Defence Construction Canada

Landfill Monitoring Program

CAM-M, Cambridge Bay

Landfill Monitoring at CAM-M

Prepared by:

UMA Engineering Ltd.
2540 Kensington Road NW
Calgary, AB T2N 3S3

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Table of Contents

List of Tables

1.0 Post-Construction Monitoring Program

1.1 INTRODUCTION

The following summary is being provided for the post-construction landfill monitoring program as described in the DND-NTI Environmental Cooperation Agreement for the former CAM-M, Cambridge Bay DEW Line site. Information on both the development and review process for the program, as well as the specific components of the program are included.

1.2 BACKGROUND

The Department of National Defence (DND), in cooperation with Nunavut Tunngavik Incorporated (NTI), developed a landfill monitoring plan to address post closure monitoring requirements for the landfills at the DEW Line Sites (DND/NTI Cooperation Agreement – Environmental Provisions). Defence Construction Canada (DCC) is managing the cleanup and monitoring programs on behalf of DND.

The objective of the landfill monitoring program is to collect sufficient information to assess the performance of the landfills from a geotechnical and environmental perspective. The landfill monitoring plan specifies the requirements for visual inspection, and chemical and thermal monitoring of landfills at the DEW Line sites under DND's jurisdiction.

1.3 PROGRAM COMPONENTS

The post-construction landfill monitoring program consists of four main components to measure the performance of the landfills, depending on the remedation plan for each landfill. These components are visual, soil, active layer water and thermal monitoring. Details on each of the monitoring components are provided below.

Visual Monitoring: The physical integrity of the landfill is inspected and reported using hand-drawn sketches. Documented observations include:

- Evidence of settlement, ponding, frost action, erosion, and lateral movement.
- Sloughing of berms/covering layers, thermal contraction cracks, etc.

Photographic records are to be provided to document the general condition of the landfill and to substantiate all recorded observations. The location of all photographic viewpoints will be referenced to existing monuments.

Soil and Active Layer Water Monitoring: The soil and active layer water monitoring program consists of baseline/background assessment and contaminant evaluation. Background conditions

represent soil and water quality from an area not impacted by the landfill. Background (naturally occurring) values are obtained from samples collected from areas that were not directly influenced by activities at the DEW Line site, but are indicative of the prevailing geochemistry. These samples are taken hydraulically upgradient and at some distance from the landfill. Baseline conditions refer to existing soil and water quality at the landfill area, prior to any remediation and/or construction work being carried out. These samples are generally collected from areas both up and downgradient of the landfill.

Soil and active layer water samples (where required) are collected prior to construction/closure of a landfill, to represent background as well as baseline conditions. The results of subsequent landfill monitoring events are compared to these baseline and background values to evaluate any potential changes in environmental conditions.

In general, one monitoring well was installed upgradient and two to three wells were installed downgradient of each landfill during the construction phase. Using water elevation data from a minimum of three wells allows assessment of the hydraulic gradient and flow velocities. Review of analytical data from water samples collected from wells up and down gradient allows evaluation of potential impacts associated with the landfill. Soil samples are collected from the toe of the landfill, generally from the same locations as the monitoring wells. Contamination in soil samples at the toe of the landfill reflects chronic input from water that may have infiltrated the landfill, and is an important factor of contaminated leachate.

Prior to collection of samples from a monitoring well, the well is purged and allowed to reach equilibrium. Physical measurements are collected prior to and after purging and are referenced to the top of the monitoring well pipe. The measured physical parameters include:

- Water elevation;
- Total depth of water;
- Presence of hydrocarbons;
- Hydrocarbon layer thickness (if appropriate);
- Colour, odour;
- pH;
- Conductivity; and
- Temperature.

Thermal Monitoring: Geothermal analysis were carried out as part of the design to predict the length of time required for permafrost aggradation through landfills requiring leachate containment, including the Tier II Soil Disposal Facility. These analyses also provided information on the long and short term thermal regime in the ground, and the depth of the active layer in the cover material.

A thermal monitoring system provides measurement of sub-surface ground temperatures, which allows comparison to and verification of the predicted ground temperatures. The thermal monitoring system consists of installation of thermistor strings, with thermistor beads at selected intervals to provide ground temperature profiles at various locations within the landfill. The thermistor strings are attached to automated data-loggers that allow for remote data collection. In general, a minimum of three thermistors are installed at each landfill where permafrost aggradation through the landfill contents is an integral part of the design.

