DILLON CONSULTING

CITY OF IQALUIT

Facility Monitoring Plan

Landfill and Waste Transfer Station

January 2020 – 19-9543

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Acronyms, Abbreviations, Definitions

– B –

BTEX, *benzene, toluene, ethylbenzene and xylenes*

– C –

C&D, *Construction and Demolition*
CALA, *Canadian Association of Laboratory Accreditation Inc.*
CCME, *Canadian Council of the Ministers of the Environment*
CSedQG, *Canadian Sediment Quality Guideline*
CSQG, *Canadian Soil Quality Guideline*
CWS, *Canada Wide Standards*
CWQG, *Canadian Water Quality Guideline*

– D –

DGPS, *Differential global positional system*
Dillon, *Dillon Consulting Limited*
DO*, Dissolved Oxygen*

– E –

EQGs, *Environmental Quality Guidelines*
EXP, *EXP Services Inc.*

– F –

FMP, *Facility Monitoring Program*

– L –

LTM, *Long-Term Monitoring*

– M –

MDL, *Method Detection Limit*

– N –

NWB, *Nunavut Water Board*
NWNSRTA, *The Nunavut Waters and Nunavut Surface Rights Tribunal Act*

– O –

ORP, *oxidation reduction potential*

– P –

PAHs, *polycyclic aromatic hydrocarbons*

PHCs, *petroleum hydrocarbons*

– Q –

QA/QC, *Quality Assurance/Quality Control*

– R –

RDL, *Reportable Detection Limit*

RPD, *Relative Percent Difference*

– S –

SCC, *Standards Council of Canada*

– T –

TDS, *total dissolved solids*

– V –

VOCs, *volatile organic compounds*

VSECs, *Valued Species of Environmental Concern*

– W –

WTS, *Waste Transfer Station*

1.0 Introduction

Dillon Consulting Limited (Dillon) was retained by the City of Iqaluit (the City) to prepare a Facility Monitoring Program (FMP) for the City's new solid waste management facility – incorporating requirements for the waste transfer station (WTS), landfill access road and new landfill (referred to as the Landfill).

The goal of the FMP is to evaluate and identify present and future potential risks to human health and the environment from the site conditions during WTS and landfill operations.

1.1 Regulatory Framework

In Nunavut, there are a number of acts and regulations applicable to waste management. The primary legislation governing waste management in Nunavut is *The Nunavut Waters and Nunavut Surface Rights Tribunal Act* (NWNSRTA), which establishes the Nunavut Water Board (NWB). A summary of the regulations, acts, legislation and guidelines relating to the construction and operation of the Landfill and WTS are presented in **Table 1-1.**

Table 1-1: Applicable Regulations, Acts, Guidelines and By-Laws

Regulation/Act/Guideline/Bylaw	Source
Building Bylaw #710	City of Iqaluit
Highway Traffic Bylaw #319	City of Iqaluit
Civic Holiday Bylaw #735	City of Iqaluit
Noise Bylaw #599	City of Iqaluit
Solid Waste Amendment By-Law #544	City of Iqaluit
Solid Waste By-Law #341	City of Iqaluit
Solid Waste By-Law Amendment #830	City of Iqaluit
Nunavut Waters and Nunavut Surface Rights Tribunal Act	Government of Canada
Water License Terms and Conditions	Government of Nunavut
Nunavut Environmental Protection Act	Government of Nunavut
Nunavut Public Health Act and General Sanitation Regulations	Government of Nunavut
Nunavut Wildlife Act	Government of Nunavut
Motor Vehicle Act	Government of Nunavut
Contingency Planning and Spill Reporting in Nunavut	Government of Nunavut
Waste Lead and Lead Paint (2014)	Government of Nunavut
Pesticide Regulations	Government of Nunavut
Biomedical and Pharmaceutical Waste	Government of Nunavut

Regulation/Act/Guideline/Bylaw	Source
Used Oil and Waste Fuel	Government of Nunavut
A Guide to Spill Contingency Planning and Reporting	Government of Nunavut
Waste Batteries (2011)	Government of Nunavut
Waste Solvent (2011)	Government of Nunavut
Waste Paint (2010)	Government of Nunavut
Waste Asbestos (2011)	Government of Nunavut
Waste Antifreeze (2011)	Government of Nunavut
Ozone Depleting Substances (2011)	Government of Nunavut
General Management of Hazardous Wastes (2010)	Government of Nunavut
Dust Suppression	Government of Nunavut
Ambient Air Quality (2011)	Government of Nunavut
Environmental Guideline for Used Oil and Waste Fuel	Government of Nunavut

1.1.1 Nunavut Regulatory Context and Water License Requirements

Water licenses and their terms and conditions are the primary means through which municipal solid waste facilities are regulated in Nunavut. The primary goal of a water license is to ensure that contaminants from solid waste disposal sites do not enter watercourses or water bodies. The most relevant Federal and Territorial legislation, applicable to solid waste management in Nunavut are detailed below:

The Solid Waste Management Plan (Government of Nunavut, 2014) outlines the key sections of the NWNSRTA that relate to waste management in Nunavut which include:

- Section 12, which states that no person shall deposit or permit the deposit of waste in waters in Nunavut or in any other place in Nunavut under conditions which the waste (or any other waste that results from the deposit of that waste), may enter waters in Nunavut except in accordance with the conditions of a license;
- Section 14 to 34, which established and describe the NWB, including the size of the NWB, the position of the NWB and their responsibilities and various rules regarding the NWB's organization structure and governance;
- Sections 42 to 81, which describes the rules governing the issuing of licenses by the NWB. Topics addressed by the sections include the maximum term for a license, application requirements, the application procedure, including when a public hearing is and is not required, conditions under which the Board may issue a license, the ability of the Board to include conditions and monitoring requirements in the license, and the requirement of the public sector; and
- Sections 85 to 94, which address enforcement of the NWNSRTA. In particular, Section 86 provides inspectors with the authority to examine works or take samples when they have reasonable ground to believe waste is entering waters and to examine any relevant documents or records. Section 87

provides inspectors with the authority to order those in charge of the wastes to take remedial measures to remedy those situations. Section 90 to 94 addresses offenses and punishments, including terms for fines and imprisonment.

