Environment Canada **Environnement Canada**

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April 26, 2007 Our file:

Manager of Licensing
Nunavut Water Board
PO Box 119
Gjoa Haven, Nunavut
X0B 1J0 *Via Email: licensing@nunavutwaterboard.org*

RE: Type "B" Water License Renewal Application, Hope Bay Windy Project – Hydrocarbon Impacted Soils Storage and Landfarm Facility
Proponent – Miramar Hope Bay Ltd (MHBL)

On behalf of Environment Canada (EC), I have reviewed the information submitted with the above-mentioned Water License (Type B) Renewal Application. The following comments are 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*.

Miramar Hope Bay Limited is applying for a renewal of their existing Type "B" Water License for a five year term. The Windy Land Treatment Area was established as a treatment method for handling the hydrocarbon contaminated soils from the June 16, 2004 spill which saw 19 000 L of diesel spilled (Spill 04-388) from a 50 000 L above ground storage tank (AST). At that time the Water License was not amended to include this facility and in October, 2005, the Nunavut Water Board (NWB) recommended incorporating the facility into its current license. The following comments relate to this landfarm facility at the Windy Camp. Please note that comments on the ***Windy Camp Closure and Reclamation Plan*** are not provided here.

Environment Canada recommends that the following general condition be applied throughout all stages of the project:

1. Meeting the requirements of the *Fisheries Act* is mandatory, irrespective of any other regulatory or permitting system. Section 36(3) of the *Fisheries Act* specifies that unless authorized by federal regulation, no person shall deposit or permit the deposit of deleterious substances of any type in water frequented by fish, or in 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. The legal definition of deleterious substance provided in subsection 34(1) of the *Fisheries Act*, in conjunction with court rulings, provides a very broad interpretation of deleterious and includes any substance with a potentially harmful chemical, physical or biological effect on fish or fish habitat.

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

2. 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.

3. 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[i]

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

Site Characterization

Given the circumstances of landfarm construction (i.e., an immediate reaction to a spill), no site characterization was carried out. 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.
- A landfarm should be sited greater than 500 m from a potable groundwater well.
- 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. ***MHBL states that it is "highly improbable that a flood event could disrupt the landfarm treatment facility." Is this statement based on documented flood data?***
- Environment Canada has some concerns relative to the availability of adequate volumes of topsoil at the site that may be required to effectively manage and operate this 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, 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[2] (USEPA, 1994) Periodically, moisture may be added to

[2] 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
	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 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 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 form 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

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 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:

(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 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). The once a month sampling program as described by MHBL is adequate.

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)

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) 669-4708 or by email at ivy.stone@ec.gc.ca.

Sincerely,

Original signed by

Ivy Stone
Environmental Assessment / Contaminated Sites

cc: Mike Fournier (Northern EA Coordinator, EPOD, Environment Canada, Yellowknife, NT)
Carey Ogilvie (Head, EA-North, EPOD, Environment Canada, Yellowknife, NT)
Cindy Parker (Environmental Assessment Technician, EPOD, Environment Canada, Iqaluit, NU)

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[i] 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.

[ii] 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.)