

SECTION 2 EXISTING CONDITIONS

The existing on-site surface runoff management system consists of a series of continuous perimeter ditches associated primarily with perimeter berm structures (see Figure 2-1). The on-site runoff control ditches drain to several runoff control ponds. Two dedicated runoff storage ponds serve the existing landfill operating area, and two dedicated runoff storage ponds serve the landfill expansion area (see Figure 2-2). The ponds provide a control area where the runoff may be sampled and pumped into a runoff retention pond. The surface runoff in the retention pond will be pumped to the proposed runoff wetland area for treatment during the frost free period every year.



Figure 2-1. Continuous ditches formed with a perimeter berm structure to control on-site and off-site surface runoff at the West 40 landfill site in Iqaluit.

CLIMATE

Weather conditions influence wetland processes and the treatment performance, especially in cold climates. The engineering limitations in the design of constructed wetlands (CWs) in cold climates are the ice formation, hydrology and temperature effects on the biological and microbiological mediated treatment processes. However, these limitations may be overcome by design and operation of the system.



The average monthly temperatures in Iqaluit vary from 2.2 to 7.7 degree Celsius from June through September and -4.4 to -28 degree Celsius from October through May based on Environment Canada data in the period of 1971 to 2000. The average annual precipitation is 198 mm of rainfall and 236 cm of snowfall for a mean annual precipitation total of 412 mm. **Appendix A** presents detailed Canadian Climate Normals for Iqaluit from 1971 to 2000. Figure 2-3 shows the average monthly temperature from 1971 to 2000. The frost free period ranges from middle May to early September.

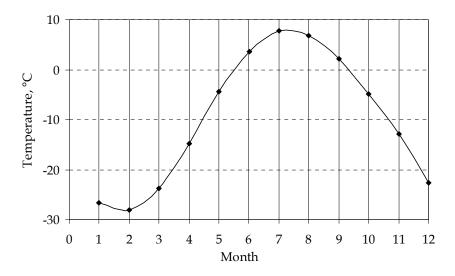


Figure 2-3. Average monthly temperature in Iqaluit from 1971 to 20000

LANDFILL RUNOFF CHARACTERIZATION

Landfill runoff sampling at the landfill site was completed in 2004 and 2006. The 2004 sampling was collected by the City of Iqaluit, and the 2006 sampling was completed by Earth Tech (Canada) Inc. The report "Runoff Sample Analysis – Comparison of 2004 and 2006 Samples" prepared on July 31, 2006 provides a detailed comparison of the 2004 and 2006 results (**Appendix B**).

The sampling results shows that the concentrations of many of the parameters have increased over the past two years, especially Aluminum (Al) concentration in 2006 increased to 5.01 mg/L from 0.048 mg/L detected in 2004 sample. The major parameters exceeding the Guidelines for the Discharge of Treated Municipal Wastewater in the Northwest Territories (1992) in 2006 sampling event are Biochemical Oxygen Demand (BOD₅), Total Suspended Solid (TSS) and metal contents including Aluminum, Iron, Copper, Lead, Manganese and Zinc.



DRAINAGE CONTROL PONDS AND RETENTION POND

Four drainage control ponds are located in the landfill area at West 40 Landfill site (see Figure 2-2). An existing pond was augmented by three new ponds in 2006. The total volume of these control ponds is approximately 3000 m³. A runoff retention pond was also constructed in 2006 as the area where accumulated runoff in the control ponds may be pumped to (Figure 2-4). The volume of the retention pond is approximately 5000 m3. Figure 2-5 shows a runoff control pond and Figure 2-6 shows the retention pond.



Figure 2-5. Runoff control pond (October 2006)

The runoff retention pond was constructed in original ground with a compacted base. The base materials are typically loamy sands based on the grain size distribution. The loamy sand is a material

permeability, and has significant fractions of silt

and gravel sized materials (see Figure 2-7).

graded

with

limited



Figure 2-6. Drainage retention pond (October 2006)

100 80 Percent smaller 60 40 20 0.001 0.01 0.1 10 100 Grain size (mm)

Figure 2-7. Grain size distribution of compacted base in the runoff retention pond

CONTAMINANT REMOVAL IN THE RETENTION POND

A portion of the runoff contaminants may be reduced by sedimentation and infiltration in the retention pond. Sedimentation of the suspended particulate matter to the base of the retention pond may occur in the quiescent conditions of the pond.

Infiltration into the base of the pond is another mechanism for the reduction of contaminants in the retention pond. The loamy sand base material has the capacity to allow the runoff to flow through the material and the contaminants reduced. The mechanisms of filtration, biodegradation and absorption/adsorption in the soil may reduce contaminants. Contaminant migration into the active layer may be limited by the permafrost regime, the permeability of the



base material, and the removal mechanisms in the soil material.

AVAILABLE LAND AREA FOR WETLAND TREATMENT

The proposed wetland treatment area is located east of the runoff retention pond. The slope in the proposed wetland location is generally from west to east (see Figure 2-4), which provides a positive drainage slope by gravity for the proposed wetland. The actual slope required for the wetland depends on the hydraulic conductivity of selected bedding materials. The existing elevations of the runoff retention pond and the proposed wetland area are summarized in Table 2-1.

Table 2-1. Elevations of the proposed wetland location

Location	Elevation (m)	Notes
Top of runoff retention pond	13.5	
Bottom of runoff retention pond	11.0	
Inlet of wetland area	11.0	
Outlet of wetland area	9.0	Can be further extended to elevation of 7.0 m if more wetland area needed.



SECTION 3 WETLAND SYSTEMS

Both natural and constructed wetland systems have been used to treat a variety of wastewaters including runoff from landfills. The use of constructed wetland, rather than natural wetlands, may be preferred because constructed systems may be specifically engineered for the particular wastewater characteristics. Constructed wetlands allow a greater degree of control of substrate, vegetation types, flow characteristics, and flexibility in sizing. Constructed wetlands are engineered systems that have been designed and constructed to utilize the natural functions of wetland vegetation, soils, and their microbial populations to treat contaminants in various wastewater streams. Constructed wetlands also have significantly lower lifecycle costs than conventional treatment systems, and may be operated using less power and less labor.

Constructed wetlands are categorized into two main groups: surface flow (SF) and subsurface flow (SSF). Figure 3-1 shows the detail of typical constructed wetland cells for SF and SFF. Factors to be considered include land area availability, capital cost, runoff composition concentrations, and the potential public health risks. Unlike a natural wetland system in which hydrology is largely fixed by the tolerance limits of the existing plant community, a constructed wetland may be designed to regulate water depth and retention time based on the influent quality.

This section will discuss two options for a constructed wetland system for the treatment of onsite surface runoff generated from the Iqaluit landfill site. The advantages and disadvantages of the options will also be discussed in this section. Section 4 will discuss the design criteria for wetland treatment of runoff in Iqaluit, and the mechanisms for removal of contaminants by wetland treatment.

OPTION 1: SURFACE FLOW WETLAND

A constructed SF wetland is a shallow, engineered pond (about 30 cm deep) that is planted with local emergent and rooted vegetation. Runoff is introduced at one end and flows across the wetland area to the discharge point.

The emergent plants of SF wetlands are not harvested to remove nutrients. Instead, the natural assimilative capacity of the microbial flora (bacteria and fungi) that attach to the plants, provides efficient and reliable removal of biodegradable organics and nitrogen (ammonia and nitrate). Metals and phosphorus may be sequestered in plant materials and wetland sediments. Most of the treatment is a function of the microbial, physical and chemical action rather than plant uptake; therefore, these processes may occur during cold weather.



OPTION 2: SUBSURFACE FLOW WETLAND

SSF wetlands are gravel or organic soil based systems, in which the wastewater substrate passes through the permeable media. The flow is subsurface in and around the roots of the wetland plants. Flow through the media may also be horizontal flow, referred as subsurface horizontal-flow wetland; or vertically downward, referred as subsurface vertical-flow wetland. The large surface area of the media and the plant roots provides sites for microbial activity, and SSF systems use many of the same emergent plant species as SF systems.

SSF wetland systems have better performance in cold weather because most of the treatment occurs below the ground surface where the treatment processes are less affected by cold air temperatures. In addition, media based systems have relatively low in maintenance requirements and are less likely to have odor and mosquito problems in comparison with SF wetlands. When properly designed, media based wetland systems have high removing efficiency rates for biodegradable organic matter and nitrate-nitrogen.