Examples of typical water license terms and conditions, as they relate to solid waste management include:

- Conditions for an effluent monitoring program, including sampling locations, frequencies and parameters;
- Post of signage for the monitoring program;
- Requirements for submitting copies of studies, reports and plans to the NWB, including:
  - Operations and Maintenance manuals;
  - Construction design and drawings, including as-built; and
  - Abandonment and restoration plans.
- The disposal of and permanent containment of all solid wastes at the solid waste disposal facilities;
- The segregation and storing of all hazardous materials and hazardous waste within the solid waste disposal facilities in a manner to prevent the deposit of deleterious substances into water, until such a time that the materials can be removed for proper disposal at a licensed facility;
- The implementation of measures to ensure leachate from solid waste disposal facilities and hazardous storage areas do not enter water; and
- Annual reports that summarize:
  - Water monitoring results; modifications or major maintenance work carried out on waste disposal facilities, unauthorized discharges and follow-up actions;
  - Abandonment and restoration work recently completed or planned;
  - Updates to operation and maintenance manuals; relevant studies; and
  - Other details requested by the NWB.

Water licenses for solid waste facilities are required to be renewed before they expire. If an Operator's water license expires before it can be renewed, the operator is required to discontinue using the solid waste facility, as well as any water covered by the water license. Otherwise, the Operator will be in contravention of the Nunavut Land Claims Agreement and the NWNSRTA. The expiry of the license does not relieve the City of its obligations imposed by the license.

The WTS and Landfill will be obligated to follow the conditions outlined in their water license, which has not been received to date.

1.1.2 Contaminated Sites Management

The Government of Nunavut Department of Environment Guideline for the Management of Contaminated Sites (revised December 2014) has adopted the federal CCME guidelines for the management of contaminated sites within its jurisdiction.

The federal environmental quality guidelines (EQGs) were developed based on the level of risk a contaminant poses to human health and/or the environment. Soil guidelines are characterized by texture (i.e., fine/coarse). Soil texture at the site is considered to be coarse, with > 50% particle sizes greater than 75 µm. The soil EQGs are also categorized by land use (i.e., agricultural/wildland, residential/parkland, commercial and industrial). The WTS and Landfill are both characterized under the industrial land use. The industrial land use criteria will be used as screening values to evaluate potential risk to human health and environment at the waste transfer station, as the surrounding land use is also considered to be industrial land use. The wildland screening values will be used at the Landfill, as the surrounding land use is wildlands, and sampling locations are either located at the property boundary or outside of the property boundary. The specific guidelines that will be used to evaluate potential impacts to surface water, sediment and soil include the following:

- Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (CSQGs), (CCME, 1999 with updates);
- Canada-Wide Standards for Petroleum Hydrocarbons in Soil (CWS-PHC), (CCME, 2008);
- Canadian Soil Quality Guidelines Polycyclic Aromatic Hydrocarbons fact sheet (CCME, 2010;
- Canadian Environmental Guidelines. Canadian Sediment Quality Guidelines (CSedQG) for the Protection of Aquatic Life (CCME, 2007, with updates); and
- Canadian Environmental Quality Guidelines. Canadian Water Quality Guidelines (CWQG) for the Protection of Aquatic Life (CCME, 2007, with updates).

Active layer groundwater results will be compared to the surface water quality guidelines, as the applicable exposure and migration pathways for this intermittent migration pathway are surface water receptors. Overland flow is the primary mode of water transport in the area. Active layer groundwater is not used as a drinking water source in Iqaluit, NU. The site lies within the continuous permafrost zone.

Given the distance to the nearest marine receptor with no direct, major tributary, guidelines that are protective of freshwater aquatic life are considered applicable.

Where background parameters were observed to exceed the federal EQGs (i.e., based on the findings from the baseline reporting, or other applicable geochemical datasets for the region), the elevated background parameter value measured concentrations will be used as the screening value threshold.

2.0 Background

2.1 Site Overview and Location

The solid waste transfer station (WTS) is located within the urban area of the City of Iqaluit (City), where residential and commercial waste will be hauled to, processed and compacted into bales or in the case of waste food and cardboard, shredded for use as a fuel source for an on-site biomass boiler. Wood, furniture and select construction and demolition (C&D) wastes will also be shredded for landfilling. The resulting solid waste bales and a smaller amount of unbaled C&D waste will be trucked to an engineered balefill/landfill site (Landfill) located approximately 6 km from the WTS. The vehicles transferring the waste bales will access the road leading to the Landfill from the WTS, to avoid having the transfer vehicle travel through the City.

Other planned features for the WTS include a public drop off area for household hazardous wastes (HHW) and a vehicle logger/compactor unit; in both instances, allowing for the preparations of waste materials prior to shipping to approved management facilities in the south.

Development of the proposed facilities is scheduled to commence in 2020, with facility commissioning occurring in the fall of 2022.

Site Plans for the WTS and Landfill are shown respectively in **Figure 1** and **Figure 2** (attached).