1.4 FREQUENCY

The landfill monitoring program consists of three phases, as described in detail below.

1.4.1 Phase I

Phase I involves monitoring of conditions to confirm that equilibrium is achieved. The frequency of monitoring events during Phase I monitoring is dependent on the closure or remediation design at specific landfills. The Main Landfill – North, Main Landfill – South and the Tier II soils disposal facility have been monitored on an annual basis for the last four years and are in the last year of Phase I monitoring. The five-year term was selected on the basis that ground-temperature thermal regimes at these specific landfills will require three to five years to reach equilibrium.

The South Shore Landfill, West Landfill and Airstrip Landfill were regraded, and the Phase I monitoring was carried out over a reduced frequency in the first, third and fifth years following construction.

An evaluation of all Phase I data will be carried out at the end of five years to confirm that thermal and chemical equilibrium had been achieved, and that no stability issues had been identified. The Phase I monitoring program may be extended, if required, to provide sufficient data to establish equilibrium conditions.

The first year of the Phase I post-construction monitoring is completed by the Environmental Sciences Group (ESG) of the Royal Military College of Canada, who are part of the DEW Line Clean Up Project Team. Subsequent landfill monitoring events are carried out by independent contractors, who successfully win the competitive tender.

1.4.2 Phase II

Phase II monitoring is the verification of equilibrium conditions established in Phase I. The monitoring frequency in Phase II is downgraded from Phase I and will be carried out according to the following schedule, year 7, year 10, year 15 and year 25. Year 25 marks the end of Phase II monitoring.

1.4.3 Phase III

Phase III involves the monitoring for long-term issues such as liner integrity, permafrost stability, and significant storm events. At the end of the Phase II program, 25 years after construction, a re-evaluation of the landfill monitoring program will be carried out prior to initiating any Phase III program. The scope of the Phase III monitoring program is not included here, but is anticipated to be based on a 10 year monitoring interval.

1.5 REVIEW AND EVALUATION PROCESS

An Environmental Working Group (EWG) was established to provide a technical report and to support to the DLCU Steering Committee. This working group is comprised of qualified engineering and environmental scientists with expertise in environmental remediation and clean up in northern climates. The EWG has four designated representatives, two from each of the Owner (DND) and the Inuit (through the NTI), respectively.

During the monitoring program, the EWG reviews the results of the monitoring program in accordance with the methodology as described previously. The results of the review and any recommendations regarding changes to the monitoring plan and/or remediation requirements are reported to the DND/NTI Steering Committee.

The requirement for further monitoring after 25 years is evaluated. Monitoring may be terminated if the performance of the landfill was satisfactory over the period of monitoring from an environmental, geotechnical and thermal perspective, as appropriate. The assessment of satisfactory performance is carried out jointly by the NTI and DND.

2.0 Detailed Landfill Monitoring Requirements

The following sections provide a summary and the detailed monitoring requirement for each landfill at CAM-M.

2.1 MAIN-LANDFILL – NORTH

The Main Landfill – North is located to the east of the main station facilities, and encompasses an area of approximately 10,000 m^2. Based on the evaluation of the landfill as a source of

contamination, potential pathways, and receptors, consistent with the Landfill Evaluation Matrix, the Main Landfill - North was classified as moderate potential environmental risk. The remediation for this landfill included installation of a leachate containment system along the toe of the landfill and regrading with the placement of additional granular fill sufficient to cause permafrost aggradation through the landfill contents.

The long term monitoring plan consists of visual monitoring for signs of settlement, collection of soil and groundwater samples to evaluate the effectiveness of the leachate containment system, and monitoring of sub-surface ground temperatures along the toe and in the main body of the landfill. Table 1 provides the coordinates of the monitoring stations, while Table 2 provides the detailed monitoring requirements at the Main Landfill - north. See Figure CAM-M.2 for details.

