LEACHATE COLLECTION AND CHARACTERIZATION PLAN

TO:	City of Iqaluit, c/o Colliers Project Leaders
FROM:	Chris Shortall, Dillon Consulting Kyle MacIntyre, Dillon Consulting Scott Kyle, Dillon Consulting
DATE:	February 2, 2023
SUBJECT:	Iqaluit Leachate Collection and Characterization Plan (Final)
OUR FILE:	19-9543
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Introduction

The City of Iqaluit ('the City') is in the process of establishing a new waste transfer station (WTS) and engineered landfill site to service their near and long-term (75 years) municipal and solid waste disposal requirements. Dillon Consulting was retained to complete the design and Stage 1 construction of the landfill. As part of the City's new Solid Waste Landfill ('the Site'), a method of leachate collection and treatment must be finalized.

As a component of the landfill predesign effort, Dillon completed a triple bottom line impact assessment on the various options of leachate management based on direction from the City and previous studies (by Others), which included an aerated lagoon and wetland treatment area (WTA) option, pre-treatment and haulage to the City's wastewater treatment plant (WWTP) option, and an on-site mechanical treatment option. The assessment identified that the aerated lagoon and WTA as the preferred option based on the financial costs and the environmental criteria. However, due to the novelty of the landfill using plastic wrapped bales in an arctic environment and limitations of lagoons for treatment of certain parameters, the quantity and quality of leachate generated is uncertain thus various implementation options were discussed with the City and Water Board.

A WTA, as paraphrased from CSA W203:19 (Planning, design, operation and maintenance of wastewater treatment in northern communities using lagoon and wetland systems), are natural areas that receive wastewater effluent from lagoons for supplemental treatment. Found typically in low-lying tundra areas, they support native plant species which use biological, physical and chemical processes to treat wastewater effluent. They are a low cost, passive treatment option used regularly throughout Nunavut. One of the primary disadvantages of WTAs is that they often require several years/growing seasons to reach peak performance. While much of their performance is via physical means (filtration, sedimentation), biological update is an important factor.

The aerated lagoon and WTA were selected to balance risk versus capital investment and long-term operating costs. It was subsequently determined that additional water quality and quantity testing be conducted after the landfill is commissioned, rather than designing on potentially over-conservative assumptions. This would determine whether the recommended treatment method will be capable of treating the generated leachate to acceptable standards, if a more robust treatment method (metals precipitation/filtration) will be required, or if the leachate will be of adequate quality to support direct discharge to environment. As an interim method of management, the City will capture leachate in new engineered lagoons for the initial two years of landfill operation.

This leachate collection and characterization plan has been developed to aid in characterizing leachate quality/quantity to support a firm direction for the leachate management strategy. As part of the final construction and commissioning phase (but before leachate is pumped from the landfill), any standing water (rainfall) in the lagoons should be removed by the Contractor to restore the full storage capacity.

Sampling and Testing Plan

Testing Locations and Frequency

Exercise extreme caution when working around the lagoons due to risk of falling into the water or down the exterior side slope.

The holding lagoons will be operational for up to two years, with the highest leachate generation rates expected during the spring thaw. It has been assumed that minimal leachate is generated during months where the average temperature is below 0^{o}C and landfill 'freezeback' has occurred. It is therefore recommended that the bulk of sampling and testing be focused during the primary leachate generation months, as this typically represents the period of greatest leachate strength and variability.

Sampling and testing should begin during the spring thaw, and be in accordance with the Water License. Should sampling results stabilize, sampling frequency can potentially be reduced over the leachate generation season. During the winter months, monthly sample collection and testing is recommended to allow for capture of any seasonal variations; however, winter testing can be eliminated or scaled back further if leachate is not generated at a substantial enough volume to allow for sample collection.

Samples should be collected over a full two-year period in order to capture seasonal and operational landfill variations and satisfy the sampling plan requirements for the Nunavut Water Board. However, as landfill material, composition and state (open cell, closed cell, partially capped cell) is subject to change over a number of years, leachate quality may undergo further variability and possibly require more robust treatment methods. It is therefore recommended that long-term monthly sampling and testing during the leachate generation season continue to occur over the landfill's lifetime, even if results stabilize.