2.2 Climate

Climate Normals data for period 1971 to 2000 and 1981 to 2010 of the Iqaluit weather station show the following:

Table 2-1: Climate Normals Data (1971-2000) Iqaluit, NU

Time Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1971-2000	-26.6	-28.0	-23.7	-14.8	-4.4	3.6	7.7	6.8	2.2	-4.9	-12.8	-22.7
1981-2010	-26.9	-27.5	-23.2	-14.2	-4.4	3.6	8.2	7.1	2.6	-3.7	-12.0	-21.3

When comparing the two data periods it shows that the mean annual air temperature increased from -9.8 °C to -9.3 °C, the mean summer air temperature increased from 5.1 °C to 5.4 °C, and the mean winter air temperature increased from -17.2 °C to -16.6 °C.

2.3 Ecological Characterization of the Site

A physical and biological assessment was conducted by EXP Services Inc. (EXP) for the City of Iqaluit in 2018 for the Landfill location. The ecological characterization for the Landfill location is assumed to be adequate for the waste transfer station, which is located within the City of Iqaluit limits.

No confirmed species at risk were recorded on or adjacent to the proposed facility location. In general, the area is characterized by a combination of bare rocky outcrops, grasses and lichens.

Identified potential habitat and breeding areas include the following:

- Identified potential habitat for Lemming, which plays an important ecological role that influences predator populations including Arctic Fox, Ermine, and Snowy Owl. A detailed inventory of potential wildlife species was not conducted for the site;
- Rock outcrops in proximity to the east boundary of the property provide suitable nesting habitat for Peregrine Falcon. The Peregrine Falcon is listed as Special Concern in Schedule 1 of the Species at Risk Act (SARA). Breeding bird surveys for Peregrine and other arctic birds has been recommended and results are pending;
- Evidence for past use by Barren-ground Caribou was observed at the Landfill location. While Caribou herds have not been observed in the Iqaluit region for several decades, there is the potential for population fluctuation and migration pattern change. Potential loss and impacts to Caribou habitat should be evaluated;
- The surface water body to the west of the Landfill has been anecdotally noted to contain Arctic Char and other fish species; and
- Surface water on the Site drains into Carney Creek, which then flows into Frobisher Bay. Frobisher Bay and connecting inland waters have been identified as important habitat for Arctic Char (considered to be Valued Species of Environmental Concern – VSECs)

2.4 Baseline Conditions

A baseline conditions assessment of the WTS and the Landfill was conducted by Dillon for the City of Iqaluit in 2019. Soil results from EXP's 2018 physical and biological assessment of the Landfill location were used for the baseline condition assessment of the Landfill.

Soil and/or groundwater investigations were conducted by Dillon at the proposed WTS and Landfill locations in July and September 2019, respectively. At the WTS, five drive-point monitoring wells were installed, four of which into test pit excavations and one by manual means. Sixteen surface soil samples were collected from various APECs across the WTS area. Groundwater samples were collected from newly installed monitoring wells hosting groundwater. Surface water sampling was conducted at a watercourse running adjacent to the WTS boundaries to the north, northeast and east. At the Landfill, five existing monitoring wells and three nearby surface water bodies were sampled. Soil, groundwater, and surface water samples were submitted to Bureau Veritas for laboratory analysis of benzene,

toluene, ethylbenzene and groundwater (BTEX), petroleum hydrocarbons (PHCs), polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), glycols, and, per-and poly-fluorinated alkyl substances (PFAS).

2.4.1 Waste Transfer Station

On July 16 and 17, 2019, Dillon conducted shallow soil sampling at the WTS. Three areas were targeted: The Fire Fighting Training Area (FFTA) and two City yards, one northwest of the FFTA and one south of the FFTA. Soil samples were collected from two test pits and sixteen surface locations within the proposed WTS boundaries. Surface soil sample locations were selected based on potential for environmental impact resulting from current and/or former materials storage, operations, or other activities. At the WTS, soil results indicated PHC F3 and select PAHs exceeded referenced guidelines in 2019. Impacts were observed across the WTS area, including the FFTA and City yards.

Groundwater samples were collected at monitoring wells 19MW-02, 19MW-03 and 19MW-04 in July 2019. Depth to groundwater ranged from 1.21 m below top of casing (m btoc) to 2.28 m btoc. Groundwater flow direction could not be determined as no survey of the well network was conducted. No measurable LNAPL was recorded in any of the monitoring wells in July 2019. Results for groundwater sampling indicated select PAH and PFAS compounds, as well as dissolved copper, exceeded referenced guidelines from the City yards and boundaries of the FFTA.

Surface water samples were also collected from three locations along the adjacent watercourse in July 2019. Surface water results were below the applicable guidelines.

WTS soil and groundwater analytical results appear to be the result of historical operations, activities, and chemical or debris storage in this area.

2.4.2 Landfill

Nine shallow soil samples were collected by EXP from across the Landfill location and submitted for laboratory analyses of metals and inorganics, PHCs, VOCs, and PAHs (EXP, 2018). No exceedances, with the exception of low pH (4.07 to 5.69), were identified for the location.

Five previously existing monitoring wells (W-107 to W-111) were monitored and sampled on September 5 to 6, 2019. Groundwater samples were collected by Dillon at monitoring wells W-107 to W-111 in September 2019. Recharge rates were noted to be slow. Dissolved and total metals, nitrite (as N) and sulphate concentrations in groundwater were observed to exceed the referenced guidelines for one or more parameters at each monitoring well location.

Surface water samples were collected from three locations (WS-100 to WS-102) from nearby water bodies in September 2019. Surface water results were below the applicable guidelines.

The Landfill groundwater results, while exceeding referenced guidelines, are considered to be representative of background geological conditions: elevated concentrations in soil and surrounding bedrock, and limited buffering capacity in the surrounding geological materials (as indicated by low pH observed in soils).

3.0 Monitoring Plan

There are three identified stages during landfill operation: construction, operation and maintenance and post-closure. Monitoring programs will differ in frequency and focus depending on the stage of the landfill. The monitoring program contained herein is intended for the operation and maintenance stage of the landfill. Long-Term Monitoring (LTM) that will take place during the post-closure stage will include an emphasis on Visual Monitoring and Seepage Monitoring of the landfill isolation cover.