Table 1: Monitoring Station Coordinates at the Main Landfill - North

Landfill Monitoring Station Coordinates	Coordinates		Elevation (masl)
	North (m)	East (m)	
MW-4 (soil & groundwater)	10232	10568	14.0
MW-5 (soil & groundwater)	10294	10634	8.9
MW-6 (soil & groundwater)	10336	10571	10.0
MW-7 (soil & groundwater)	10420	10453	10.9
MW-8 (soil & groundwater)	10254	10427	16.5
ITN1 (temperature)	10374.6	10503.3	13.1
ITN2 (temperature)	10313.7	10549.9	12.2
VT1 (temperature)	10337.2	10521.6	13.7
VT2 (temperature)	10284.2	10568.8	15.3
VT3 (temperature)	10365.7	10418.3	15.7

NOTE: Coordinates are referenced to a local site grid and are approximate only for the soil sampling locations. Monitoring well and thermistor coordinates are as provided by the cleanup contractor's survey.

Table 2: Detailed Monitoring Requirements at the Main Landfill – North

Location	Sample Type	Frequency	Parameters
Determined on site	Visual	Once per year in years 5, 7, 10, 15, 25 post-construction	N/A
MW-4 → MW-8	Groundwater	Once per year in years 5, 7, 10, 15, 25 post-construction	Total Arsenic
			Total Cadmium
			Total Chromium
			Total Cobalt
			Total Copper
			Total Lead
			Total Nickel
			Total Zinc
			Total Mercury
			PCBs
			Total Petroleum Hydrocarbons (C_6-C_{32})
MW-4 → MW-8	Soil	Once per year in years 5, 7, 10, 15, 25 post-construction	PCBs
			TPH as F1 (C_6-C_{10})
			TPH as F2 (C_{10}-C_{16})
			TPH as F3 (C_{16} to C_{34})
			Arsenic
			Cadmium
			Chromium
			Cobalt
			Copper
			Lead
			Nickel
			Zinc
			Mercury
ITN1, ITN2, VT1, VT2, VT3	Thermal	Once per year in years 5, 7, 10, 15, 25 post-construction	Temperature

2.2 MAIN LANDFILL - SOUTH

The Main Landfill – South is located to the east of the main station facilities, and encompasses an area of approximately 15,000 m^2. Based on the evaluation of the landfill as a source of contamination, potential pathways, and receptors, consistent with the Landfill Evaluation Matrix, the

Main Landfill – South was classified as moderate potential environmental risk. The remediation for this landfill included installation of a leachate containment system along the toe of the landfill and regrading with the placement of additional granular fill sufficient to create permafrost aggradation through the landfill contents.

The long term monitoring plan consists of visual monitoring for signs of settlement, collection of soil and groundwater samples to evaluate the effectiveness of the leachate containment system, and monitoring of sub-surface ground temperatures along the toe and in the main body of the landfill. Table 3 provides the coordinates of the monitoring stations and Table 4 provides the detailed monitoring requirements at the Main Landfill – South. See Figure CAM-M.3 for details.

Table 3: Monitoring Station Coordinates at the Main Landfill - South

Landfill Monitoring Station Coordinates	Coordinates		Elevation (masl)
	North (m)	East (m)	
MW-1 (soil & groundwater)	10009	10340	10.2
MW-2 (soil & groundwater)	10034	10448	-
MW-3 (soil & groundwater)	10114	10515	-
MW-9 (soil & groundwater)	10140	10180	20.4
MW-14 (soil & groundwater)	10020	10389	8.0
ITS1 (temperature)	10110.8	10447.7	-
ITS2 (temperature)	10061.7	10398.7	-
VT4 (temperature)	10111.2	10384.6	16.5
VT5 (temperature)	10055.9	10400.8	11.5

NOTE: Coordinates are referenced to a local site grid and are approximate only for the soil sampling locations. Monitoring well and thermistor coordinates are as provided by the cleanup contractor's survey.

Table 4: Detailed Monitoring Requirements at the Main Landfill – South

Location	Sample Type	Frequency	Parameters
Determined on site	Visual	Once per year in years 5, 7, 10, 15, 25 post-construction	N/A
MW-1 → MW-3, MW-9, MW-13	Groundwater	Once per year in years 5, 7, 10, 15, 25 post-construction	Total Arsenic
			Total Cadmium
			Total Chromium
			Total Cobalt
			Total Copper
			Total Lead
			Total Nickel
			Total Zinc
			Total Mercury
			PCBs
			Total Petroleum Hydrocarbons (C_6-C_{32})
MW-1 → MW-3, MW-9, MW-13	Soil	Once per year in years 5, 7, 10, 15, 25 post-construction	PCBs
			TPH as F1 (C6-C10)
			TPH as F2 (C10-C16)
			TPH as F3 (C16 to C34)
			Arsenic
			Cadmium
			Chromium
			Cobalt
			Copper
			Lead
			Nickel
			Zinc
			Mercury
ITS1, IT22, VT4, VT5	Thermal	Once per year in years 5, 7, 10, 15, 25 post-construction	Temperature

2.3 TIER II SOIL DISPOSAL FACILITY

A DCC Tier II Soil Disposal Facility was constructed at the CAM-M site for the disposal of Tier II contaminated soils excavated during the cleanup. The location of the Tier II Soil Disposal Facility is approximately two kilometres northwest of the Station Area.