A consideration that makes the SSF system attractive is the reduced potential for human contact with partially treated wastewater, which reduces public health concerns.

SELECTION OF WETLAND PROCESS

The advantage and disadvantage of SF wetland and SSF wetland are compared in Table 3-1. As previously discussed, on-site surface runoff is collected and stored in the runoff retention pond before discharge to the wetland. The suspended solids will be reduced by sedimentation in the retention pond (as discussed in section 2), therefore, the clogging may not be a significant operational problem for subsurface flow (SSF) wetlands. Since the wetland may be only operated during the frost free period every year in Iqaluit, the snow or ice insulation of SF wetland is not an advantage over SSF system.

There are some general considerations for the design of a constructed wetland, and every wetland system is site-specific and the assistance of an experienced wetland designer is critical to the success of a wetland project. Some key components to consider are:

- Available land area
- Available vegetation
- Available soil materials
- Contaminant removal objectives
- Operating window dictated by freezing conditions
- Hydraulic retention time (HRT)
- Gravity flow availability
- Nuisance controls (i.e. mosquito and odour control)
- Maintenance and self-sustainability



Table 3-1. Comparison of surface flow and subsurface flow wetlands

Wetlands	Advantages	Disadvantages
Surface flow	 Minimal clogging problems Air stripping potential of organic toxic contents Snow/ice cover as an insulation 	More area than SSFPotential air quality degradation
Subsurface flow	 Less area need than SF Better contact between soil and water Greater thermal protection than SF 	 Tendency of plugging of pore space Higher cost than SF for a certain pollutant mass removal

For Iqaluit, the proposed wetland treatment system will be located adjacent to the existing landfill site. The available and optimal location is the area east of the runoff retention pond, which is sloped from west to east. An existing stream just north of this area may be used for effluent discharge. The runoff stored in the retention pond will be pumped to the wetland inlet by setting up a potable pump over the berm structure.

As stated in Section 2, the average temperature from June to September is approximately 5°C with an average daytime high of 11.6 °C and an average overnight low of -0.4 °C. The construction of a SSF system will reduce or eliminate the potential of the runoff freezing. Layers of snow, ice, and organic materials will provide an insulating barrier to the cold. This may help to extend the wetland operation period from May to October.

To meet the perspective discharge criteria, it is important to design the wetland system with a hydraulic retention time (HRT) sufficient to reduce the organic contaminant and nitrogen concentrations under cold water temperature conditions. This will require additional land area as compared to a system operated with a warmer water temperature. The minimum HRT is 7 to 10 days for SF wetlands and 2 to 4 days for SSF wetlands. Based upon this criterion, the land area required for a SF wetland system will be at least twice as large as a SSF wetland system.

The porous media of SSF wetland will provide more contact area between contaminants and microbes/medium particles. The contaminants will first partition from the liquid phase into the solid phase, and then be absorbed by the plant roots. The SSF wetland systems have a higher removal efficiency for biodegradable organic matter and nitrate-nitrogen than SF wetland system in comparing the areal removal rate constant (Kadlec and Knight 1996).

Considering the advantages and disadvantages listed in Table 3-1, and the local conditions in Iqaluit, a SSF wetland system is recommended for Iqaluit landfill surface runoff treatment process. This conclusion is supported by the conceptual process information from Riparia Aquatic Ltd., a wetland treatment specialist. The technical memo from Riparia regarding the wetland conceptual design for the City of Iqaluit is presented in **Appendix C**.



SECTION 4 DESIGN CRITERIA

WATER QUALITY PARAMETERS

Wetland performance may be characterized by contaminant concentration reduction, by mass reduction or by areal load reduction. There are no guidelines for treated landfill surface runoff in Nunavut. The benchmark conditions on the treated discharge are the discharge limits for Sewage Lagoon effluents of the City of Iqaluit Water Licence issued by NWB, 2006. The major parameters are summarized in Table 4-1.

Table 4-1. Proposed treated wetland outflow water quality parameters

Parameters	Limits of Water Licence	Maximum Concentration of Any Grab Sample			
BOD ₅ (mg/L)	120	180			
TSS (mg/L)	180	270			
Oil and Grease	No visible sheen				

The following paragraphs discuss the removal potential of major contaminants contained in the runoff by constructed wetlands in general.

TOTAL SUSPENDED SOLIDS

Suspended solids are principally removed in a wetland system by physical filtration processes. Both surface flow (SF) and subsurface flow (SSF) wetland systems effectively remove suspended solids from contaminated water. Suspended solids within SSF system may block the pores or bedding media, and as a result, will decrease the hydraulic conductivity or the flow through the system, especially near the inlet.

ORGANICS - BOD

Organic matter is removed in the wetland systems by deposition and filtration for settleable BOD, and by microbial metabolism for soluble BOD. The removal efficiencies for BOD₅ vary significantly depending on the organic loading rates, dissolved oxygen concentration, water temperature, bedding media and plant species. The oxygen sources for these reactions are important for the efficient removal of organic matters. The major oxygen source in surface flow wetlands is aeration at the water surface. However, the water mixing at the surface will be



reduced by the vegetation and snow or ice cover. Oxygen conveyed through the plant root system supports the aerobic microbial activity adjacent to roots. The average temperature from June to September of 5°C in Iqaluit will lower biological activity, which ultimately means a decreased oxygen transfer efficiency and lower biochemical activity. This may be compensated by providing a longer hydraulic retention time and a lower hydraulic loading rate for the proposed wetland.

METALS

Metals are removed by cation exchange to wetland sediments, precipitation as insoluble salts and plant uptakes. The major concerned metals are Iron, Zinc, Copper, Aluminum and Lead in Iqaluit, based on the 2006 sampling results. The average removals of these metals were reported in the range of 50 to 90 percent by constructed wetlands in the literature.

NUTRIENTS - N & P

The reduction of nutrients, nitrogen (N) and phosphorus (P) requires the longest hydraulic retention time of any of the anticipated pollutants. The phosphorus concentration measured in 2006 sampling event was 0.8 mg/L, which is lower than the Canadian Guideline 1.0 mg/L. For most wetland treatment, P is not regarded as an important pollutant; however, P is a required supplement to support biological processes.

The total nitrogen concentration was measured 20.7 mg/L as Kjeldahl Nitrogen (TKN) for the 2006 sampling event, which includes organic nitrogen and ammonia. The nitrite (NO_2^- -N) and nitrate (NO_3^- -N) are less than 0.07 mg/L, which is not a concern. The NWT guidelines (1992) do not provide a discharge limit on the ammonia, however, ammonia in wastewater effluent may be deleterious to fish in the receiving water body if the concentration is more than 0.2 mg/L. A certain level of ammonia removal is expected from a SSF wetland. However, it is not possible to achieve high total nitrogen removal in cold climate constructed wetland without adding supplemental oxygen for nitrification, and carbon sources for denitrification.

HYDRAULIC DESIGN PARAMETERS

The retention pond provides storage for runoff generated from landfill site during the period of October through May. It is anticipated that the wetland treatment for the retention pond accumulation will be operated during the frost free period of June through September.

SURFACE RUNOFF VOLUME

Based on the monthly precipitation from November through May (8 months), the average total precipitation is 161 mm. The total landfill area (existing and new area) is approximately 48,000 m²; therefore, the anticipated total volume of runoff generated from snowfall is approximately



7,700 m³. During the summer and fall months (June through October), the anticipated surface runoff volume is approximately 6,600 m³ (Table 4-2), assuming that 50% precipitation will retain in the runoff control ponds and retention pond.

A significant portion of the summer and fall runoff will infiltrate into the landfill subsurface, therefore, the surface runoff volume generated will be much less than the amount shown in Table 4-2. Assuming fifty percent (50%) of rainfall precipitation accumulates into surface runoff, the runoff control ponds and the retention pond have enough capacity for storing the surface runoff from landfill site for spring runoff. The actual runoff resulting from summer and fall precipitation and stored in the control ponds and the retention pond may be monitored as part of the on-going facility operations. Summer runoff may be directed through the wetland with retention.

Table 4-2. Surface Runoff Volume Projection at Landfill Site (1971 to 2000)

	November to May	June to October
Precipitation (mm)	161	252 *
Estimated runoff volume (m³)	7,700	6,600

Note: * 50% precipitation was used to estimate the runoff volume.