Data should be analyzed on a continuous basis, with annual summaries prepared. Depending on variations in leachate quality and quantity, recommendations can be made regarding increasing/decreasing sampling frequencies over subsequent months in consultation with the Water Board.

If possible, samples should be collected at both the areas of leachate generation (i.e. collection sumps) and from the inlets and outlets/discharge manhole of both of the holding ponds[1]. This is to identify characteristics of the raw leachate as well as the leachate that has been held over a period of time, which may aid in determining how retention time, settling, and/or passive aeration may impact contaminant concentrations and guide future management plans. Refer to Figure 1 for general sampling locations.

Parameters

The parameters that should be analyzed, at minimum during the initial testing, are as follows in accordance with the Water License.

- Biological Oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)
- Total Suspended Solids (TSS)
- Total Kjeldahl Nitrogen (TKN)
- Nitrite (NO_2)
- Nitrate (NO_3)
- Total ammonia
- Total Phosphorus (TP)
- Orthophosphate
- Conductivity (field and lab)
- Temperature (field)
- Total metals
- PCBs
- BTEX

Leachate samples will be collected from the identified sample point and shipped to an accredited 3rd-party laboratory to be analyzed for the above parameters. It is assumed that all sample collection and reporting activities will be performed by City staff or third-party contractors. Lab QA/QC procedures are to be followed, and any issues noted with sample collection.

Leachate Flow Monitoring

The City's Operations and Maintenance Manual for the landfill and WTS outlines the leachate flow/volume characteristics that are required to be monitored and reported within facility records. These data include:

- Daily landfill leachate generation rates
- Leachate collection manhole water depths
- Storage volumes within the ponds (nominal 10,575 m^3 and 4,935 m^3 respectively)
- Diversion of leachate to an alternative discharge location, or to the environment

It should be ensured that during the leachate characterization phase, the procedures for collecting, collating, and documenting the above parameters are maintained to allow for a full record of leachate flow/volume and generation rates. Daily, weekly and monthly precipitation data and incoming material quantities should also be collected and documented to help correlate leachate generation rates with rainfall and waste material volumes.

[1] It is noted that not all collection sumps (i.e. the four leachate collection sumps located in Cell 1, Cell 4, Cell 7 and Cell 10) may be active during the 2-year collection period, and sample collection will be limited to the sumps that are receiving leachate from active cells.

Leachate generation rates can be monitored daily by measuring water levels in the ponds (using the staff gauge welded to the liner of the lagoon) and corresponding capacity chart. As this does not account for evaporative losses, generation rates can also be estimated by monitoring/logging pump runtimes and flowrates. As tracking this information could prove to me operationally burdensome, it is recommended that a portable flow meter be installed on the sump pump outlet to allow for more reliable logging of leachate flows.

Leachate Characterization

Leachate quality characteristics are generally highly variable based on the life of the landfill and nature of solid waste being baled. To appropriately design a treatment system, leachate characterization is required to avoid a potentially overly conservative design, and subsequently increased CAPEX/OPEX.

Raw leachate data should be used to estimate the average and worst-case raw influent quality entering the leachate treatment system, and holding cell data can be used to estimate levels of treatment achieved through retention time and passive aeration. Flow and volume data can be analyzed to determine leachate generation rates and extrapolated alongside precipitation data to determine future 75-year design flows. When a new cell opens the leachate strength is typically artificially lower than after years of waste have been placed. When selecting a sample location, consider whether the large volumes of runoff may be diluting certain results depending on conditions at time of sample.

