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Leslie Payette  
Manager of Environmental Administration  
Nunavut Impact review Board  
Cambridge Bay, NU

via e-mail

**RE: Part 4 screening for Land Farm, Hamlet of Pond Inlet – NIRB 07UN061**

On behalf of Environment Canada, I have reviewed the information submitted with the above-mentioned application. The following specialist advice has been provided pursuant to Environment Canada's mandated responsibilities for the enforcement of the *Canadian Environmental Protection Act*, Section 36(3) of the *Fisheries Act*, the *Migratory Birds Convention Act*, and the *Species at Risk Act*.

The Government of Nunavut-Community Government Services is proposing to construct and operate a landfarm facility in the Hamlet of Pond Inlet. The landfarm is designed with an area of 6400 square meters and is located within a fenced area. The cell is approximately 1.8 m in height and 70 m by 70 m in length and width respectively. The surrounding berm is constructed of re-compacted native fill, and covered with an impermeable membrane.

Environment Canada has reviewed the submitted application for the construction of a landfarm facility in Pond Inlet and is pleased to provide technical advice relative to the design, siting, construction, operation, monitoring and eventual decommissioning of the soil remediation facilities. The design specifications submitted are a carbon copy of those submitted for the Qikiqtarjuaq landfarm facility (name still included in the document) and do not provide a detailed framework for some of the operation and maintenance required of a landfarm in the North. EC recommends that a site-specific Operation & Maintenance Plan be developed for the Pond inlet landfarm. The plan should include but not limited to:

- Location of monitoring wells and frequency of monitoring
- Inspection and maintenance of the landfarm in ensuring effectiveness
- Standards the proponent plans on achieving for soil remediation
- Microbial population density, moisture content
- Sampling protocol for end of treatment including intended final end use of soil
- Methodology for treating, sampling and releasing leachate and or pond water from landfarm.
- Procedure for snow removal/treatment prior to spring melt

Given the importance of this plan to the successful remediation of the contaminated soils in the landfarm, EC recommends that the plan be revised prior to approval.

EC recommends that the following conditions should be applied throughout all stages of the project:

- Section 35 of the *Migratory Birds Regulations* states that no person shall deposit or permit to be deposited, oil, oil wastes or any other substance harmful to migratory birds in any waters or any area frequented by migratory birds. If water collects on the contaminated soil, this may encourage birds to land on the ponded oil-contaminated water within the land farm. Environment Canada recommends that areas that may attract birds (e.g., areas with potential for ponding of contaminated water) be monitored to ensure that birds are not using these areas. If birds are

being attracted to the land farm, the proponent should consider mitigation measures to discourage birds from landing in the contaminated area. One mitigation measure is to string rope with flagging at regular intervals (e.g., every 1-2 m) over areas that are attracting birds.

- The proponent shall not deposit, nor permit the deposit of any fuel, chemicals, wastes, or sediment into any water body. According to the Fisheries Act, Section 36(3), the deposition of deleterious substances of any type in water frequented by fish or any place under any conditions where the deleterious substance, or any other deleterious substance that results from the deposit of the deleterious substance, may enter any such water, is prohibited. Details should be provided on methodology for treating, sampling and releasing leachate and or pond water from LTU.
- The proponent shall not deposit, nor permit the deposit of sediment into any water body. It is recommended that an undisturbed buffer zone of at least 100 meters be maintained between the proposed stockpiles and the normal high water mark of any water body.
- Tilling as a means of aerating the soil 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.

### **Landfarm Facility**

Many of the following recommendations relative to design, siting, operation, monitoring, sampling and analytical methods, decommissioning and closure as well as record keeping and reporting recommendations reference the following guidance documents and can be provided if the proponent wishes.

- ***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.

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<sup>1</sup>**

Contaminant Source	Parameters Analyzed								
	CWS – PHC fractions	BTEX	TPH	Lead	Total Heavy Metals <sup>ii</sup>	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: 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)<sup>1</sup>;
- electrical conductivity (EC) < 4 dS/m;
- and sodium adsorption ratio (SAR) < 6 (Alberta EUB, 1996).

### **Site Characterization**

This is important in order to determine the following parameters:

- 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. The full nature of surface water flow at the site should be known.
- The “Federal Guidelines for Landfarming Petroleum Hydrocarbon Contaminated Soils” (December 2005) recommend a minimum buffer of 500 m between any waterbodies and proposed landfarms. This distance is recommended to protect groundwater sources from subsurface flow.
- 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 a liner/barrier (see Section 8.3.9). 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. It is important to determine if there is fractured bedrock at this site as fractured bedrock could make the investigation of groundwater flow, direction etc very problematic.
- 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

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**

<b>Landfarming Parameter</b>	<b>Optimal Characteristics</b>
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, as noted in Section 0, 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 <sup>2</sup> (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 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 coarse-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.

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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.

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 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 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***

#### ***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](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 °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.

#### ***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.

#### ***Nutrient Amendments Requirements***

Biodegradation requires that micro-organisms are meeting nutritional requirements. The optimal range of carbon: nitrogen: phosphorus (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.

### *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 an 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:

- drainage control systems for evidence of deterioration, malfunction, leaks or improper operation, and
- 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 site once remediation is complete. By laying out the closure procedures at this time, the responsible party or site sponsor can review and endorse them prior to proceeding with the system construction. This closure plan should 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 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 <i>A Federal Approach to Contaminated Sites</i> (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: <ul style="list-style-type: none"> <li>• Into surface water: CCME Environmental Quality Standard (EQS) for Freshwater Aquatic Life (CCME, 2003) for surface water reception; and</li> <li>• Into groundwater: none, as per <i>A Federal Approach to Contaminated Sites</i> (CSMWG, 1999) whereby provincial/territorial guidelines are recommended</li> </ul>
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)

If there are any changes in the proposed project, EC should be notified, as further review may be necessary. Please do not hesitate to contact me with any questions or comments with regards to the foregoing at (867) 975-4631 or by email at [cindy.parker@ec.gc.ca](mailto:cindy.parker@ec.gc.ca).

Yours truly,

**Original signed by**



Cindy Parker  
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Cc: Carey Ogilvie (Manager, Environment Canada EPOD, Yellowknife, NWT)