HYDRAULIC RETENTION TIME (HRT)

Hydraulic retention time for constructed wetlands is typically in the range of 1 to 10 days. The HRT for the proposed SSF wetland system is 4 days to maximize the removal of the contaminants based on the local conditions, as recommended by Riparia (Appendix C) and Alberta Environment guidelines.

HYDRAULIC LOADING RATE

Hydraulic loading rate is a primary design factor for constructed wetlands. The selection of an appropriate design loading rate should be based on several factors, including treatment objectives, wetland used for levels of treatment, wetland types (SF or SSF), and safety factors. Since constructed wetlands technology is a variable science, the facility may be conservatively designed with low loading rates. The average loading rates for wetland treatment of municipal wastewater is approximately 3 cm/day. Considering the cold climate and runoff parameters at the landfill site, the proposed design hydraulic loading rate is 2.5 cm/day.



SECTION 5 CONCEPTUAL DESIGN

Based on the information in the preceding sections of this report, it is possible to develop a conceptual design for the selected SSF wetland. The design of the wetland will include the sizing of wetland, a pumping system to pump runoff from the retention pond to the wetland, the plant selection suitable for the local climate and removal of contaminants, bedding materials, and the reduction of suspended materials in the retention pond.

The proposed approach to the facility design is to complete a pilot study to determine the performance of the wetland system. A series of sampling tests will be needed to determine the surface runoff water characteristics in the retention pond and the wetland itself over the duration of the wetland operating season.

CONCEPTUAL DESIGN OPTIONS

Based on the discussion in Section 4, the estimated surface runoff volumes are 7,700 m³ from November to May and 6,600 m³ for June to October. Runoff testing to meet the guidelines of NWT, may provide some flexibility in the discharge strategies. The potential total runoff treatment needs for the wetland may be up to 14,300 m³ per year.

It should be pointed out that these volume numbers are based on the following assumptions:

- Average precipitation will occur as the statistics from Environment Canada.
- All the snow runoff will be collected and stored in the drainage control ponds and the retention pond.
- Fifty percent of summer rainfall runoff will filtrate into the landfill area and 50% will flow into the control ponds.
- There is no peak factor selected due to the buffer capacity of the retention pond.

Table 5-1 compares the referred guidelines for the proposed wetland discharge with Environment Canada guidelines and Alberta Environment guidelines. The current discharge limits for BOD5 and TSS from Sewage Lagoon in Water Licence of the City of Iqaluit are the same as those in NWT guidelines. The more strict guidelines may be warranted within the next 10 or 20 years. In 2005, Yukon government prepared Draft Interim Guidelines for Community Wastewater Discharges, which is intended to help communities in the planning of new and upgraded sewage treatment systems to comply with the Canada-wide Strategy. The Canada-wide Strategy for wastewater discharge will include all the provinces and territories.

Based on the above assumptions, the proposed wetland system may be implemented as follows:

• Phase 1 surface runoff volume 7,700 m³ with phase 2 expansion (6,600 m³) in the future.



Table 5-1. Comparison of Guidelines of Treated Wastewater Discharge in Canada

Guidelines	NWT Guidelines ³	Yukon Interim Guidelines 7 Environment Alberta 4		Environment Canada ⁵
BOD ₅ , mg/L	120	45	25 ¹	20
TSS, mg/L	180	60	25 ¹	25
TP, mg/L	Site specific	-	1 ²	16
NH ₃ +-N, mg/L	-	-	Site specific	-
Fecal coli., cfu/100 mL	-	20,000	200	400
Iron, mg/L	0.3	-	ı	-
Zinc, mg/L	0.5	-	-	-
Aluminum, mg/L	2.0	_	-	-
Lead, mg/L	0.05	-	-	-

¹ Population < 20,000;

CONSTRUCTED WETLAND STRUCTURE

The proposed wetland will be a subsurface flow wetland with permeable soil matrix growing medium as discussed in Section 3. Runoff will be introduced via perforated head pipe to a gravel flow dispersion trench. Runoff will permeate through the side of the flow spreader trench, through a peat bed, then into the permeable medium. The sacrificial peat bed will buffer the wetland against spike concentrations of contaminants (Figure 5-1). Since there is a slope from the inlet to the discharge point of the proposed wetland area, the SSF will be designed as a horizontal subsurface flow. The design slope will be calculated based on the anticipated hydraulic conductivity of available materials for the bedding media. At the outlet of the wetland, another gravel trench will be placed with a perforated pipe. The treated runoff may then be discharged to a stream on the northeast corner of proposed SSF wetland (See Figure 2-4).

² Populations > 20,000;

³ Guidelines for the Discharge of Treated Municipal Wastewater in the NWT, 1992 (Season: Summer, 150-600 Lcd, Receiving Environment: Marine/Bay);

⁴ Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage System, Alberta Environment, 2006;

⁵ Guidelines for Effluent Quality and Wastewater Treatment at Federal Establishments, 1976, Report EPS-1-EC-76-1, Federal Activities Environmental Branch;

⁶ Applicable when phosphorus removal is required.

⁷ Draft 2005 Interim Guidelines for Communities Wastewater Discharge, Yukon Environment, 2005.



NATURE IN ACTION

The ability of wetlands to remove contaminants from water relies on the emergent plants, which play a key role in a wetland treatment process. Plants provide an oxygen source to help sustain aerobic conditions in the wetland, and plant roots provide passages for water to filtrate through the bedding media.

As water slowly flows through a wetland, pollutants are removed through physical, chemical, and biological processes. The physical processes include entrapment, sedimentation and adsorption. The biological processes include nitrification and denitrification, the uptake of nutrients and metals by plants, and by organisms that occupy on the bedding media. The different species of organisms and plants may have markedly different success depending on factors such as type and toxicity of individual pollutant, water level and temperature.

WETLAND SIZING

The performance of a constructed wetland for contaminant removal often depends on the proper interaction among hydraulic retention time (HRT) and flow, contaminant compositions, vegetation and seasonal temperatures. It is difficult to determine the exact area needed for effective treatment of runoff since specific hydraulic and pollution fluctuations, as well as varying local climatic conditions have to be taken into consideration. There are two methods to estimate the preliminary area for the constructed wetland. One method is to use the model based on reaction kinetics developed by Kadlec and Knight (1996). The other method is to calculate the land area required using the selected hydraulic loading rate. **Appendix D** illustrates the model and calculation used in this report to estimate the land area required for wetland construction.

PHASE 1: RUNOFF 7,700 M³

Reaction Model Method of Area Determination

Kadlec and Knight provided a model to determine the preliminary area requirements based on desired effluent quality, first areal rate constants and background limits of the contaminants. To achieve a conservative estimate of land area required, modeling was conducted on BOD and TSS. The other factors can be used in modeling are TP, TN, ammonia, and organic nitrogen. However, the sampling programs conducted in 2004 and 2006 shown that the results of these parameters are below the guidelines of NWT, 1992. **Appendix D** presents the detail calculation using this model.

The land area calculated is 840 m^2 to meet the BOD discharge guideline 120 mg/L. Should the BOD discharge concentration be 45 mg/L (as in 2005 Yukon Interim), the area required is $2,070 \text{ m}^2$.



Hydraulic Loading Rate Method of Area Determination

The hydraulic loading rate is assumed to be 2.5 cm/day (0.025 m³/m²/day) for optimal removal efficiency (as discussed in Section 4). Therefore, the area estimated for surface runoff treatment during average 105 frost free days is

$$(7700 \text{ m}^3) / (105 \text{ days}) / (0.025 \text{ m}^3/\text{m}^2/\text{d}) = 2940 \text{ m}^2$$

The land area required for a SSF wetland system to treat 7,700 m³ of surface runoff, as sampled in June 2006, is approximately 2,940 m².

PHASE 2: ADDITIONAL 6,600 M³ TO A TOTAL OF 14,300 M³

Reaction Model Method of Area Determination

As the same method used in Phase 1, the required land area is 720 m² for a 120 mg/L BOD discharge limitation. If the discharge limit of BOD is 45 mg/L, the total land required for a wetland treatment system will be 1,770 m² to meet the BOD discharge guideline.