Consistent with Environmental Provisions of the Cooperation Agreement, monitoring of the Tier II soil disposal facility consists of visual monitoring for evidence of settlement, erosion, differential movement, collection of soil and groundwater samples from around the facility to monitor the effectiveness of the containment system, and monitoring of sub-surface ground temperatures in the berms and in the main body of the disposal facility.

Table 5 provides the coordinates of the monitoring stations and Table 6 provides the detailed monitoring requirements at the Tier II Soil Disposal Facility. See Figure CAM-M.6 for details.

Table 5: Monitoring Station Coordinates at the Tier II Soil Disposal Facility

Landfill Monitoring Station Coordinates	Coordinates		Elevation (masl)
	North (m)	East (m)	
MW-10 (soil & groundwater)	11976	8962	43.6
MW-11 (soil & groundwater)	12034	9096	35.1
MW-12 (soil & groundwater)	12078	9053	34.9
MW-13 (soil & groundwater)	12114	8976	35.3
TA1 (temperature)	12007.3	8993.5	43.8
TA2 (temperature)	12016.8	9037.1	43.4
TA3 (temperature)	12066.6	8984.7	43.0
TA4 (temperature)	12035.0	8953.8	44.2

NOTE: Coordinates are referenced to a local site grid and are approximate only for the soil sampling locations. Monitoring well and thermistor coordinates are as provided by the cleanup contractor's survey.

Table 6: Detailed Monitoring Requirements at the Tier II Soil Disposal Facility

Location	Sample Type	Frequency	Parameters
Determined on site	Visual	Once per year in years 5, 7, 10, 15, 25 post-construction	N/A
MW-10 → MW-13	Groundwater	Once per year in years 5, 7, 10, 15, 25 post-construction	Total Arsenic
			Total Cadmium
			Total Chromium

			Total Cobalt
			Total Copper
			Total Lead
			Total Nickel
			Total Zinc
			Total Mercury
			PCBs
			Total Petroleum Hydrocarbons (C_6-C_{32})
MW-10 → MW-13	Soil	Once per year in years 5, 7, 10, 15, 25 post-construction	PCBs
			TPH as F1 (C6-C10)
			TPH as F2 (C10-C16)
			TPH as F3 (C16 to C34)
			Arsenic
			Cadmium
			Chromium
			Cobalt
			Copper
			Lead
			Nickel
			Zinc
			Mercury
TA1 → TA4	Thermal	Once per year in years 5, 7, 10, 15, 25 post-construction	Temperature

2.4 SOUTH SHORE LANDFILL

The South Shore Landfill is located approximately two kilometres east of the main facilities, near the POL Beach Staging area. No evidence of leachate was identified, nor was any contaminated soil detected in the area of the landfill. Based on the evaluation of the landfill as a source of contamination, potential pathways, and receptors, consistent with the Landfill Evaluation Matrix, the South Shore Landfill was classified as moderate potential environmental risk. However, based on discussions with residents of Cambridge Bay, representing the NTI, the risk potential of the landfill was re-assessed as low. The remediation for this landfill included regrading with the placement of additional granular fill.

The long term monitoring plan consists of visual monitoring for signs of settlement, and periodic collection of soil samples to monitor for the presence of leachate. Table 7 provides the coordinates of the monitoring stations, while Table 8 provides the detailed monitoring requirements at the South Shore Landfill. See Figure CAM-M.4 for details.

Table 7: Monitoring Station Coordinates at the South Shore Landfill

Landfill Monitoring Station Coordinates	Coordinates		Elevation (masl)
	North (m)	East (m)	
CM-1 (soil)	8820	10900	-
CM-2 (soil)	8850	11050	-
CM-3 (soil)	8800	11040	-
CM-4 (soil)	8730	10990	-

NOTE: Coordinates are referenced to a local site grid and are approximate only for the soil sampling locations.

