be between 6 and 8. Outside this range, landfarming may still be effective through soil amendments.
Moisture content:	Bacterial growth requires moisture, optimally between 40-85% of field capacity[3] (USEPA, 1994) Periodically, moisture may be added to landfarmed soil to maintain this moisture level. Excess moisture due to periods of high precipitation, during spring thaw or due to poor site drainage may need to be addressed. Site drainage may be improved through landfarm design, but uncontrollable influx of moisture may simply mean that longer operating times will be required for the landfarm.
Nutrient concentration:	For proper growth, micro-organisms require inorganic nutrients that may be naturally-occurring in the soil. Nitrogen and phosphorous may be added in the form of commercial fertilizer. For effective biodegradation, carbon:nitrogen:phosphorus ratios need to be between 100:10:1 and 100:1:0.5 (USEPA. 1994). This ratio may be calculated from the soil bulk density and the total hydrocarbon

[3] The most reliable measure of moisture content is expressed as a percent of field capacity (also referred to as “soil capacity”). Field capacity itself is the maximum %-weight of moisture the unconfined, gravity-drained soil can retain. An example would be a sandy soil with a field capacity of 25%, meaning a maximum of 250 grams of water retained in 1,000 grams (dry wt.) of unconfined soil. Typically the target moisture content is expressed as a percent of the field capacity; for example, 50% of field capacity for the above sandy soil would be 125 grams water per 1,000 grams dry soil.

Landfarming Parameter	Optimal Characteristics
	concentration.
Soil Type:	Clayey soils hamper biodegradation because of difficulties in aeration and the distribution of nutrients and moisture. Soil amendments such as gypsum and bulking agents such as sawdust, may be required. Clumpy soils may also require pre-treatment in the form of shredding, in order for landfarming to be effective. Very coarse soils are not suitable to landfarming as they do not retain moisture and nutrients (University of Saskatchewan, 2002). Volatile compounds will also volatilize more readily from course-grain soils than from fine grain soils. Typically, large diameter soil particles have a low contamination concentration due to their low surface area. As such, these particles can be screened out prior to placing soils in the landfarm.

Once a landfarm is operating, generic or site-specific remediation limits as per the CCME Environmental Quality Guidelines (EQGs) or CWS-PHC should be used to monitor the extent to which the soil has been remediated to acceptable levels. The parameters analyzed during the environmental site assessment should be evaluated using these guidelines to determine chemicals of concern (CoCs) and those identified should be tracked during the remediation process.

Leachate Control

Groundwater and leachate criteria become applicable once the landfarm location is sited. One approach is to follow the **Environment Canada Contaminated Sites Management Working Group (CSMWG) policy: *A Federal Approach to Contaminated Sites* (CSMWG, 1999)**. This policy recommends the use of appropriate provincial/territorial guidelines or criteria when there is an absence of similar guidelines/criteria available.

Groundwater sampling and analysis should adhere to the CCME sampling procedures (CCME. 1993). Leachate monitoring performed during the landfarm operations is primarily for characterization purposes only, as leachate is often recirculated over the landfarm as a means of irrigation (or stored in a tank in the event that irrigation may be required at some point in the landfarming season). If this tank is discharged into the environment, the CCME EQGs apply as a standard.

A means to collect and treat run-off from the landfarm may be necessary. A leachate control system capable of handling a 24 hour duration, 1:10 year frequency storm is required in such a case. Leachate may be recirculated over the landfarm soil surface as a means of irrigation to maintain optimal biodegradation rates, or discharged if surface water analyses indicate contaminant levels are within CCME EQGs. **Environment Canada strongly recommends a containment system where all leachate from the soil treatment facility is fully controlled.**

Barriers/Liners

When native soils at the landfarm site have high conductivity, a barrier or liner having a maximum seepage rate equivalent to clay liner under 0.3 m head of water or a 10^{-7} cm/s hydraulic conductivity at a thickness of 0.6 m, should be used beneath the soil to be treated.