Hydraulic Loading Rate Method of Area Determination

The hydraulic loading rate is assumed to be 2.5 cm/day ($0.025 \text{ m}^3/\text{m}^2/\text{day}$) for optimal removal efficiency. Therefore, the area needed for surface runoff during average 105 frost free days is

$$(6600 \text{ m}^3) / (105 \text{ days}) / (0.025 \text{ m}^3/\text{m}^2/\text{d}) = 2520 \text{ m}^2$$

The wetland sizing estimated by above two methods was quite different. The land area required to treat 6,600 m³ of runoff is estimated to be 2,520 m² by selecting larger land area. This wetland system will also meet the land area required for the future BOD discharge limit as discussed above.

MODEL COMPARISONS

Comparing the reaction model method with hydraulic loading rate method, the difference for the calculated land area to treat the same runoff volume is significant. The calculated land area by the reaction model method is the area required to treat BOD to meet the effluent guidelines as indicated in Appendix D, BOD is the governing parameter based upon its larger area requirement.

The temperature has significant effect on the reaction rate model based on van't Hoff Arrhenius equation, where K_{T1} and K_{T2} are first-order rate constants at temperature T1 and T2 (see Appendix D).

$$K_{T1} = K_{T2} \cdot \boldsymbol{\theta}^{(T1-T2)}$$

The rate constant and temperature coefficient in the calculation are based on the broad range of study results, not specifically for the cold climate. Therefore, these parameters may not



represent the actual biochemical reaction and rate constants in the proposed wetland system, particularly the temperature coefficient, θ .

The land area requirement calculated from hydraulic loading rate is much larger than the land area calculated from the reaction model. In order to be conservative, the larger land area requirements will be applied to the proposed wetland system during the conceptual design. The pilot study results will allow for an optimization of the wetland system based upon the local conditions.

CONCEPTUAL LEVEL COST ESTIMATE

A conceptual level cost estimate of various components has been completed for the two phases of the wetland (Table 5-2). The spreadsheet showing the breakdown of this cost estimate is presented in **Appendix E**. The total construction cost for both phases does not include capital for land acquisition since it is assumed that the land for the wetland is the property of City of Igaluit.

Table 5-2. Cost Estimation of Proposed Wetland System

Wetland Component	Phase 1	Phase 2
Wetland Construction	\$ 176,550	\$ 173,425
Vegetation	\$ 9,000	\$ 8,316
Pumping system	\$ 10,000	\$ 10,000
Engineering contingency (40%)	\$ 78,220	\$ 76,696
Total construction cost estimate	\$ 273,770	\$ 268,437



SECTION 6

RECOMMENDATIONS & IMPLEMENTATION

RECOMMENDATIONS

It was recommended that the subsurface flow wetland system be designed to treat the surface runoff from the landfill site of Iqaluit, as discussed in Section 3. Horizontal flow may be designed to utilize the slope of the wetland area.

Based on the information presented in this report, Iqaluit may develop the wetland system for the treatment of landfill on-site surface runoff in two phases. Phase 1 will have a 7,700 m³ treatment capacity to meet the current discharge quality requirement. Phase 2 will have a 6,600 m³ treatment capacity for the future process improvements. During the pilot operation, by collecting the water quality parameters of the wetland influent and discharge, the operation of the wetland treatment system will be monitored and evaluated for the need of Phase 2 expansion.

It is important to point out that wetland technology is still in a developing phase, and it is not possible to predict the ultimate wetland performance.

IMPLEMENTATION

The conceptual design for Iqaluit West 40 Landfill site surface runoff provides a practical and valuable solution for the management and protection of water bodies surround the landfill site. Following the recommendations made within this report, the next steps are:

- 1) Submit the conceptual design report for regulators' review;
- 2) Monitoring the quality of runoff contained in control ponds and the retention pond;
- 3) Complete preliminary engineering for the pilot program (Phase 1) for the proposed wetland treatment;
- 4) Complete detailed design and tendering for Phase 1 and construction;
- 5) Operate the Phase 1 facility and monitor results;
- 6) Plan for facility optimization based on Phase 1 results.



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Appendix A

City of Iqaluit Weather Climate Normals

from Environment Canada

(1971 - 2000)

Climate Normals for City of Iqaluit from 1971 to 2000 (Data adapted from Environment Canada)

Temperature: Temperature:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Average (°C)	-26.6	-28	-23.7	-14.8	-4.4	3.6	7.7	6.8	2.2	-4.9	-12.8	-22.7	
Standard Deviation	5	3.8	3.7	2.6	2.1	1.7	1	0.9	1.1	2.5	3.6	4.7	
Daily Maximum (°C)	-22.5	-23.8	-18.8	-9.9	-0.9	6.8	11.6	10.3	4.7	-2	-8.9	-18.5	
Daily Minimum (°C)	-30.6	-32.2	-28.6	-19.6	-7.8	0.3	3.7	3.3	-0.4	-7.7	-16.7	-26.9	
Extreme Maximum (°C)	3.9	4.4	3.9	7.2	13.3	21.7	25.8	25.5	17.2	7.3	5.6	3.4	
Date (yyyy/dd)	1958/21	1965/22	1955/19	1981/23	1954/30	1955/22+	2001/28	1991/08	1964/03+	1981/05	1952/19	2001/29	
Extreme Minimum (°C)	-45	-45.6	-44.7	-34.2	-26.1	-10.2	-2.8	-2.5	-12.8	-27.1	-36.2	-43.4	
Date (yyyy/dd)	1953/24+	1967/10+	1991/01	1983/10	1949/02	1978/02	1961/03	1996/31	1965/30	1978/30	1978/18+	1993/30	
	1												
Rainfall (mm)	0.1	0	0	0.2	2.8	24.7	59.2	64.8	41.5	4.5	0.5	0	
Snowfall (cm)	22.8	16.8	25.3	32.4	25.1	9.8	0.1	0.8	13.7	34.9	32.4	21.7	
Precipitation (mm)	21.1	15	21.8	28.2	26.9	35	59.4	65.7	55	36.7	29.1	18.2	
Average Snow Depth (cm)	22	23	25	29	18	2	0	0	0	6	16	20	13
Median Snow Depth (cm)	21	23	25	28	16	1	0	0	0	6	15	19	13
Snow Depth at Month-end													
(cm)	23	25	29	27	10	0	0	0	1	10	21	21	14
Extreme Daily Rainfall (mm)	2.5	2	0.5	5.1	11.7	28.4	52.8	48.2	40.4	23.3	11.9	0.5	
Date (yyyy/dd)	1958/21	1963/03	1958/09	1950/20	1986/14	1961/30	1968/14	1995/08	1979/01	1985/24	1955/01	1963/16	
Extreme Daily Snowfall (cm)	30.7	32.2	24.6	21.8	29.5	19.2	3.6	6.2	21.3	20.6	27.9	21.8	
Date (yyyy/dd) Extreme Daily Precipitation	1958/18	1981/12	1973/08	1973/07	1965/09	1984/09	1970/08	1981/29	1946/26	1961/08	1960/24	1951/03	
(mm)	30.7	27.4	23.9	23.9	27.4	30.2	52.8	48.2	40.4	27.2	27.9	21.8	
Date (yyyy/dd)	1958/18	1981/12	1953/29	1973/07	1965/09	1980/06	1968/14	1995/08	1979/01	1985/25	1960/24	1951/03	
Extreme Snow Depth (cm)	57	74	69	86	86	43	1	3	15	33	52	48	
Date (yyyy/dd)	1977/15+	1956/27	1963/01+	1958/30	1958/01+	1987/02	1978/01+	1957/24+	1992/29	1961/29+	1989/27	1958/23	

Appendix B

Surface On-site Runoff Wastewater

Quality Data and Report

City of Iqaluit Solid Waste Disposal Facility (Landfill) Improvements

Runoff Sample Analysis – Comparison of 2004 and 2006 Samples

July 31, 2006

INTRODUCTION

Earth Tech (Canada) Inc. was retained by the City of Iqaluit for the "Solid Waste Disposal Facility (Landfill) Improvements" project. The scope of the project is to provide engineering consulting services for the landfill expansion, and onsite and offsite drainage improvements.

According to the City's Water License (3AM-IQA0611 Type "A; valid till May 15, 2011), the City has to submit an annual report to the Nunavut Water Board highlighting the collection and analysis of samples from a specified location at landfill. As a part of the project scope/license requirement, Earth Tech collected a sample of runoff in duplicate from the City's landfill on June 28, 2006.