Table 8: Detailed Monitoring Requirements at the South Shore Landfill

Location	Sample Type	Frequency	Parameters
Determined on site	Visual	Once per year in years 5, 7, 10, 15, 25 post-construction	N/A
CM1 → CM4	Soil	Once per year in years 5, 7, 10, 15, 25 post-construction	PCBs
			TPH as F1 (C6-C10)
			TPH as F2 (C10-C16)
			TPH as F3 (C16 to C34)
			Arsenic
			Cadmium
			Chromium
			Cobalt
			Copper
			Lead
			Nickel
			Zinc
			Mercury

2.5 WEST LANDFILL

The West Landfill is located approximately 600 metres northwest of the main station facilities, and encompasses an area of approximately 4500 m^2. No evidence of leachate was identified in the area. Based on the evaluation of the landfill as a source of contamination, potential pathways, and receptors, consistent with the Landfill Evaluation Matrix, the West Landfill was classified as low potential environmental risk. The remediation for this landfill included regrading with the placement of additional granular fill.

The long term monitoring plan consists of visual monitoring for signs of settlement, and periodic collection of soil samples to monitor for the presence of leachate. Table 9 provides the coordinates of the monitoring stations and Table 10 provides the detailed monitoring requirements at the West Landfill. See Figure CAM-M.5 for details.

Table 9: Monitoring Station Coordinates at the West Landfill

Landfill Monitoring Station Coordinates	Coordinates		Elevation (masl)
	North (m)	East (m)	
CM-5 (soil)	10900	9140	-
CM-6 (soil)	10950	9160	-
CM-7 (soil)	10920	9220	-

NOTE: Coordinates are referenced to a local site grid and are approximate only for the soil sampling locations.

Table 10: Detailed Monitoring Requirements at the West Landfill

Location	Sample Type	Frequency	Parameters
Determined on site	Visual	Once per year in years 5, 7, 10, 15, 25 post-construction	N/A
CM5 → CM7	Soil	Once per year in years 5, 7, 10, 15, 25 post-construction	PCBs
			TPH as F1 (C6-C10)
			TPH as F2 (C10-C16)
			TPH as F3 (C16 to C34)
			Arsenic
			Cadmium
			Chromium
			Cobalt
			Copper
			Lead
			Nickel
			Zinc
			Mercury

2.6 AIRSTRIP LANDFILL

The Airstrip Landfill is located southwest of the airstrip, along the edge of the West Arm of Cambridge Bay. The disturbed area associated with the landfill extends along the road over a length of two kilometres. Based on the available information, the landfill was classified as moderate potential environmental risk. To address the contributing risk factors, the remediation for this landfill included: removal of surface debris, excavation of contaminated soils, removal of pockets of buried materials that were associated with contaminated areas, regrading with the placement of additional fill material at remaining pockets of buried material.

The long term monitoring plan consists of visual monitoring for signs of settlement, and/or other disturbance, and periodic collection of soil samples to monitor for the presence of leachate. Table 11 provides the coordinates of the monitoring stations at the Airstrip Landfill. Table 12 provides the detailed monitoring requirements at the Airstrip Landfill. See Figure CAM-M.7 for details.

Table 11: Monitoring Station Coordinates at the Airstrip Landfill

Landfill Monitoring Station Coordinates	Coordinates		Elevation (masl)
	North (m)	East (m)	
CM-8 (soil)	9720	7610	-
CM-9 (soil)	9600	8000	-
CM-10 (soil)	9410	8280	-
CM-11 (soil)	9510	7860	-
CM-12 (soil)	9520	7570	-
CM-13 (soil)	9550	7270	-

NOTE: Coordinates are referenced to a local site grid and are approximate only for the soil sampling locations.

Table 12: Detailed Monitoring Requirements at the Airstrip Landfill

Location	Sample Type	Frequency	Parameters
Determined on site	Visual	Once per year in years 5, 7, 10, 15, 25 post-construction	N/A
CM8 → CM13	Soil	Once per year in years 5, 7, 10, 15, 25 post-construction	PCBs
			TPH as F1 (C6-C10)
			TPH as F2 (C10-C16)
			TPH as F3 (C16 to C34)
			Arsenic
			Cadmium
			Chromium
			Cobalt
			Copper
			Lead
			Nickel
			Zinc
			Mercury