BRITISH COLUMBIA
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Ministry of Environment

PROTOCOL 15
FOR CONTAMINATED SITES

Soil Treatment Facility Design and Operation for Bioremediation of Hydrocarbon Contaminated Soil

Prepared pursuant to Section 64 of the
Environmental Management Act

Approved: _____ _____

Director of Waste Management — Date

1.0 Definitions

"berm" means an earthen embankment constructed around a soil treatment facility.

"decommission" for the purposes of this protocol, means the removal and appropriate disposal of all works related to the operation of a soil treatment facility including but not limited to liners, berms, covers, drain lines, aeration lines, buildings, and monitoring wells.

"halogenated hydrocarbons" also known as halocarbons, means an aliphatic or aromatic hydrocarbon in which one or more hydrogen atoms are substituted by any of the following halogens: fluorine, chlorine, bromine or iodine.

"hazardous waste" means hazardous waste as defined in the Hazardous Waste Regulation.

"hydrocarbon contaminated soil" means soil contaminated with a petroleum product, including, but not limited to gasoline, diesel, fuel oil, hydraulic oil and lubricating oil.

"liner" means a continuous layer of low permeability material, either synthetic or compacted fine-grained soil, constructed as the base of a soil treatment cell to restrict downward or lateral movement of substances.

"ministry" means the Ministry of Environment.

"soil treatment facility" for the purposes of this protocol, means an engineered structure designed to contain hydrocarbon contaminated soil while reducing concentrations of hydrocarbon constituents through biodegradation. Examples of soil treatment facilities include biocells, biopiles and windrows.

"non-hazardous waste" means soil as defined in the Contaminated Sites Regulation, which is not classified as hazardous waste, but contains one or more substances whose concentrations exceed the numeric standards of the Regulation for the applicable land use at the site where the soil being treated originates.

2.0 Introduction

This protocol is intended to ensure province-wide consistency in the design, operation and regulation of bioremediation soil treatment facilities by describing requirements for the containment and treatment of non-hazardous waste hydrocarbon contaminated soils as part of a remediation strategy. This protocol applies to both commercial and non-commercial facilities. Hazardous waste must not be accepted at a soil treatment

facility unless such a facility is approved to manage hazardous waste pursuant to the Hazardous Waste Regulation under the *Environmental Management Act* (the Act).

This protocol provides minimum standards for the design, operation and maintenance of a bioremediation soil treatment facility. The Director of Waste Management may impose additional requirements under section 54(3)(d) of the Act, which he or she deems necessary to achieve remediation and to protect human health and the environment.

Compliance with this protocol does not authorize the discharge of waste to the environment or the movement or deposit of soil.

3.0 Background

Bioremediation soil treatment facilities are used to reduce concentrations of hydrocarbon constituents in excavated soils through biodegradation. This technology is a controlled process which involves constructing cells, piles or rows of excavated contaminated soils and stimulating aerobic microbial activity within the soils through aeration and/or addition of minerals, nutrients, and moisture.

Soil treatment facilities have been proven effective for treating soils contaminated with petroleum hydrocarbons and to a lesser extent, halogenated hydrocarbons. Demonstration trials may be necessary to determine the effectiveness of bioremediation for contaminants other than those indicated above.

Bioremediation is not an effective treatment method for soils contaminated with metals, salts or other inorganic contaminants. High concentrations of these contaminants may be toxic to the microbial population and consequently inhibit the bioremediation process.

4.0 Regulatory authority

Section 56 of the Act requires a responsible person conducting or otherwise providing for remediation at a contaminated site to give preference to remedial alternatives that provide permanent solutions.

Section 64 (2)(j) of the Contaminated Sites Regulation states that a director may establish protocols endorsing certain remediation approaches as the preferred alternatives for a certain type of site.

The ministry considers bioremediation technology to be a permanent remedial solution and endorses its use for the treatment of hydrocarbon contaminated soil.

5.0 Siting requirements

A soil treatment facility must not be constructed on any land where:

- the slope is greater than 5%;
- the seasonal high water table is less than 1 m below ground surface;
- the boundaries of the facility would be within any area specified as a wildlife management area, wildlife area or sanctuary, ecological reserve or bird sanctuary under the *Wildlife Act, Ecological Reserve Act, Migratory Birds Convention Act (Canada)* or the *Canada Wildlife Act (Canada)*.

6.0 Site access and security

Access to the soil treatment facility must be restricted through fencing or other suitable means to prevent unauthorized access into the treatment area and possible disturbance or compaction. Access to the soil treatment facility must be limited to authorised personnel only.

Appropriate notices must be clearly posted; for example, warning the public of the presence of contaminated soil, the presence of excavations, or the presence of equipment.

7.0 Basic design

Soil treatment facility designs must incorporate the components identified in Table 1, below.