This report provides a summary of sample results, and their comparison with the 2004 sample results. The purpose is to determine the change in runoff quality over the time.

SAMPLING HISTORY

The 2004 sample was collected by the City (Geoff Baker, Manager of Capital Projects) on July 6, and was shipped on the same day to the PSC Analytical Services, Ontario. Figure 1 shows the location of sampling points.

The 2006 sample was collected in duplicate by Earth Tech on June 28 from the sampling point that corresponds to "x 103" on Figure 1. The samples were transported to Edmonton on the same day, and delivered at the Norwest Labs (Edmonton) on the morning of June 29.

SAMPLING DATA AND DISCUSSION

Table 1 presents a summary of the sample results. The results are compared with the Guidelines for the Discharge of Treated Municipal Wastewater in the Northwest Territories, 1992, considering values for summer season with a rate of 150-600 Lcd and a marine/bay as the receiving environment.

CONCLUSIONS AND RECOMMENDATIONS

The results show that the concentrations of two thirds of measured runoff parameters are within the MWWE Guidelines. The concentrations of many of the parameters have increased over the past two years. The parameters that currently exceed the MWWE Guidelines are TSS, BOD_5 , $Fe_{dissolved}$, Al_{total} , Cu_{total} , Pb_{total} , Mn_{total} and Zn_{total} .

The most significant increase is in the Al_{total} concentration, which has increased over 100 times from the concentration detected in the 2004 sample. Other significant increases have occurred in the concentration of TSS, BOD_5 , Cu_{total} , Sn_{total} and V_{total} . It should be noted that the results comparison is based upon no consideration of the potential errors in 2004 sample results arising from no sample preservation before shipping to the laboratory, and high temperature at the time of receiving by the laboratory (9°C).

Overall, the historic runoff sample results suggest that the landfill runoff needs to be appropriately managed, and direct discharge into the environment should be controlled.

Table B-1. Comparison of runoff samples in 2004 and 2006

Table B-1.	Joinparison (ples in 2004 an	
Runoff Discharge Parameter	Units		mple Results	MWWE
		Jul-04	Jun-06	Guidelines ⁽¹⁾ 6.5 - 8.5 ⁽²⁾
pH	pH units	7.41	7.52	6.5 - 8.5
Specific Conductivity	μmoh/cm	1667.0	2050.0	0.0*
Iron (dissolved), Fe ⁻	mg/L	0.2	0.7	0.3*
Chloride, Cl ⁻	mg/L	215.0	249.0	
Nitrite Nitrogen, NO ₂ -N	mg/L	< 0.2	< 0.02	
Nitrate Nitrogen, NO ₃ -N	mg/L	< 0.2	< 0.05	
Ammonia Nitrogen, NH ₃ -N	mg/L	4.42		
Kjeldahl Nitrogen (TKN)	mg/L		20.7	
Phosphate, PO ₄ ⁻³	mg/L	< 0.1	0.8	
Sulphate, SO ₄ -2	mg/L	398.0	307.0	500.0*
Sulfur, S	mg/L		105.0	
Phenols	mg/L	4.42		
Mercury, Hg	mg/L	< 0.0001	0.0001	0.0006
Biochemical Oxygen Demand, BOD ₅	mg/L	5.2	269	120.0
Oil and Grease	mg/L	2		
Total Suspended Solids, TSS	mg/L	32.0	868.0	180.0
Total Dissolved Solids (Calc.), TDS	mg/L		1330.0	
Hardness	mg/L		660.0	
Silver, Ag _{total}	mg/L	< 0.0001	0.0006	0.1
Aluminum, Al _{total}	mg/L	0.048	5.01	2.0
Antimony, Sb _{total}	mg/L	0.0051	0.0238	
Arsenic, As _{total}	mg/L	0.002	0.018	0.05
Boron, B _{total}	mg/L	0.71	1.06	5.0*
Barium, Ba _{total}	mg/L	0.035	0.12	1.0*
Beryllium, Be _{total}	mg/L	< 0.001	<0.0002	
Bismuth, Bi _{total}	mg/L	< 0.001	<0.001	
Bromide, Br	mg/L	2.3	V0.001	
Calcium, Ca _{total}	mg/L	166	203	
Cadmium, Cd _{total}	mg/L mg/L	0.0024	0.0024	0.005*
Cobalt, Co _{total}	mg/L mg/L	0.0024	0.0024	0.1*
Copper, Cu _{total}	mg/L	0.0039	0.294	0.2*
Chromium, Cr _{total}	mg/L	< 0.005	0.0241	0.1
Iron (total), Fe _{total}		8.86		0.1
	mg/L		0.0993	0.05*
Lead, Pb _{total}	mg/L	0.0191		0.03
Lithium, Li _{total}	mg/L	267	0.02	
Magnesium, Mg _{total}	mg/L	26.7	49 [±]	0.05*
Manganese, Mn _{total}	mg/L	0.903	1.02	0.05
Molybdenum, Mo _{total}	mg/L	0.006	<0.001	
Nickel, Ni _{total}	mg/L	0.016	0.0226	0.3*
Phosphorous, P _{total}	mg/L	0.25	0.8	Site-Specific
Potassium, K _{total}	mg/L	36.8	61.7	
Sodium, Na _{total}	mg/L	125.0	207.0	
Selenium, Se _{total}	mg/L	< 0.002	0.0009	0.05

Down off Disabours Downwater	TT\$4-a	Runoff Sample Results		MWWE
Runoff Discharge Parameter	Units	Jul-04	Jun-06	Guidelines ⁽¹⁾
Silicon, Si _{total}	mg/L		9.42	
Strontium, Sr _{total}	mg/L	0.8600	1.0100	
Tin, Sn _{total}	mg/L	0.001	0.02	5.0
Titanium, Ti _{total}	mg/L	< 0.005	0.382	
Thallium, Tl _{total}	mg/L	< 0.00005	< 0.0001	
Uranium, U _{total}	mg/L	< 0.0001	< 0.001	
Vanadium, V _{total}	mg/L	< 0.0005	0.01	
Zinc, Zn _{total}	mg/L	15.2	0.763	0.50
Zirconium, Zr _{total}	mg/L		0.005	

Notes:

the concentration of runoff discharge parameter exceeds the MWWE guidelines.

no specific guidelines are available.

no results are available.

⁽²⁾ Water License requirement.

^{*} Dissolved content.

Appendix C

Technical Memo

Iqaluit Landfill Leachate Treatment Wetland Cell Conceptual Design

By Riparia Aquatic, Wetland and Shoreland Environments

Date: October 12, 2006 Project #: 93107-04

To: Ken Johnson cc:

From: Bernie Amell

Riparia Aquatic, Wetland and Shoreland Environments #202, 403 - 30th Ave NE, Calgary AB T2E 9B3

Subject: Iqaluit Landfill Leachate Treatment Wetland Cell Conceptual Design

The following are my recommendations based on available site area of 2000 sq m.

Limiting issues will be temperature and high BOD loads. High nutrient loads are not anticipated. Advice by Earth Tech that heavy metals and other industrial chemicals are not evident.

Leachate should be stored in a pond area throughout the cold period. Releases to the treatment wetland would be pumped, when the leachate is at 5 degrees C. Propose creating a subsurface flow wetland with 0.5m deep permeable soil growing medium. Permeable medium will be mix of sand, fine gravel and peat. Local sedges and wetland mosses will be established on the surface.

Leachate would be introduced via perforated header pipe to gravel flow spreader trench wrapped with geotextile. Liquid will permeate into the side of the flow spreader trench, through a "sacrificial" peat bed of 3 meters width, then into the permeable medium. The sacrificial bed will buffer the main wetland against spike concentrations of hazardous materials.

The subgrade and surface of the permeable medium will be sloped to induce horizontal flow within the soil voids, without liquid emerging to surface. Slope will be calculated when information on locally available materials allows estimation of hydraulic conductivity. At the downstream end there will be another gravel trench wrapped with geotextile and with a perforated weeping tile pipe. This will drain to the recirculation/release vault. A small pump in this vault may continuously recirculate 1/2 volume of the leachate, providing an opportunity entrain atmospheric oxygen to improve BOD removal performance of the system. The remaining half volume will be released as treated leachate.