Based on discussions with regulators and the NWB, two different effluent standards have been deliberated:

- The CCME limits describe the effluent quality targets required for discharge directly to the environment, for the protection of aquatic life. This generally applies to fresh or marine waters, whereas there is no discernible watercourse or waterbody near the landfill site.
- The design effluent (WTA) objectives are the effluent targets suggested for discharge to a wetland, per the original basis of design of a lagoon + WTA treatment system. This effluent objective was derived from discussions with NWB and considers the CCME limits as well as the discharge limits as stated in the Environmental Guideline for Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities (2011), considering landfill leachate as a “non-point source discharge”.
    - While the design effluent objectives for an aerated lagoon + WTA treatment system have been derived from GN Dept of Environment guidelines and guidance from NWB, it is ultimately the regulator’s decision to confirm these values as a pertinent objective. Design effluent objectives are therefore subject to change based on regulatory review and approval.

The concentrations for these guidelines are shown below in Table 1.

Table 1. Effluent objectives for discharge to environment (CCME) and wetland (design effluent objective).

	Parameter	CCME[1]	Design Effluent Objective[2]
Biological Parameters	Carbonaceous Biochemical Oxygen Demand (5 day)	25 mg/L	15 mg/L
	pH	6.5 – 9.0	6.5 – 9
	Total Ammonia (NH_3-N)	Varies (10.3 mg/L used)[4]	10 mg/L
	Total Suspended Solids	Varies (typ. 25 mg/L)	15 mg/L
	Total Phosphorus	-	1.0 mg/L
Heavy metal and chloride parameters	Chloride	120 mg/L	-
	Cadmium[3]	0.09 ug/L	100 ug/L
	Chromium[3]	1 – 8.9 ug/L	100 ug/L
	Copper[3]	4.0 ug/L	1000 ug/L
	Iron	0.3 mg/L	0.3 mg/L
	Lead	7 ug/L	50 ug/L
	Arsenic[3]	5 ug/L	1000 ug/L
	Nickel[3]	25 ug/L	1000 ug/L
	Zinc	7.0 ug/L	50 ug/L

Notes:
1) CCME Water Quality Guidelines for the Protection of Aquatic Life.
2) Proposed effluent objective to be confirmed by regulatory body.
3) Preliminary influent quality estimated to be below effluent objectives but impacts to treatment process still considered.
4) Assuming a pH of 7.0 and temperature of 10° C. As temperature and pH increase, the CCME TAN discharge limit decreases due to the relationship between un-ionized and ionized ammonia.
5) List is not comprehensive of full sampling regime; please refer to other sections.

The above guidelines can be used to help guide suggested treatment methods. In general, the leachate can be categorized into the following categories:

- Meets CCME targets (low biological, low metals)
- Meets Design Effluent Objectives (low biological, moderate metals)
- Meets no targets (high biological, low metals)
- Meets no targets (moderate to high biological, moderate metals)
- Meets no targets (high biological, high metals)

Figure 1 below represents a generalized decision flow chart to provide insight into how leachate characterization may be used to guide the appropriate management and treatment method. This is a generalized methodology that can be used to illustrate the level of treatment complexity required for different leachate strengths, and more specific recommendations will be made based on actual raw/holding pond leachate characteristics and quantities generated; the final adopted approach will form the basis for detailed engineering design following the completion of the monitoring period.

In general, biological parameters (BOD, TSS, nutrients) are more easily treated through lagoon and wetland processes, although additional process intensification may be required to target nutrients such as ammonia and phosphorus to target levels. Heavy metals generally require removal via physical processes such as flocculation, settling, pH adjustment (precipitation), and/or filtration.

A higher BOD/COD ratio (>0.5) generally represents wastewater that is readily biodegradable, whereas a lower BOD/COD ratio (<0.5) typically indicates more slowly biodegradable wastewater; ratios below 0.2 indicate the presence of toxicity and suggests that biological treatment alone may not be successful in reducing organics.