The following operational monitoring activities are recommended:

- Visual Monitoring;
- Soil Temperature Monitoring;
- Seepage Monitoring;
- Soil Sampling (if seepage is observed);
- Surface Water Monitoring;
- Sediment Sampling; and
- Natural Environmental Monitoring.

Seepage and soil sampling will be completed as required based on landfill performance, and are not viewed as necessary at this time for the waste transfer station. No thermistors have been installed at the WTS, therefore, soil temperature monitoring will be conducted at the landfill only.

Any field equipment employed should be maintained, calibrated, and used in accordance with manufacturer's requirements, and industry best practices.

Field procedures and methodologies should be conducted in accordance with industry standards and/or best practices (e.g., the Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment by the CCME, 2016).

3.1 Visual Monitoring

Visual monitoring documents information on the condition of the daily cover, associated berms, culverts, site activities (changes from year to year) and site drainage. Observations should be documented with photographs. Photograph locations will be established in the first year of monitoring, and these will be used to monitor future changes. Additional photos documenting site activities and changes to the site will be taken.

3.1.1 Visual Monitoring Plan

The visual inspections will look for evidence of erosion, frost action, vegetation (changes including growth or stress), staining, seepage points, exposed debris, breeches, condition of monitoring instruments and conditions of any warning signage.

At the Landfill, regular visual inspections (i.e., weekly) will be conducted to check the physical integrity of the berms, leachate pond conditions, etc. while the landfill is in operation.

A complete inspection of the leachate collection system elements (manhole, pump, hosing, holding ponds) shall be conducted on an annual basis.

Photographs will be taken to document the condition and substantiate the recorded observations. Pre-determined photograph locations will be established in the first year of monitoring, and these will be used to monitor future changes. At a minimum, photographs should be taken from each of these locations during each monitoring event.

Observations will be recorded, including dimensions and location of each feature and its extent using a differential global positional system (DGPS) unit, noting significant changes.

3.2 Soil Temperature Monitoring

Soil temperature monitoring documents the changing climatic conditions that may impact the integrity of the facility. Seasonal effects and annual trends will be collected and compared over the years to the initial design assumptions regarding permafrost depth and active layer variable thickness.

3.2.1 Soil Temperature Monitoring Plan

Data will be retrieved from each of the data logger stations installed at the Landfill (or retrieved by manual methods, on a monthly basis). Once the data is retrieved and confirmed to be retrieved by a second party, the memory of the logger may be deleted to make space for the following years' measurements. Additional manual readings will be taken from each of the four thermistor strings that were installed at the landfill facility, as shown in **Figure 2** (attached).

The readings will be placed into a spreadsheet that converts the voltage readings to °C. The data will be compared with anticipated design maximum and minimum assumptions for the facility location. Specifically, anticipated permafrost depth and active layer thickness will be recorded and compared to design assumptions. The data will be presented in a graph in the annual report.

Soil temperature monitoring locations are shown in **Table 3-1**.

Table 3-1: Soil Temperature Monitoring Locations

Facility	Monitoring Station ID	Node #	Node Depth (mbgs)	Easting (UTM83)	Northing (UTM83)
Landfill	T-107	1	+1.3	521118.485	7076084.874
		2	+0.8		
		3	0.3		
		4	0.8		
		5	1.3		
		6	1.8		
		7	2.3		
		8	2.8		
		9	3.3		
		10	3.8		
		11	4.3		
		12	4.8		
		13	5.3		
		14	5.8		
		15	6.3		
		16	6.8		
Landfill	T-108	1	+1.0	520951.525	7075784.502
		2	+0.5		
		3	0.0		
		4	0.5		
		5	1.5		
		6	2.0		
		7	2.5		
		8	3.0		
		9	3.5		
		10	4.0		
		11	4.5		
		12	5.0		
		13	5.5		
		14	6.0		
		15	6.5		
		16	7.0		

Facility	Monitoring Station ID	Node #	Node Depth (mbgs)	Easting (UTM83)	Northing (UTM83)
Landfill	T-109	1	+1.8	520669.000	7076311.199
		2	+1.3		
		3	+0.7		
		4	+0.2		
		5	0.3		
		6	1.2		
		7	1.7		
		8	2.2		
		9	2.7		
		10	3.2		
		11	3.7		
		12	4.2		
		13	4.7		
		14	5.2		
		15	5.7		
		16	6.2		
Landfill	T-110	1	+1.5	520760.676	7076653.9
		2	+1.0		
		3	+0.5		
		4	0.0		
		5	0.5		
		6	1.0		
		7	1.5		
		8	2.0		
		9	2.5		
		10	3.0		
		11	3.5		
		12	4.0		
		13	4.5		
		14	5.0		
		15	5.5		
		16	6.0		

Facility	Monitoring Station ID	Node #	Node Depth (mbgs)	Easting (UTM83)	Northing (UTM83)
Landfill	T-111	1	+2.0	521441.000	7076739.000
		2	+1.5		
		3	+1.0		
		4	+0.5		
		5	0.0		
		6	0.5		
		7	1.0		
		8	1.5		
		9	2.0		
		10	2.5		
		11	3.0		
		12	3.5		
		13	4.0		
		14	4.5		
		15	5.0		
		16	5.5		

Notes:
mbgs denotes metres below ground surface
"+" in front of a depth denotes above ground surface (i.e., +2.0 denotes 2.0 metres above ground surface)

3.3 Seepage Monitoring

Observed areas for potential seepage identified along the berms will be noted during the Visual Inspection. Water that contacts unfrozen landfill waste may become acidic and contain elevated concentrations of constituents (e.g., metals). Seepage monitoring, in combination with visual inspections, will assist in identifying whether containment measures are sufficient, or whether corrective action is required.