Capacity Calculations

12 weeks (84 days) of flow

Permeable soil medium assumed to have 25% voids @ 0.5m depth = 0.125 m³ liquid/m² wetland area Desirable 4 day hydraulic retention time (HRT).

84/4 = 21 cycles per year

 $21 \times 0.125 = 2.625 \text{ m}^3 / \text{m}^2$ net hydraulic loading per treatment bed surface area Subtract assumed net precipitation/evaporation per bed area $(0.325 \text{ m}) = 2.3 \text{ m}^3$ net hydraulic loading per year

If 2000 m^2 area is available, assume 75% as effective treatment bed area, then total treated capacity = $1500 \text{ X } 2.3 = 3450 \text{ m}^3$ leachate per year.

Please verify the basis of my assumptions – and provide other feedback. Thanks!

Appendix D

Wetland Sizing

Subsurface Flow (SSF) Treatment Wetland **Preliminary Feasibility Calculation Sheet**

Phase 1 (BOD limit = 120 mg/L)

Location: City of Iqaluit West 40 Landfill Site

Runoff Volume, m³

7,700

Design Flow, m³/d

O = 73

Influent Concentration

Target Effluent Concentration Wetland background limit, mg/L

	TSS	BOD	TP	TN	NH ₄ ⁺ -N	Org-N
Ci =	868	269	0.8	20.7	4.42	16.21
Ce =	180	120				
C* =	62	18	0.05	2	0	1.5

for TSS,
$$C^* = 7.8 + 0.063Ci$$

for BOD, $C^* = 3.5 + 0.053Ci$

Areal rate constant @ 20°C, m/yr.

Required wetland area, ha

Λ _	0.0365×Q	C-C*)
A-	k	^ m\	١

	1 _z —	3000	180	12	27	10	17
F	A =	0.0017	0.0134	12	21	18	17

maximum calculated area from above boxes (Amax) =

0.013 ha

 134 m^2

Areal rate constant @ 5°C, m/yr.

Required wetland area, ha

$\theta =$	1.050	1.130	1.000	1.050	
k =	1443	29	12	13	
A =	0.0036	0.0836			

maximum calculated area from above boxes (Amax) =

0.084 ha

 836 m^2

use van't Hoff Arrhenius equation:

$$K_{T1} = K_{T2} \cdot \boldsymbol{\theta}^{(T1-T2)}$$

Effluent concentration, mg/L

Co @						
maximum						
area =	62	78	1	17	4	18

$$C_0 = C * + (C_i - C *) \exp \left| -\frac{kA_{max}}{0.0365 \times Q} \right|$$

Subsurface Flow (SSF) Treatment Wetland Preliminary Feasibility Calculation Sheet

Phase 2 (BOD limit = 120 mg/L)

Location: City of Iqaluit West 40 Landfill Site

Runoff Volume, m³

Design Flow, m³/d

Q= 63

6,600

Influent Concentration

Target Effluent Concentration

Wetland background limit, mg/L

	TSS	BOD	TP	TN	NH ₄ ⁺ -N	Org-N
Ci =	868	269	0.8	20.7		
Ce =	180	120				
C* =	62	18	0.05	2	0	1.5

for TSS, $C^* = 7.8 + 0.063Ci$

for BOD, $C^* = 3.5 + 0.053Ci$

Areal rate constant @ 20°C, m/yr.

Required wetland area, ha

k =	3000	180	12	27	18	17
A =	0.0015	0.0115				

Λ_Ι	0.0365×Q	$\times \ln \left(\frac{C_i - C^*}{C_i - C^*} \right)$
A=	k	^ m(C ₀ - C *

maximum calculated area from above boxes (Amax) = 0.011 ha

= 115 m²

 717 m^2

 $\theta = \begin{vmatrix} 1.050 & 1.130 & 1.000 & 1.050 \\ k = \begin{vmatrix} 1443 & 29 & 12 & 13 \end{vmatrix}$

Areal rate constant @ 5°C, m/yr. Required wetland area, ha

A =	0.0031	0.0717					
maximu	m calcula	ated area fro	m above	e boxes	(Amax) =	0.072	ha

use van't Hoff Arrhenius equation:

$$K_{T1} = K_{T2} \cdot \boldsymbol{\theta}^{(T1-T2)}$$

Effluent concentration, mg/L

Co @ maximum area = 62 78 1 16 0 2

$$C_0 = C * + (C_i - C *) \exp \left| -\frac{kA_{max}}{0.0365 \times Q} \right|$$

Subsurface Flow (SSF) Treatment Wetland **Preliminary Feasibility Calculation Sheet**

Phase 1 (BOD limit = 45 mg/L)

City of Iqaluit West 40 Landfill Site Location:

Runoff Volume, m³

7,700

Design Flow, m3/d

Q = 73

Influent Concentration **Target Effluent Concentration**

Wetland background limit, mg/L

					NH ₄ +-	Org-
	TSS	BOD	TP	TN	N	N
Ci =	868	269	0.8	20.7	4.42	16.21
Ce=	45	45				
C* =	62	18	0.05	2	0	1.5

for TSS,
$$C^* = 7.8 + 0.063Ci$$

for BOD, $C^* = 3.5 + 0.053Ci$

Areal rate constant @ 20°C, m/yr.

Required wetland area, ha

k =	3000	180	12	27	18	17
A =	-	0.0330				

$$A = \left| \frac{0.0365 \times Q}{k} \right| \times ln \left(\frac{C_i - C^*}{C_e - C^*} \right)$$

maximum calculated area from above boxes (Amax) = 0.033 ha

330 m²

Areal rate constant @ 5°C, m/yr.

Required wetland area, ha

$\theta =$	1.050	1.130	1.000	1.050	
k =	1443	29	12	13	
A =	-	0.2066			

maximum calculated area from above boxes (Amax) = 0.207 ha

2066 m²

use van't Hoff Arrhenius equation:

$$K_{T1} = K_{T2} \cdot \theta^{(T1-T2)}$$

Effluent concentration, mg/L

Co@ maximum 62 42 10 18 area = 0

$$C_0 = C * + (C_i - C *) exp | - \frac{kA_{max}}{0.0365 \times Q} |$$

Subsurface Flow (SSF) Treatment Wetland Preliminary Feasibility Calculation Sheet Phase 2

(BOD limit = 45 mg/L)

Location: City of Iqaluit West 40 Landfill Site

Runoff Volume, m³

Design Flow, m3/d

6,600

Q = 63

Influent Concentration
Target Effluent Concentration
Wetland background limit,
mg/L

Ī						NH ₄ +-	Org-
		TSS	BOD	TP	TN	N	N
	Ci =	868	269	0.8	20.7	4.42	16.21
	Ce=	45	45				
	C* =	62	18	0.05	2	0	1.5

for TSS, $C^* = 7.8 + 0.063Ci$ for BOD, $C^* = 3.5 + 0.053Ci$

Areal rate constant @ **20**°C, m/yr.

Required wetland area, ha

Δ _	0.0365×Q	Q-C*	1
Λ-	k	^	,

k =	3000	180	12	27	18	17
A =	-	0.0283				

maximum calculated area from above boxes (Amax) = 0.028 ha

= 283 m^2

Areal rate constant @ 5°C, m/yr. Required wetland area, ha

$\theta =$	1.050	1.130	1.000	1.200	
k =	1443	29	12	2	
A =	-	0.1771			

maximum calculated area from above boxes (Amax) = 0.177 ha

= 1771 m²

use van't Hoff Arrhenius equation:

$$K_{T1} = K_{T2} \cdot \boldsymbol{\theta}^{(T1-T2)}$$

62

Effluent concentration, mg/L

Co @ maximum area =

42	0	20	4	18

$$C_o = C * + (C_i - C *) exp | - \frac{kA_{max}}{0.0365 \times Q} |$$

Appendix E

Conceptual Level Cost Estimation

Conceptual Level Cost Estimation

Runoff Volume land area required	m^3 m^2		Phase 1 7700 2934			Phase 2 6600 2518		
	Unit	Unit Price	Quantity	Ex	tension	Quantity	Ex	ktension
Common excavation to waste disposal	m^3	\$ 15.00	3000	\$	45,000	2520	\$	41,580
Control Berm	m^3	\$ 20.00	410	\$	8,200	380	\$	8,360
Ditch	m	\$ 40.00	300	\$	12,000	250	\$	11,000
Bedding materials								
Permeable Medium (mix of sand, fine gravel and peat)	m ³	\$ 50.00	1500	\$	75,000	1260	\$	75,600
Gravel	m^3	\$ 40.00	<i>7</i> 5	\$	3,000	70	\$	3,360
Peat	m^3	\$ 30.00	150	\$	4,500	130	\$	3,900
Geotextile	m^2	\$ 5.00	270	\$	1,350	250	\$	1,375
Culvert 200 mm	m	\$ 150.00	50	\$	7,500	50	\$	8,250
Mobilization				\$	20,000			\$20,000
Subtotal				\$	176,550		\$	173,425
Vegetation Pump and temporary	m^2	\$ 3.00	3000	\$	9,000	2520	\$	8,316
piping				\$	10,000		\$	10,000
Subtotal Engineering Contingency					195,550		\$	191,741
(40%)				\$	78,220		\$	76,696
Total				\$	273,770		\$	268,437

Notes

Assume 20% increase of the base price for all the components at Phase 2.