Placement of Soil in Landfarm

A contaminated soil depth less than 0.5 m within cell(s) or in windrows is recommended. However, the type of equipment available for tilling, as well as the land availability, will dictate soil depth. Typically, landfarming is practiced with soil depths between 0.30 and 0.45 m.

Contaminated soil should not be applied on a continuous layer of snow or ice or when the existing soil base is saturated with moisture.

Landfarm Design/Operational Requirements

Land Availability

Please note that the expected landfarm soil depth of between 0.30 and 0.45 m and a maximum soil thickness of 0.5 m is recommended. Therefore, a single plot or multiple plots may be required. Additional area surrounding the plot(s) for berms and leachate control should be considered.

Microbial Population Density Monitoring

If microbial amendments are being considered, the user should be aware that products containing microorganisms, biochemicals (such as enzymes) or biopolymers, are "biotechnology products" and may be subject to the New Substances Notification (NSN) Regulations, pursuant to the Canadian Environmental Protection Act, 1999 (CEPA, 1999). (Contact the New Substances Division of Environment Canada and http://www.ec.gc.ca/substances/nsb/eng/index_e.htm for more information.)

Although a few petroleum hydrocarbon-degradable micro-organisms have been found to be active at temperatures below 0^{o}C (Whyte and Greer, 1999; Whyte, *et al*. 2001 and 2003; Rike, *et al*. (2003)), most biodegradation occurs above freezing. Research has shown appreciable biodegradation may occur after one summer season, additional biodegradation over a second season is usually required. Therefore, it is recommended that the landfarm should operate for a minimum between 6 months to 2 years. This operation period assumes optimal conditions are maintained (i.e. regular tilling; moisture control; nutrient amendment, if required). Please note that soil sampling and analyses are required to confirm remediation progress and completion.

pH Maintenance

The optimal pH for landfarming operations is between 6 and 8. The soil pH may be increased with the addition of lime and decreased with the addition of elemental sulphur.

Moisture Content Monitoring

The amount of moisture in the landfarm soil impacts biodegradation and, therefore, should be monitored and adjusted if possible and necessary. If moisture levels are too high, the movement of air through the soil is restricted thereby reducing oxygen availability. Effective moisture levels are 40 - 85% of water-holding capacity in the soil, but 20 – 85% will support microbes. Water spraying is often needed during summer months, particularly prior to tilling, in order to reduce wind erosion. Soil may be amended with organic matter to increase moisture retention. A rule of thumb is the soil should be moist, not dry and dusty or dripping wet.

Nutrient Amendments Requirements

Biodegradation requires that micro-organisms are meeting nutritional requirements. The optimal range of carbon:nitrogen:phosporus (C:N:P) is 100:10:1 to 100:1:0.5. If the available nutrients are not sufficient, soil amendment in the form of commercial fertilizers, is required. Note that the addition of nitrogen may inadvertently lower the pH. Nutrients can be supplied to the soil in either liquid or solid form. Solid nutrients can be added directly to the soil when the soil is mixed prior to placement in the landfarm or during tilling events once the landfarm is operational. Liquid nutrient can be added to watering or irrigation systems. The frequency of nutrient addition can be reduced by using slow release nutrients.

Tilling

Tilling, with a rototiller or turning over the soil with a backhoe or other similar equipment, is a means of aerating the soil. This provides oxygen for the micro-organisms as well as distributes nutrients and moisture in the soil, thereby aiding biodegradation. Tilling is recommended once per

month during the operating season of the landfarm, provided the soil is uniformly moist but not saturated. Tilling when soil is excessively wet is unproductive, whereas tilling while the soil is excessively dry may erode the soil and cause wind-blown dust problems. Tilling must be carefully carried-out by an experienced operator, since it is possible to disturb or damage the liner placed under the contaminated soil.

System Maintenance

Maintenance of the landfarm is essential in ensuring its effectiveness. At some appropriate point during landfarm construction, inspection of the synthetic liner(s) should be conducted to ensure that the seams and joints are tight, and that there is the absence of punctures, blisters or tears. Imperfections (e.g. lenses, cracks, channels) can occur in soil and clay liners. Weekly, during landfarm operations, and immediately after a major storm or catastrophic event, inspections should be conducted on the:

(i) drainage control systems for evidence of deterioration, malfunction, leaks or improper operation, and
(ii) leachate collection systems to ensure proper functioning and to determine if leachate is being generated or is accumulating.