3.3.1 Seepage Monitoring Plan

Potential observe areas of seepage on the surface and edges of the berms will be noted during the Visual Inspection. As the berms are to be constructed as part of a geomembrane-lined landfill, seepage is limited to springs along uncapped slopes. Seepage along the berms is not anticipated. If seepage is identified, seepage samples will be collected (where sufficient volume exists) and analyzed for:

- Field parameters including pH, conductivity, temperature;
- Petroleum Hydrocarbons (PHCs) Fractions F1 to F4, including benzene, toluene, ethylbenzene and xylenes (BTEX);

- Total metals;
- Polycyclic Aromatic Hydrocarbons (PAHs); and
- Major ions, hardness, total dissolved solids, total suspended solids.

The results will be compared to baseline sample concentrations, as well as the applicable License requirements (Section 3.10) and CCME guidelines (Section 1.1.2). Soil may also be collected at any potential seepage point as per **Section 3.4**. Results will be reported summarized and tabulated in the annual report to the City.

3.4 Soil Sampling

Soil sampling would be conducted on an as-needed basis in the event of observed seepage at the landfill, and or based on site activities and observations at the waste transfer station.

When soil samples are retrieved, the results will be compared to baseline sample concentrations and CCME guidelines (**Section 1.1.2**). Results will be reported summarized and tabulated in the annual report to the City.

3.5 Surface Water Monitoring

Natural drainage surrounding the facilities is influenced by the bedrock structure and small, elongated ponds that have formed along topographic lows. The surface water areas are relatively shallow and are considered to be under a freshwater environment. Surface water monitoring will provide information on the on-going state of the down-gradient surface water bodies.

3.5.1 Surface Water Monitoring Plan

Surface water sampling will be conducted at pre-determined surface water sampling stations that have been identified below in **Table 3-2** and are shown in **Figure 1** and **Figure 2**. These sampling stations correspond with the sampling stations established during the baseline monitoring.

During the landfill operation stage, each station will be monitored on a monthly basis for field parameters including pH, temperature, conductivity, Dissolved Oxygen (DO) and turbidity using a field-calibrated multi-meter (e.g., YSI ProDSS Multi-parameter Water Quality Meter). Equipment calibration and operation should be conducted in accordance with the manufacturer's recommendations and/or specifications.

In addition to monthly monitoring for field parameters, surface water sampling during the twice-annual FMP will be analysed for:

- Field parameters as described above;
- PHCs Fractions F1 to F4, including BTEX;
- Total Metals;

- PAHs; and,
- Major ions, hardness, total dissolved solids, total suspended solids.

Surface water monitoring locations are shown below in **Table 3-2**.

Table 3-2: Surface Water Monitoring Locations

Facility	Monitoring Station ID	Easting (UTM83)	Northing (UTM83)	Monitoring Type	Monitoring Frequency
WTS	SW1	522504.900	7070955.410	Field measurements	Monthly
				Field measurements + surface water samples	Twice per year
	SW2	522582.950	7070828.940	Field measurements	Monthly
				Field measurements + surface water samples	Twice per year
	SW3	522652.770	7070728.700	Field measurements	Monthly
				Field measurements + surface water samples	Twice per year
Landfill	WS-100	521440.475	7076184.088	Field measurements	Monthly
				Field measurements + surface water samples	Twice per year
	WS-101	520238.151	7076753.751	Field measurements	Monthly
				Field measurements + surface water samples	Twice per year
	WS-102	520353.135	7076116.866	Field measurements	Monthly
				Field measurements + surface water samples	Twice per year
	WS-103 (leachate discharge point)	TBD	TBD	Field measurements	None
				Field measurements + surface water samples	Twice per year (to characterize) and, upon discharge.

Notes:
TBD denotes To Be Determined, i.e., location to be established upon final design/construction. Approximate location shown in **Figure 2**.

The results will be compared to baseline sample concentrations, as well as the applicable License requirements (**Section 3.10**) and CCME guidelines (**Section 1.1.2**). Results will be reported summarized and tabulated in the annual report to the City.

3.6 Sediment Sampling

The natural drainage at both sites is influenced by the bedrock structure. Sediment samples are not a part of the facility monitoring program but may be introduced upon site closure or to whether surface water sample concentrations warrant further investigation. Sampling locations will correspond with surface water monitoring locations. Analysed samples will be compared to baseline/background samples, as well as the applicable CCME guidelines (**Section 1.1.2**). Results will be reported summarized and tabulated in the annual report to the City.

3.7 Active Layer Groundwater Monitoring

Active Layer Groundwater sampling will be conducted at pre-determined groundwater sampling stations that have been identified, and are presented below in **Table 3-3** and are shown in **Figure 1** and **Figure 2**. These sample stations correspond with the sampling stations established during the baseline monitoring.

During the landfill operation stage, each station will be monitored on a monthly basis for field parameters, including pH, temperature, conductivity, Dissolved Oxygen (DO) and turbidity using a field-calibrated multi-meter. It is anticipated that these monthly sampling events will be limited to months when the active layer is thawed and groundwater is available (i.e., June to September).

In addition to monthly monitoring for field parameters, groundwater sampling during the twice-annual FMP will be analysed for:

- Field parameters as described above;
- PHCs Fractions F1 to F4, including BTEX;
- Total Metals;
- PAHs; and,
- Major ions, hardness, total dissolved solids, total suspended solids.

Groundwater monitoring locations are shown below in **Table 3-3**.