Appendix G

West 40 Landfill Drainage Management Review

Membrane Bioreactor Technology Report

City of Iqaluit Landfill Surface Runoff Treatment - Membrane Bioreactor Technology

Prepared by Earth Tech Canada, April 24, 2007 Ken Johnson, M.A.Sc., P.Eng., Project Manager

Introduction

Earth Tech has prepared this letter report at the request of the City of Iqaluit regarding the use of mechanical wastewater treatment technology for treating the West 40 landfill runoff. The purpose of this letter report is to provide information for the City to compare with the proposed wetland treatment system. In March 2007, Earth Tech Canada submitted a Conceptual Design Report recommending the use of subsurface flow wetland system for landfill runoff treatment.

The Membrane Bioreactor (MBR) technology was chosen as an alternative process because it represents an advanced biological and membrane coupled process that has been successfully applied for the treatment of a wide range of industrial and municipal wastewaters (Stephenson et al., 2000). The applications include old or stabilized landfill leachates, as it may be the case with landfill runoff from the West 40 Landfill site.

This letter report is intended to develop the basis for the conceptual design of the MBR system and to illustrate the system process along with order of magnitude capital and operational costs.

MBR Process

MBR technology offers an alternative process which replaces two stages of the conventional activated sludge process (ASP) (biotreatment and settlement) with a single, integrated suspended growth biological reactor and membrane clarification step. Using membranes in biological wastewater treatment reactors offers the potential to overcome operational problems experienced with conventional ASP treatment, such as:

- 1. relatively large land areas for the bioreactors,
- 2. downstream solids separation by sedimentation, increasing the land area further,
- 3. the requirement to equalize hydraulic and organic loadings to maintain a constant treated effluent quality, and
- 4. inhibition of the solids settling process by "bulking", i.e. the inhibition of sedimentation by filamentous microorganisms,

In addition, MBR technology consistently produces a high quality effluent. The high biomass concentration in the reactor reduces both bioreactor tank size and sludge production, and enables influent of varying quality to be treated while maintaining a disinfected final effluent. Furthermore, an increased rate of nitrification may be achieved since a large amount of slow-growing nitrifying bacteria may be retained in the aeration tank.

MBR Configuration

The MBR process may be configured with the membrane unit located either external to the bioreactor (SideStream - SS) or mounted directly within it (submerged or IMmersed - IM) (see Figure 1).

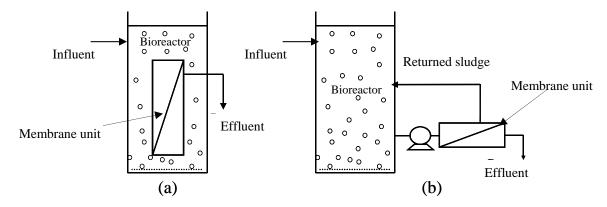


Figure 1. Two MBR configurations: (a) immersed (Im) and (b) Sidestream (SS).

In the SS configuration, a high cross flow fluid velocity (between 2 and 4.5 m/s) provided by a recirculation pump reduces the deposition of suspended solids at the membrane surface. Although this configuration is simple and provides more direct control of fouling of the membrane, the energy demand is relatively high. This configuration has the longest history and is primarily used for industrial wastewater treatment. From the early 1990s, Im MBR systems have been introduced and preferred to SS configuration for treating municipal wastewater on a larger scale. The IM configuration relies on coarse bubble aeration to produce in-tank recirculation and reduces fouling of the membrane. Although the energy demand of the IM system may be up to 2 orders of magnitude lower than that of SS systems, IM systems operate at a low flow, demand more membrane area, and rely on coarse bubble aeration. The membranes themselves may have tubular or flat configuration. Membranes used for MBR application have pore sizes ranging from the ultrafiltration (UF) range (0.01 to 0.1 μ m) to microfiltration (MF) range (from 0.1 μ m up to 1 μ m).

A hollow fiber UF membrane system may be appropriate as a proposed membrane system for Iqaluit landfill runoff treatment.

Water quality parameters and design considerations

A common basis of design for MBRs during the treatment of landfill runoff are Volumetric Loading Rates (VLRs) for carbonaceous material (measured as COD) and ammonia nitrogen,

along with "fouling" potential indexes of organic and inorganic contaminants. Since none of these parameters are available in the existing laboratory analyses of the landfill runoff, the quality was assumed to be similar to a typical old landfill leachate. Runoff sampling results from July 2004 and June 2006 were compared to old landfill leachate matrices shown in literature reviews. (Table 1).

Table 1. Average leachate runoff quality vs. key characteristics of old leachates.

Parameter	City of Iqaluit Runoff	Robinson (1995)	Irene and Lo (1996)	Urbini et al. (1999)
pН	7.5	7.5	7.9 – 8.1	8
BOD (mg/L)	120 - 180	260	160	150
TSS (mg/L)	180 - 270	ND*	ND*	ND*
$NH_4^+(mg/L)$	4.42	5 - 370	26 - 557	10 - 40
Metal values (mg/L)	0.09 - 15	0.1 - 26.5	0.7 - 24	0.03 - 25.9
Chlorides (mg/L)	215 - 250	70 - 2,780	2 - 119	180 - 2,650

ND*: No available data.

Experiences of MBRs treating old leachates show that a membrane flow of $5 \text{ L/m}^2/\text{h}$ is common and have a low impact on membrane fouling (Alvarez-Vazquez et al., 2004). Therefore, $5 \text{ L/m}^2/\text{h}$ was chosen as the membrane flux value of the proposed conceptual design. A hydraulic retention time (HRT) value of 5 days was also chosen to counteract the biological impact on the biomass at low operating temperatures in Iqaluit. Such a HRT lies slightly above reported data for old leachate treatment where contaminant removals of up to 80% for COD have been observed at HRTs between 2-3 days. It is expected that only a partial reduction of nitrogen compounds may be achieved due to the low operating temperatures. Metals and TSS will be completely removed as they will either be assimilated by the biomass or physically retained by the membrane.

Bioreactor volume

According to the calculations shown in the Conceptual Design Report for Wetland Treatment, leachate runoff volumes are estimated to be 7,700 m³ for Phase 1. Such flow is to be treated during summer periods, thus a period of 120 days was selected to perform the total treatment of the runoff. The MBR capacity will be approximately 65 m³/d; therefore, a total bioreactor volume basin of 325 m³ is required to conform to the predetermined 5 days HRT.

Membrane surface area

The required membrane surface area is calculated considering the most critical conditions of peak influent flow and lowest temperature. Because the influent flow is fixed, temperature becomes the dictating design factor. A minimum water temperature of 5° C was used for the operating period, along with a correction factor for water viscosity at that temperature. The membrane area is 755 m^2 to comply with a $5 \text{ L/m}^2/h$ flux, corresponding to 24 membrane modules with individual areas of 31.6 m^2 per module.

MBR configuration schematic

The proposed MBR corresponds to the immersed (IM) configuration, and a general schematic showing the complete process is shown in Figure 2. The system is integrated with anoxic and aerobic reactor tanks for nitrogen removal.