Table 1: Soil treatment facility design requirements

Component	Minimum Requirements	Additional Recommendations
Liner	All soil treatment facilities must have a liner with a permeability of less than or equal to $1x10^{-6}$ cm/sec. The following types of liners are considered acceptable: • compact soil with a minimum thickness of 1 m; or • synthetic material with a minimum thickness of 20 mil polyethylene that is chemically resistant to the waste undergoing treatment and	

Component	Minimum Requirements	Additional Recommendations
	constructed in one piece or with sealed impermeable joints; or • composite liner (combination of compact soil and synthetic material liners) All liners must be covered with a sacrificial indicator layer of sand, gravel, straw, asphalt, plywood or other suitable alternative to ensure that the liner is not penetrated during tilling or soil removal operations	
Berms	Soil treatment facilities must be surrounded by berms that: • collect and control all run-off resulting from a one in ten year, 24-hour duration rainfall event; and • are constructed to ensure complete containment of the entire volume of soil undergoing treatment. There must be no gap between the liner and the berm.	Soil treatment facilities should not be constructed in areas prone to flooding unless they are engineered to withstand such an event.
Cover	A low permeability cover is required if the facility would be within 100 m of the property boundary of land which is used for urban park, residential, commercial, or industrial purposes .	All soil treatment facilities should be covered (except while being worked) to minimize leachate generation, erosion, fugitive dust and air emissions
Leachate Collection	The base of the soil treatment facility must be sloped (1 to 5%) toward one or more collection sumps.	Leachate collected from sumps may be recycled back into the soil treatment facility to maintain moisture, treated or disposed of in accordance with legal requirements
Aeration Measures	Mechanical tilling or ventilation piping is required where soil thickness is greater than 30 cm.	

8.0 Multiple waste streams

Subject to Protocol 3 "Blending, Mixing or Dilution as a Remediation Approach" [1], a soil treatment facility may be used to treat soil with different origins, and of different compositions or contaminant concentrations. These soils must be kept and treated in separate cells or stockpiles within the soil treatment facility. Each treatment cell or

stockpile must be managed to provide the quickest and most environmentally sound remediation for the type of contaminant being managed.

9.0 Soil preparation

Soils which tend to clump together are difficult to aerate, difficult to uniformly distribute nutrients and may retain water. Soil amendments which will enhance remediation potential, including bulking materials such as sawdust or straw, may be used to ensure the soil has a loose or divided texture prior to treatment.

10.0 Operation and maintenance

- Soil treatment facility works including liners, berms, cover and leachate collection and treatment (if applicable) systems must be inspected monthly during the operating season (typically between April and October) and following significant storm events and be maintained in good working order.
- For soil treatment facilities where tilling is required, tilling must be completed at least once every 4 weeks during the operating season.
- Accumulations of liquid in leachate collection sumps must be reused or disposed of appropriately consistent with the requirements of the Act.
- Management of a soil treatment facility must be carried out so as to ensure optimal biodegradation of contaminants and to ensure the integrity of the works. Table 2 outlines the optimal levels of key environmental parameters:

Table 2: Optimal levels of key environmental parameters

Parameter	Optimal Operating Level	Additional Information
Micro-organisms	Variable	Microbial populations can be raised via blending the soil with cultured micro-organisms or animal manure
Oxygen	Variable	Added via tilling or aeration piping
pH	6 ≤pH≥ 8	pH can be raised by adding lime or lowered by adding elemental sulphur
Soil Temperature	10 - 45°C	Soil temperature can be maintained by covering the facility or through warm air injection
Moisture Content	40 – 85 % of field capacity 10 – 30 % by weight	Facilities may require drainage or cover in areas with high precipitation. Moisture may be added through irrigation piping or spraying
Nutrient Levels	Nitrogen to Phosphorus Ratio 2:1 to 10:1	Nutrients may be added via fertilizer

11.0 Monitoring and sampling

11.1 Sample collection and laboratory analysis

Soil and groundwater sampling is to be performed in accordance with applicable procedures described in the ministry's Technical Guidance 1 [2] and the most recent edition of the British Columbia Field Sampling Manual [3] or by suitable alternative procedures authorized by the director.

Analyses are to be carried out in accordance with procedures described in the most recent edition of the British Columbia Environmental Laboratory Manual [4], or by suitable alternative procedures authorized by the director.

11.2 Baseline information

Prior to operation of a soil treatment facility, subsurface baseline information must be obtained on soil and groundwater chemistry conditions beneath and surrounding the proposed treatment area, to serve as the basis for future comparisons. Groundwater monitoring wells must be installed both up gradient and down gradient (minimum 1 up gradient and 2 down gradient) of the soil treatment facility.

11.3 Operational monitoring

To confirm the performance of the biodegradation process, representative soil samples must be collected from within the soil treatment facility during the treatment process and prior to any soil removal or facility decommissioning activities. Soil samples must be analysed for appropriate indicator parameters including but not limited to pH, temperature, moisture, microbial content, contaminant concentrations, and nutrient levels.

A groundwater monitoring program must be completed annually. Groundwater must be monitored for appropriate indicator parameters associated with the contaminants of concern.

12.0 Decommissioning and closure

Following successful remediation of soil to the applicable environmental quality standards, the soil treatment facility must be decommissioned, the treated soil disposed of appropriately, and the land surface must be contoured to its original grade. Table 3 summarizes options for final disposal of treated soil.