If any defects or malfunctioning works are detected, immediate repair is required to maintain the integrity of all works.

The drainage control system should be inspected as necessary/required during periods of precipitation or spring thaw to ensure control measures are taken if the system is approaching its capacity.

Closure Procedures

During the system design phase, it is important to determine the requirements for closing the sites once remediation is complete. By laying out the closure procedures at this time, the responsible party or site sponsor can reviewed and endorsed them prior to proceeding with the system construction. This closure plan must be consistent with the current land use and will need to recognize how future land use changes or ownership will be taken into consideration after landfarm closure.

Monitoring and Record Keeping Requirements

For the purpose of monitoring the performance of the land treatment process, soil samples should be taken no less frequently than once every four months, during the period of active land treatment to monitor contamination levels until analytical results are below acceptable levels as set forth in the CCME's Canadian Soil Quality Guidelines (CSQG).

For the purpose of monitoring for potential impact of the facility on groundwater quality in the active layer, groundwater samples should be taken from the down gradient monitoring wells no less frequently than twice per year and analyzed for indicators of petroleum hydrocarbon contamination. Should analytical results indicate groundwater contamination associated with the land treatment facility, corrective action should be taken as soon as possible.

A sampling plan should include sampling methods (grid, composite) and frequency (number of samples per surface area). Since the landfarmed material is relatively thinly applied and homogenized through tilling, only one depth of sample collection is required. The samples should then be analyzed for the contaminants of interest and compared with the remediation guidelines presented in the CCME EQG and the CWS-PHC documentation. These protocols are recommended for the landfarm soils to determine at which point the soils have been remediated and the landfarm can be closed. Monitoring of contaminant levels in the leachate is only required prior to discharge to the environment; during recirculation, testing may be done for purposes of tracking remediation progress. It is also recommended that groundwater on-site be monitored and compared to the appropriate CCME EQGs. **Table 3** summarizes the criteria that should be used for the various media involved in landfarming operations.

The landfarm soils may be considered remediated once analyses confirms these soils are within the CCME EQGs or CWS-PHC for the particular land use of the property. The remediated soil may then be used in a manner that is consistent and appropriate with the site use. If other contaminant levels (such as heavy metals, PCBs, etc.) exceed CCME EQGs, the landfarmed materials should be then further remediated using an alternative remediation technique.

Accurate records should be maintained by the owner/operator which contain the following information:

- A detailed description of the size and location of the land treatment facility
- Quantitative and qualitative data on the soil treated at the site
- Monitoring data as set forth above
- The final destination of the treated soil and its intended use.

Table 3: Summary of Landfarming Standards for Federal Contaminated Sites

Media Monitored	Criteria
Landfarm soil and soil remaining at the delineated (excavation) site	Canada Wide Standard for Petroleum Hydrocarbons (CWS-PHC) (CCME, 2003)
	Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (CCME, 2003)
Groundwater	Non-potable - none; as per *A Federal Approach to Contaminated Sites* (CSMWG, 1999) whereby provincial/territorial guidelines are recommended. Potable - Guidelines for Canadian Drinking Water Quality (Health Canada, 1996)
Leachate	For recirculation – none (operations monitoring only) For discharge to environment ▪ Into surface water: CCME Environmental Quality Standard (EQS) for Freshwater Aquatic Life (CCME, 2003) for surface water reception; and ▪ Into groundwater: none, as per *A Federal Approach to Contaminated Sites* (CSMWG, 1999) whereby provincial/territorial guidelines are recommended
Surface Water	CCME Environmental Quality Standard (EQS) for Freshwater Aquatic Life (CCME, 2003) or, for potable water, the Guidelines for Canadian Drinking Water Quality (Health Canada, 1996)
Ambient Air	Canadian National Ambient Air Quality Objectives: Process and Status (CCME, 2003)