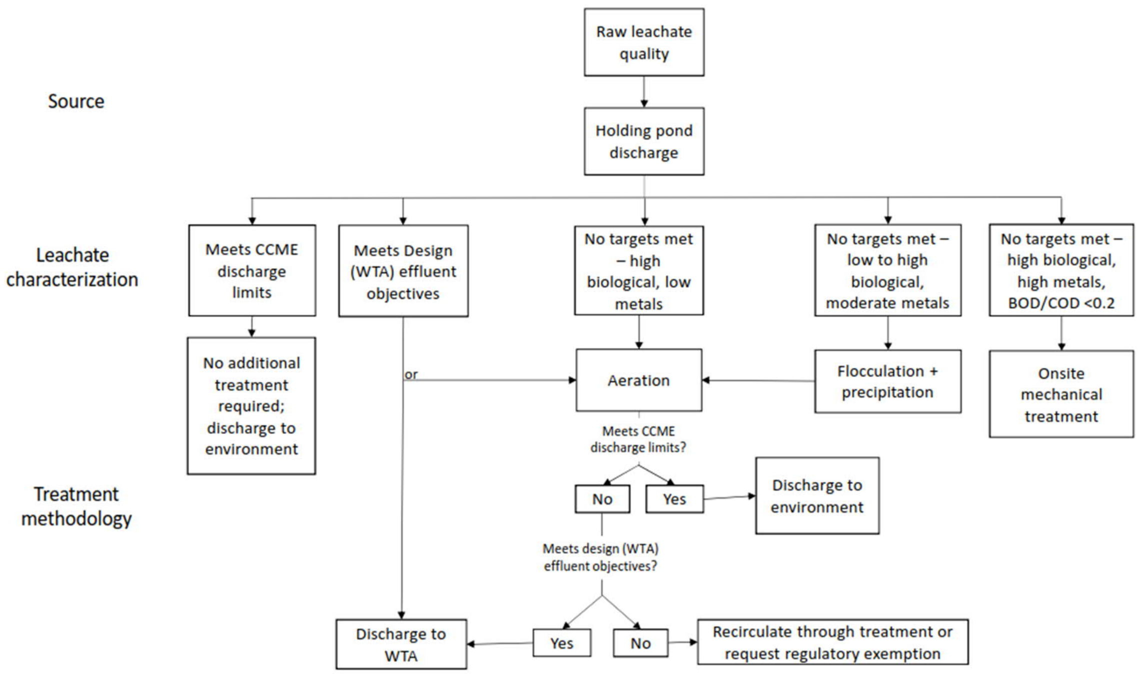

Figure 1. Recommended treatment considerations based on leachate characterization. Note that recommended management approaches will change based on actual leachate quality and quantity. Should any mechanical system need to be installed, power to the site will need to be considered.

Contingency Measures & Emergency Discharge

The lagoons are designed to hold a total of approximately 2 years' worth of leachate generation (using current precipitation values plus an allowance for climate change). Should the actual two year rainfall (and by association leachate generation) exceed the current storage capacity, there are several contingency options:

- Referring to Figure 1, receive regulatory approval and discharge the leachate to an appropriate location (level spreader/WTA);
- If still operational, haul leachate to the former North 40 landfill site and utilize treatment system (aerated lagoons, chemical addition and filtration with marine discharge);
- Stop pumping from the landfill sump to the lagoons temporarily. This will temporarily increase the level of leachate in the landfill and require additional monitoring to ensure

it does not overtop the geomembrane liner, but would not require any emergency environmental releases;
- Use of temporary deployable pre-fabricated storage tanks (not preferred)

The lagoon level can be lowered by either removing/changing the weir gates or by portable pump and generator.

In the event of a lagoon berm failure or significant liner leak, efforts should be focused on reducing the water level in the lagoon to below the failure point, and directing any unauthorized discharges to the general level spreader/WTA location. While approximately 6 km away, the city’s water supply lake is generally downstream of the landfill site and appropriate measures should be taken in the event of any spill. These may include the installation of temporary environmental controls such as silt curtains, sand bags, and water quality monitoring. The interior and exterior berms should be monitored for leaks, signs of settlement and general integrity/condition weekly during active pumping, and monthly during the winter months.

Spills should also be directed away from the adjacent access road where possible. Runoff could erode the granular subbase and lead to road damage, which would further hinder emergency response capabilities.