Table 3: Final disposal options for treated soil

Treatment Location	Soil Disposal Option	Authorization Requirements
Onsite	Reuse on land where the soil originated	No authorization required
	Transfer to a facility authorized to accept contaminated soil (For example, to a landfill for either permanent disposal or reuse as landfill cover, or to an industrial site for use in a specific process such as solidification/stabilization with cement or incorporation into asphalt)	No additional authorization required
	Reuse on land at a site, other than where the soil originated, that is not otherwise authorized to accept contaminated soil	A Contaminated Soil Relocation Agreement (CSRA) may be required
Offsite	Reuse on land where the soil originated	A CSRA may be required to relocate the soil to an offsite treatment location and/or to return the treated soil to the source site
	Reuse on land where the soil was treated	A CSRA may be required to relocate the soil to an offsite treatment location
	Transfer to a facility authorized to accept contaminated soil (see above for examples)	A CSRA may be required to relocate the soil to an offsite treatment location No additional authorization required for soil disposal
	Reuse on land at a site (other than the source or treatment site) that is not otherwise authorized to accept contaminated soil	A CSRA may be required to relocate the soil to an offsite treatment location Soil disposal may require authorization by either a CSRA or waste discharge permit

Following decommissioning, closure samples must be collected from the soil beneath and surrounding the former soil treatment facility and from the groundwater monitoring well network. Soil and groundwater samples must be submitted for laboratory analysis of contaminants of concern to ensure that the underlying soil and groundwater has not been contaminated during the soil treatment process. Remediation of any contaminated soil and groundwater encountered beneath the treatment facility is required as part of the closure process.

13.0 Record keeping and reporting

13.1 Record keeping requirements

Operators of a soil treatment facility must maintain the following records which must be available for inspection by ministry staff if requested:

- Results of any demonstration trials conducted to determine the biodegradation potential of the contaminant type;
- All drawings and specifications for the soil treatment facility (accompanied by a statement signed by a qualified professional licensed to practice in British Columbia indicating that the design fully complies and was built in accordance with this protocol);
- Inventory of the soil undergoing treatment including origin, volume, contaminant types and concentrations of contaminants;
- Documentation of operational activities including aeration activities and addition of nutrients;
- Results of all monitoring activities and soil and groundwater analysis;
- Documentation of any maintenance or repairs completed;
- Copies of any required authorizations for waste discharge (for example: leachate or air emissions) or movement of soil;
- All records of inspections previously completed by ministry staff.

13.2 Reporting requirements

Spills must be reported in accordance with the Spill Reporting Regulation. Appropriate corrective action must be taken to contain and control any release of contaminants from a soil treatment facility and measures must be taken to prevent occurrence of similar events in the future.

As per section 54 of the Act and section 57 of the Contaminated Sites Regulation, any person undertaking independent remediation must notify the Director within three days after the commencement of any remediation activity and within 90 days of completing remediation. The Director may impose additional requirements under section 54(3)(d) of the Act.

14.0 References

1. BC Ministry of Environment. (1999). Protocol 3: Blending, Mixing or Dilution as a Remediation Approach. Victoria, BC. July 1999.
2. BC Ministry of Environment. (2005). Technical Guidance 1 on Contaminated Sites: Site Characterization and Confirmation Testing. Victoria, BC. August 2005.

3. BC Ministry of Environment. (2003). British Columbia Field Sampling Manual — For Continuous Monitoring and the Collection of Air, Air-Emission, Water, Wastewater, Soil, Sediment and Biological Samples**.** Victoria, BC. January 2003.
4. BC Ministry of Environment. (2007). British Columbia Environmental Laboratory Manual - For the Analysis of Water, Wastewater, Sediment and Biological Materials". Victoria, BC. April 2007.

15.0 Additional Information

1. Hazardous Waste Regulation. B.C. Reg. 63/88 including amendments up to B.C. Reg. 261/2006. Consolidated September 21, 2006.
2. Alberta Environment. (2005). Code of Practice for Land Treatment of Soil Containing Hydrocarbons. Edmonton, AB. September 2008. Available at: http://www.qp.gov.ab.ca/documents/codes/HYDROCARBONS.CFM
3. Manitoba Conservation. (2002). Guideline 96 – 05: Treatment and Disposal of Petroleum Contaminated Soil. Winnipeg, MB. April 2002. Available at: http://www.gov.mb.ca/conservation/envprograms/contams/standards/treat-disp-96-05-apr02-2002.pdf
4. Yukon Environment (2007). Land Treatment Facilities (Guidelines for Construction, Operation and Decommissioning). Whitehorse, YT. 2007. Available at: http://www.environmentyukon.gov.yk.ca/monitoringenvironment/EnvironmentActandRegulations/landtreatment.php
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9. State of Indiana, Department of Natural Resources (2001). Spill Management Guide, Handling oil and saltwater spill in Indiana. January 19, 2001. Available at: http://www.in.gov/dnr/dnroil/pdf/spillgde.pdf

10. State of Oklahoma, Department of Environmental Quality (2007). Bioremediation of Excavated Petroleum Contaminated Soil. August 21, 2007. Available at: http://www.deq.state.ok.us/factsheets/land/ExcavatedPetroleum.pdf