Table 3-3: Groundwater Monitoring Locations

Facility	Monitoring Station ID	Easting (UTM83)	Northing (UTM83)	Monitoring Type	Monitoring Frequency
WTS	19MW-01	522597.930	7070755.780	Field measurements	Monthly
				Field measurements + surface water samples	Twice per year

Facility	Monitoring Station ID	Easting (UTM83)	Northing (UTM83)	Monitoring Type	Monitoring Frequency
Landfill	19MW-02	522541.680	7070812.280	Field measurements	Monthly
				Field measurements + surface water samples	Twice per year
	19MW-03	522945.780	7070726.690	Field measurements	Monthly
				Field measurements + surface water samples	Twice per year
	19MW-04	522477.550	7070799.770	Field measurements	Monthly
				Field measurements + surface water samples	Twice per year
	19MW-05	522493.750	7070873.090	Field measurements	Monthly
				Field measurements + surface water samples	Twice per year
	W-107	521118.485	7076109.874	Field measurements	Monthly
				Field measurements + surface water samples	Twice per year
	W-108	520951.525	7075809.502	Field measurements	Monthly
				Field measurements + surface water samples	Twice per year
	W-109	520669.000	7076331.199	Field measurements	Monthly
				Field measurements + surface water samples	Twice per year
	W-110	520760.676	7076678.900	Field measurements	Monthly
				Field measurements + surface water samples	Twice per year
	W-111	521441.000	7076739.000	Field measurements	Monthly
				Field measurements + surface water samples	Twice per year

3.8 Natural Environment Monitoring

Natural environment data will be collected as part of the facility monitoring program for both the WTS and the Landfill. This will include the following:

- Observations of animal usage at the site (i.e., direct observations, tracks, feces, etc.); and,
- Discussions with locals knowledgeable with the site regarding site usage.

A more detailed natural environment monitoring plan will be developed for the LTM upon site closure.

3.9 Effluent Discharge Limits

No discharge of effluent is anticipated to occur with site activities. Should seepage be identified or discharge events occur, the sample results will be compared against water quality criteria as defined under the Licence. Should it be determined that storage volumes within the ponds are nearing design capacity, the City, in consultation with the Nunavut Water Board, will access contingency actions including transporting quantities of effluent via pumper truck from the site to either the West 40 landfill (e.g., controlled discharge through the existing waste mass) or the City's WWTP. As secondary contingency (to be implemented only with the approval of NWB), a valved discharge manhole at the second storage pond will allow for the controlled release of effluent to a gravel bed diffuser. The implementation of the secondary contingency measure will necessitate additional surface water monitoring requirements at the Landfill site.

Table 3-4: Effluent Discharge Limits as per the Water Licence

Parameter	Maximum Concentration of any Grab Sample (mg/L)
TBD	TBD
TBD	TBD
TBD	TBD
TBD	TBD
TBD	TBD

Notes:
TBD denotes To Be Determined

3.10 Quality Assurance and Control Plan

The data quality objectives for this site are to produce a data set that is representative, and consistent in methodologies between sampling periods. A quality assurance and quality control (QA/QC) plan has been developed to meet these objectives.

3.10.1 Soil/Sediment Samples

Samples will be collected from test pits or sediments manually excavated with hand tools (shovel and/or hand shovel) which will be decontaminated between locations using Alconox and distilled water. Field personnel will use a new pair of Nitrile gloves for each sample station. Each solid sample will be collected in laboratory supplied containers that are specific for their analyses (i.e., metals/inorganics plastic bag, methanol vials and jars for organics). Jars will be filled with soil such that no headspace remains in the jars. Samples collected for analysis of volatiles (i.e., VOCs and/or BTEX) will be collected in two 40 mL clear glass vials with methanol for preservation.

Soil sampling locations will be backfilled after the collection of soil samples. Sampling locations will be photographed during sampling and after backfilling is completed, and these photographs will be included in the photographic records (**Section 3.1.1**).

3.10.2 Surface Water/Groundwater Samples

Surface water samples will be collected by dipping laboratory supplied containers with the appropriate preservative directly into the water body. Stirring up/contact with sediments is to be avoided to minimize introducing potential bias to the surface water samples. Surface water sampling will be conducted prior to sediment sampling.

Groundwater samples will be collected using the low flow technique (electric or manual pump) into clean, laboratory supplied containers. Due to the remote nature of the site and sampling locations, coupled with a potential for low productivity of groundwater in the monitoring wells, opportunistic sampling will be completed (as needed) following a limited purge. A limited purge of one bailer volume followed by sample collection provides a better chance of collecting a full suite of samples for lab analysis. Groundwater samples to be submitted for metals analysis will be field-filtered and preserved to maintain sample integrity.

Field personnel will use a new pair of nitrile gloves at each sampling station.

Field parameters to be monitored (both surface water and groundwater) using a calibrated multimeter include pH, temperature, conductivity, oxidation-reduction potential (ORP), dissolved oxygen (DO), and total dissolved solids (TDS). The field meter will be contaminated between each sampling station using Alconox and water.

3.10.3 Quality Assurance/Quality Control

A field quality assurance/quality control (QA/QC) program will be followed that is consistent with the CCME's Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk assessment (CCME, 2016). The goal of QA/QC is to limit errors and bias in sampling and analysis through the implementation of management, assessment, and control measures.

Analytical laboratories should be accredited by either the Canadian Association of Laboratory Accreditation Inc. (CALA) and/or through the Standards Council of Canada (SCC). Mandated protocols for specific parameters (e.g., CCME PHC Fractions F1 to F4 as defined in the Canada-Wide Standard for Petroleum Hydrocarbons in Soil, CCME, 2008) should be followed as applicable.

Two types of QA/QC samples have been identified for this program: field duplicate and blank samples. Samples will be given sequential, alphanumerical coding prior to being submitted to the analytical laboratories. The coding will be used to mask information concerning site location, sample type, or possible concentrations in the samples.