Solids Management Requirements

All treatment methods will require solids management as part of the overall treatment process, and consideration for the appropriate methods should be reviewed. Solids are generated as part of biological processes, chemical precipitation and physical separation, and typically require removal by dredging accumulated solids from the lagoon, dewatering (e.g. Geotube bags or centrifuge) and disposal. Should chemical addition be required to facilitate metals removal, pH adjustment, or carbon supplementation, the amount of solids generated will increase as will the frequency of required solids management operations. Recommendations for solids removal and disposal can be made following characterization of leachate and chemical dosing requirements.

Lagoon sludge surveys are recommended to occur once every five years (more frequently if necessary) to monitor remaining storage volume and plan accordingly. This can be done via ROV survey boat using bathymetric sonar (preferred) or manual measurements (e.g. sludge judge) from a boat on a grid pattern.

Implementation Schedule

Engineering and construction of any upgrades deemed necessary to the lagoons can take several months-years, and should be planned for accordingly. Based on the current landfill construction schedule with completion in fall 2024, the following general milestones are recommended:

Milestone	Description

Fall/Winter 2024	Construction of the landfill, WTS and storage lagoons is complete. Bales start being placed in January 2025.
Spring 2025	Freshet/melt begins, leachate generation expected to increase significantly. Sampling program implemented (unless already, deemed necessary due to winter leachate)
Summer 2025	Begin engineering review/design based on preliminary data. Evaluate if any additional field information is necessary (e.g. survey, geotechnical) for upgrades and complete before first snowfall. If available leachate data presents a case that it will be poor quality (i.e. high metals, organics, solids), detailed engineering and procurement could be advanced on a risk basis. Identify any upgrades that can proceed immediately while additional data is collected (e.g. earthworks, power)
Fall 2025	Winter freezeup sets in, leachate flow expected to decrease significantly; continue monitoring. Procurement of any long-lead time items identified for treatment upgrades.
Winter/Spring 2026	Determine amount of leachate generated in the first year of operation, and correlate expected increase of annual MSW placement alongside rainfall data. Begin monitoring during snowmelt and leachate generation.
Summer 2026	Continue monitoring and engineering/procurement as needed. If initial summer '26 results support '25 data, a final treatment approach can be considered and finalized. In mid-late summer if leachate generation values are above expected, implement any contingency measures needed in the next 12 months.
Fall 2026	Continue monitoring and implementation of any upgrades.
Winter/Spring 2027	Expected time when the leachate lagoons will reach their maximum storage. Final implementation plan should be completed, or scheduled for completion in spring/summer 2027 (refer to flow chart). Contingency measures may need to be made depending on amount of leachate generated during spring 2027 and timeline for remaining work.
Ongoing	Monitor leachate quality and quantity trends; prepare annual summaries and backup data; review treatment system performance (if applicable) and make changes as necessary.
Late 2040s	20 year design life for the system will be approaching; consider any major capital upgrades needed to extend service life.

Leachate Generation Estimates

Year	Month	Precipitation (mm)			Cell Status												Approximate Monthly Leachate	
		Open Cell Area (O)	Active Cell Area (A)	Closed Cell Area (C)	1	2	3	4	5	6	7	8	9	10	11	12		
		Approximate Cell Area (m^2)			16,300												m^3	
1	Jan	0.73	15.511	25.298	253												253	
	Feb	0.345	2.43	1.369	40												40	
	Mar	0.255	1.429	0.778	23												23	
	Apr	0.181	3.901	0.488	64												64	
	May	0.147	5.297	0.369	86												86	
	Jun	45.75	12.741	0.272	208												208	
	Jul	64.298	26.695	8.124	435												435	
	Aug	33.862	46.565	47.548	759												759	
	Sep	26.939	60.181	59.768	981												981	
	Oct	79.097	51.97	50.58	847												847	
	Nov	51.328	69.117	23.907	1,127												1,127	
	Dec	4.122	85.759	94.376	1,398												1,398	6,220
2	Jan	0.73	14.947	25.374	244												244	
	Feb	0.345	1.285	1.37	21												21	
	Mar	0.255	0.718	0.778	12												12	
	Apr	0.181	3.975	0.488	65												65	
	May	0.147	8.076	0.369	132												132	
	Jun	0.116	13.696	0.279	223												223	
	Jul	72.883	21.857	1.091	356												356	
	Aug	46.325	47.298	50.307	771												771	
	Sep	53.336	39.447	28.342	643												643	
	Oct	9.826	68.659	64.191	1,119												1,119	
	Nov	4.624	34.265	43.816	559												559	
	Dec	0.692	5.975	1.944	97												97	4,241
3	Jan	0.363	1.264	0.852	21												21	
	Feb	0.222	0.628	0.49	10												10	
	Mar	0.184	0.473	0.394	8												8	
	Apr	0.14	1.879	0.294	31												31	
	May	0.119	6.511	0.246	106												106	
	Jun	46.255	7.45	0.223	121												121	
	Jul	4.243	11.629	31.143	190												190	
	Aug	48.642	40.443	35.463	659												659	
	Sep	22.685	51.26	41.332	836												836	
	Oct	17.621	50.651	27.446	826												826	
	Nov	2.708	11.162	4.485	182												182	
	Dec	0.622	2.151	1.172	35												35	3,024
	Jan	0.342	0.892	0.652	15												15	
	Feb	0.219	0.514	0.419	8												8	
	Mar	0.176	0.493	0.338	8												8	
	Apr	0.135	0.508	0.26	8												8	

Year	Month	Precipitation (mm)			Cell Status												Approximate Monthly Leachate	
		Open Cell Area (O)	Active Cell Area (A)	Closed Cell Area (C)	1	2	3	4	5	6	7	8	9	10	11	12		
		Approximate Cell Area (m^2)			16,300												m^3	
4	May	0.115	11.348	0.222	185												185	
	Jun	44.348	4.079	0.169	66												66	
	Jul	32.615	23.235	14.692	379												379	
	Aug	82.83	30.738	26.465	501												501	
	Sep	40.599	82.628	59.444	1,347												1,347	
	Oct	38.259	72.039	53.931	1,174												1,174	
	Nov	5.064	70.819	88.467	1,154												1,154	
	Dec	1.617	5.117	6.123	83												83	4,929
5	Jan	0.531	12.574	1.204	205												205	
	Feb	0.286	1.277	0.61	21												21	
	Mar	0.223	3.128	0.463	51												51	
	Apr	0.163	1.905	0.334	31												31	
	May	0.135	11.855	0.274	193												193	
	Jun	45.904	6.272	0.29	102												102	
	Jul	52.126	12.957	36.628	211												211	
	Aug	64.205	36.374	17.988	593												593	
	Sep	73.568	73.33	37.976	1,195												1,195	
	Oct	43.74	83.969	68.617	1,369												1,369	
	Nov	1.955	89.064	94.344	1,452												1,452	
	Dec	0.577	45.25	28.118	738												738	6,161

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2022 07 18

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8	RELEASED FOR CONSTRUCTION	2022/07/18	K.B.
7	RELEASED FOR TENDER	2022/04/14	K.B.
6	REVIEW	2021/09/24	K.B.
5	REVIEW	2021/06/25	K.B.
4	100% ISSUED FOR APPROVAL	2020/12/15	K.B.
3	90% REVIEW	2020/01/24	K.B.
2	50% REVIEW	2019/10/23	K.B.
1	30% REVIEW	2019/06/04	K.B.

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REVIEWED BY: S.D.K.
DRAWN: D.B.C./ D.T.M.
CHECKED BY: K.B.
DATE: MAY 2019
SCALE: 1:500 (22x34) 1:1000 (11x17)

CITY OF IQALUIT
SOLID WASTE LANDFILL

LEACHATE LAGOONS PLAN & PROFILE

PROJECT NO. 19-9543

SHEET NO. LF-C26