3.10.3.1 Field Duplicate Samples

Field duplicates are where split samples or co-located samples are obtained in the field using the same sampling procedure and are submitted to the analytical laboratory "blind". These are used to assess sampling and analysis precision. The recommended frequency for field duplicates is 1 in 10 samples (i.e., 10%). The analytical laboratory will provide its own laboratory duplicate samples. The recommended frequency for laboratory duplicate samples is 1 in 20 samples (i.e., 20%).

The sampling and analytical precision will be evaluated by calculating the relative percent difference (RPD) for a sample and duplicate pair using the following equation:

RPD = |X1-X2| / ([X1+X2]/2) x 100

Where:
X1 is the parent sample concentration.
X2 is the duplicate sample concentration.

The calculated RPD for field duplicates will be compared against a value approximately 2 times that of the analytical laboratory's RPD criteria to account for the greater variability anticipated in field duplicate samples (as compared to laboratory duplicate samples). The calculated RPD will be method and analytical laboratory-specific, and the values to be used for each parameter group will be clearly defined in the summary reports.

RPDs cannot be calculated when either the parent or duplicate sample concentrations are below or near the analytical method detection limits (MDLs). RPDs can only be calculated when the concentrations detected in both the parent and duplicate sample are greater than five times the reportable detection limit (RDL) or MDL. Alternative criteria is proposed for evaluating the data when one or both of the results is less than the RDL or MDL and is adapted from Zeiner (1994). When both concentrations are below the RDL or MDL, no calculation/evaluation criteria is required. A summary of the different scenarios is provided below in **Table 3-5**.

Table 3-5: Criteria for the Evaluation of Duplicate Sample Results

Scenario	X1	X2	Criteria for Acceptance (Soil/Sediment)	Criteria for Acceptance (Water)
1	Non-detect	Non-detect	Acceptable precision, no evaluation required	
2	Non-detect	Detect	X2 – (0.5xMDL) < 2xMDL	X2 – (0.5xMD)L < MDL
3	Value	Value	Calculated RPD < (parameter, analytical laboratory specific RPD)	Calculated RPD < (parameter, analytical laboratory specific RPD)
4	Value	Detect	|X2-X1| < 2 x MDL	|X2-X1| < MDL

Notes:
Non-detect denotes concentrations that are below the RDL/MDL.
Detect denotes concentrations that are above the RDL/MDL, but less than 5 x the RDL/MDL.
Value denotes concentrations that are greater than 5 x the RDL/MDL.
In Scenario D, when the result reported is less than half the quantitation limit, half the limit will be used in the equation.

3.10.3.2 Blank Samples

There are three types of blank samples: trip, equipment and field.

- **Trip Blanks:**
  - Where a clean sample of the matrix being analyzed is transported to and from the site unopened using the same container as the samples analyzed; used to assess whether cross-contamination occurred during sample transport and storage. The recommended frequency for equipment blanks is 1 in 10 samples (i.e., 10%) being analyzed for volatile parameters (e.g., VOCs, BTEX, PAHs).
- **Equipment Blanks:**
  - Prepared in the field, where for example, contaminant-free water (distilled-deionized) or air is passed through a sampling device (e.g., pump and tubing); used to assess equipment decontamination procedures. The recommended frequency for equipment blanks is 1 in 10 samples (i.e., 10%).

Field Blanks:

- Which consist of a clean sample (e.g., distilled-deionized water) where the sample container is exposed to sampling conditions (i.e., cap removed) or where an ambient air sample is obtained; used to check for artifacts introduced by background conditions. The recommended frequency for equipment blanks is 1 in 10 samples (i.e., 10%) being analyzed for volatile parameters (e.g., VOCs, BTEX, PAHs).

4.0 Monitoring Schedule and Reporting

4.1 Schedule

During Landfill Operation, the recommended initial monitoring frequency will be semi-annual, capturing site information upon spring melt, and again in the late summer/early fall before freeze-up. When groundwater and surface water are accessible for monitoring, monthly surface water and groundwater field parameter measurements will be collected. At a minimum, monthly thermistor measurements will be retrieved from the Landfill.

A detailed LTM will be developed prior to site closure.

4.2 Reporting

4.2.1 Nunavut Water Board Annual Reporting

It is anticipated that annual reporting will be submitted to the Nunavut Water Board in accordance with the Water Licence. Items to be included in the report will be outlined in the Water Licence.

4.2.2 Facility Monitoring Reporting

Upon the completion of the semi-annual monitoring events, one Annual Facility Monitoring Report will be created as per contractual agreements between the City of Iqaluit and Dillon. The report will include:

- An executive summary describing the main observations, assessment and conclusion (visual inspection results, assessment and conclusions) and any items to be addressed during subsequent site visits;
- An outline of annual work program activities, including work objectives and scope of work, location map, site plan, timing of and weather conditions during field work, field staff and schedule, approach/methodology and equipment used for each monitoring component, and any deviations from the monitoring plan;
- Annotated drawings of the Landfill and WTS areas showing all visual inspection features, photograph viewpoints, chemical monitoring sample points and surface water flow directions;
- Analytical data from any chemical testing will be tabulated in excel format and presented;
- Formal laboratory certificates will be included as an appendix;
- A discussion and comparison of chemical data to both historical and background concentrations, as well as to the selected EQGs (Section 1.1.2);
- A discussion on QA/QC relative to the analytical results;
- An analysis of the overall performance of the Landfill and WTS areas, based on a combination of current and historical (when available) visual, geotechnical, and chemical values;
- Review concentrations and trends to evaluate future monitoring requirements; and,
- Recommendations for future action and conclusions.

Figures

KEY PLAN

Sampling Locations	NORTHING	EASTING
19MW-01	7070775.7800	522597.9300
19MW-02	7070812.2600	522541.6800
19MW-03	7070726.6900	522495.7800
19MW-04	7070799.7700	522477.5500
19MW-05	7070873.0900	522493.7500

SW1
CONSTRUCTION AND DEMOLITION DEBRIS PAD
BALE STORAGE AREA
SNOW STORAGE
QAQQAMUIT ROAD
N7070881.58
E522468.39
19MW-05
EMERGENCY GENERATOR
HHW DEPOT
WASTE TRANSFER STATION
N7070854.22
E522446.08
SNOW STORAGE
HHW STORAGE CONTAINERS
N7070848.74
E522531.34
REUSE CONTAINER
SW2
N7070821.38
E522519.03
19MW-02
MISCELLANEOUS METALS/WHITE GOODS STORAGE PAD
TIRE STORAGE
PARKING
19MW-04
SCALE HOUSE
SITE OFFICE
SNOW STORAGE
END OF LIFE VEHICLE AND MISCELLANEOUS METALS STORAGE
19MW-01
GREENHOUSE (FUTURE)
COMPOST PAD (FUTURE)
SNOW STORAGE
KAKIVAK COURT
19MW-03
TP3
BALER LOGGER
SW3
AREA FOR POTENTIAL COMPOST AND BIO-MASS EQUIPMENT

LEGEND:

- APPROXIMATE PROPERTY BOUNDARY
- SURFACE WATER FLOW
- 19MW-00 — MONITORING WELLS
- SURFACE WATER SAMPLING LOCATIONS
- SURFACE STAINING
- TIRE STORAGE — PROPOSED SITE INFRASTRUCTURE / DESCRIPTIONS

Iqaluit

DILLON CONSULTING

DATE JANUARY 2020

PROJECT CITY OF IQALUIT
FACILITY MONITORING PLAN

PROJECT NO. 19-9543

TITLE WASTE TRANSFER STATION
PROPOSED FACILITY LAYOUT

FIGURE NO. 1

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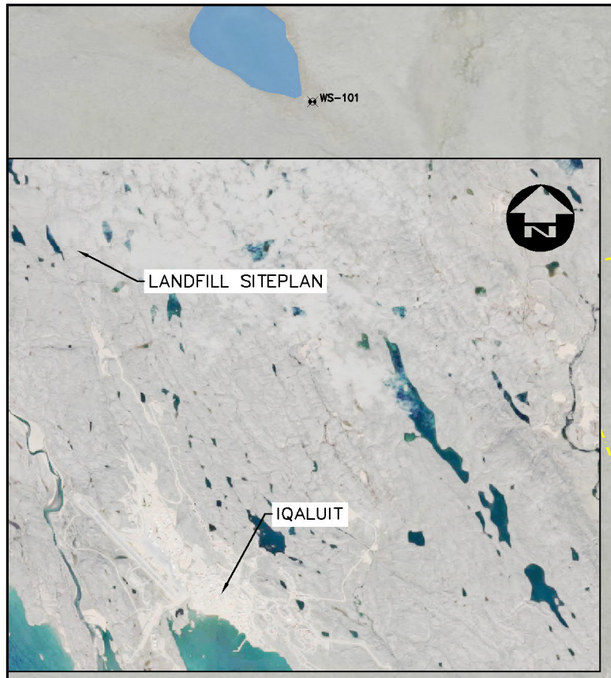

KEYPLAN

SAMPLING LOCATIONS	NORTHING	EASTING
WS-100	7076184.088	521440.475
WS-101	7076753.751	520238.151
WS-102	7076116.866	520353.135
W-107	7076109.874	521118.485
W-108	7075809.502	520951.525
W-109	7076331.199	520669.000
W-110	7076678.900	520760.676
W-111	7076749.000	521441.000
T-107	7076084.874	521118.485
T-108	7075784.502	520951.525
T-109	7076311.199	520669.000
T-110	7076653.900	520760.676

LEGEND:

- SITE PROPERTY BOUNDARY
- FUTURE ROAD
- 50m BUFFER
- BOULDER FIELD
- GLACIOFLUVIAL TERRACE
- GROUND WATER PONDING
- GROUND WATER FLOW
- BEDROCK OUTCROP
- T-108 THERMISTOR
- W-108 ACTIVE WATER MONITOR STATION
- WS-108 SURFACE WATER
- DITCH FLOW DIRECTION
- DRAINAGE DITCH
- LEACHATE PIPING

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Iqaluit

DILLON CONSULTING

DATE JANUARY 2020

PROJECT **CITY OF IQALUIT**
FACILITY MONITORING PLAN

PROJECT NO. **19-9543**

TITLE **LANDFILL SITE PLAN**

FIGURE NO. **2**

References

CCME, 2016. Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment, Volume 1: Guidance Manual. PN 1551.

Dillon Consulting Limited, 2019. Soil and Groundwater Sampling Results Summary – Baseline Environmental Data Collection. Prepared for: City of Iqaluit.

EXP Services Inc., 2018. Physical and Biological Assessment, Proposed New Landfill Site, Iqaluit, NU. Prepared for: City of Iqaluit.

EXP Services Inc., 2018. Phase II Environmental Site Assessment, New Waste Transfer Station, Iqaluit, NU. Prepared for: City of Iqaluit.

Zeiner, S.T., Realistic Criteria for the Evaluation of Field Duplicate Sample Results, Proceedings of Superfund XV, November 29-December 1, 1994, Sheraton Washington Hotel, Washington, D.C. – modified to use Method Detection Limit (MDL) or Reportable Detection Limit (RDL) in lieu of the Quantitation Limit (QL), the Instrument Detection Limit (IDL) and/or Laboratory Reporting Limit (LRL).