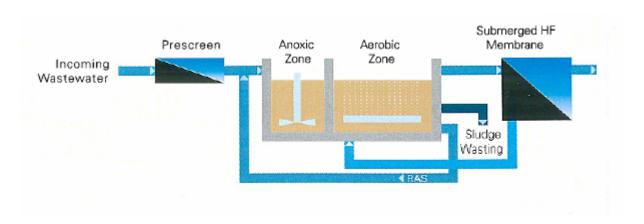


Figure 2. Immersed MBR configuration, including nitrogen removal steps.

Cost Estimate

The cost estimate for the MBR system treating Iqaluit landfill runoff have been projected based on previous old leachate experiences, and are an "order of magnitude" estimates only for one season of operation (i.e. 120 days) (Table 2). The estimate is 2.4 million dollars including a 40% contingency allowance for construction and engineering services.

The capital costs are equipment costs including membrane modules, feed pumps, permeate/recirculation pumps and chemical cleaning pumps, blowers, air diffusers, mixers, valves, fittings, controls and control panel with remote access capabilities. In order to obtain more detailed costs and to recommend spare parts and membrane replacements; membrane cleaning

frequency, and volumes of chemicals and nutrients needed, a comprehensive chemical and physical analysis of the leachate runoff matrix would be required.

Due to the simplicity of operation for MBRs, manpower requirements are similar or even less than a conventional wastewater treatment plant. The cost for manpower to the cost associated with one 8 hour shift in a 40-hour week for one operator for the annual operating period of 120 days. One operator is sufficient to fulfill with standard operational and maintenance needs of the MBR, such as valve replacements, water sampling, nutrient dosing, data collection and in situ membrane chemical cleaning. Major events such as ex-situ membrane cleaning or membrane replacements will require anywhere from 2 to 4 operators.

Table 2. Estimated costs of the proposed immersed MBR system

Item No.	Component	Estimated cost (Million \$)
1	Complete MBR system	1.6
2	Operation and maintenance costs and operator time	0.1
3	Contingency allowance (40%)	0.7
4	Total estimate	2.4

Note: Item 2 includes electrical and mechanical standard spare parts replacement, chemical reagents for periodical cleaning and nutrient dosing.

Summary

The proposed MBR system will produce wastewater effluent exceeding the discharge guideline for the landfill runoff treatment in Iqaluit, provided the MBR system is operated and maintained as required from the manufacture specifications. However, the City will face challenges associated with the MBR system for landfill runoff treatment.

Challenge 1 – Higher capital costs and operation/maintenance costs

Challenge 2 – The maintenance of MBR system during the off-season, since the MBR system will be only operating from a period of 120 days per year. The membrane system needs to be well maintained during 245 days of the rest of the year.

Challenge 3 – The treatment of wasted sludge. Normally, the costs associated with sludge treatment for the MBR could be in the same order of magnitude as the capital cost of MBR system itself.

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Appendix H

West 40 Landfill Drainage Management Review

WESATech Proposal Iqaluit Landfill Runoff



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Kingston, Ontario, Canada K7K 1Z7
Tel: 613-531-2725 Fax: 613-531-1852
Email: wesaking@wesa.ca www.wesa.ca

City of Iqaluit
Attn: Meagan Leach
Director of Engineering and Sustainability
PO Box 460
Iqaluit, NU
XOA 0H0

Dear Ms. Leach,

WESA Technologies is pleased to submit a proposal to design, build and operate a small treatment facility to manage the volume of water contained in the Iqaluit landfill runoff detention pond. The objective of this exercise is to reduce the volume contained in the pond by treating and discharging it to the environment. The primary treatment goal is to reduce the concentration of the iron, manganese and zinc. This will be achieved through pH adjustment and coagulation.

Design and Process

The proposed design will consist of a two-stage chemical treatment, solid filtration and neutralization step, all carried out in a continuous process. The treatment of 5000m³ will be conducted within a 3 week period. A process flow diagram of our proposed treatment facility is attached.

In the first chemical treatment stage, a calcium hydroxide solution (lime, CaOH) will be added to raise the pH of the runoff water to 10.5 – 11.5 in order to induce the precipitation of the metals. Further, the first and second chemical treatment stages are air mixed to promote the oxidation of the iron and manganese in the solution. The oxidation of these metals leads to their precipitation out of the solution. In the second chemical treatment stage, aluminum sulfate (Alum, KAI(SO₄)₂) and polymer (Magnafloc® 338) will be added to flocculate the precipitated metals into larger, filterable particles. The effluent from the second chemical treatment stage is clarified by filtration using a Geotube® to remove suspended solids. The metal solid waste will be contained within the Geotube® and can be returned to the pond or appropriately containerized and transported for disposal at a suitably engineered facility. The filtered water will enter a final neutralization tank to achieve a pH between 7 and 8. This final pH adjustment will be conducted with the addition of hydrochloric acid (HCI). While the plant is in operation, we will be monitoring for the three parameters of concern in the discharge; total iron concentration, total zinc concentration and total manganese concentration, as well as pH and Total Suspended Solids (TSS).

Cost

The cost for the associated plant equipment and consumables (pumps, tanks, Geotube®, piping, fittings, and chemicals for one season) and its transportation is estimated to be \$75,000. This does not include the cost of manpower (time and expenses on site). Also, this does not cover the cost of field analytical equipment or sample analysis at a water testing laboratory. From the city of Iqaluit, we will require



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a shipping container to store all the required gear over the winter season as well as a power supply to operate the electrical equipment. This system can readily be commissioned seasonally to treat the spring and fall landfill runoff volumes projected over the next few years with a treatment cost of \$10,000 for consumables for each additional treatment event. The treatment system will be operated by two people. WESA Technologies will provide an operator (\$1000/day plus expenses). The Municipality of Iqaluit can provide an additional support person to assist with the operation of the plant and to be trained in the treatment process or WESA Technologies can provide a second operator.

Cost Summary

Initial Capital Cost: \$75,000

Operator Time and Expenses per Seasonal Treatment and Discharge Event: \$25,000

Supplies for Subsequent Season Treatment Event: \$10,000

All prices exclude applicable taxes.

Schedule

Upon approval, equipment and supplies will be airlifted to Iqaluit within 2 weeks. Construction and commissioning will proceed immediately and is anticipated to be ready to discharge within one week. Discharge will only commence with the approval of the regulatory agents.

Thank you for contacting WESA Technologies to provide support to AECOM and the Municipality of Iqaluit in resolving their landfill runoff discharge concerns. We hope that this provides sufficient information to support your decision to proceed with this innovative and effective time sensitive solution to the current retention pond capacity and landfill runoff discharge issue. Please feel free to contact me if you require any additional information or clarification.

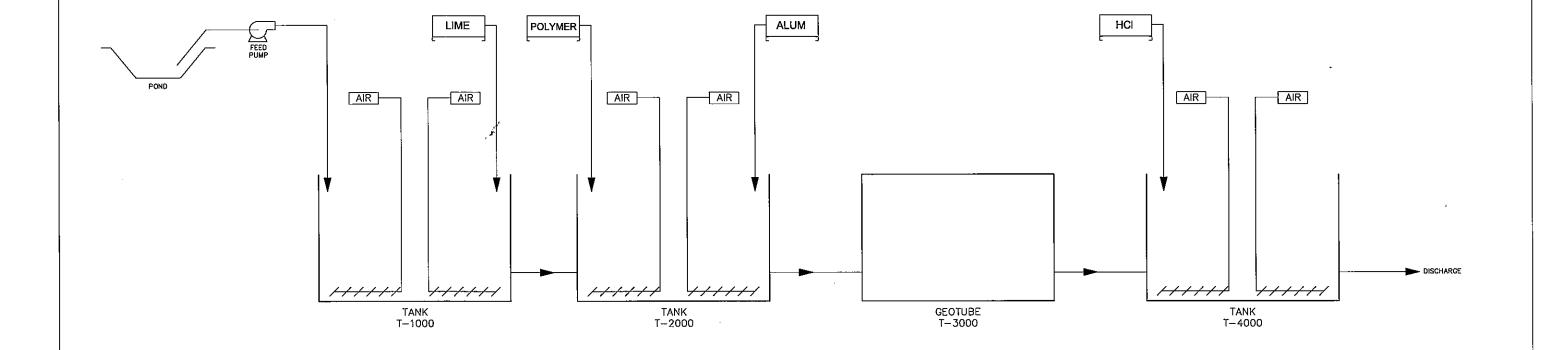
Regards,

Harry Marshall CET

Lawy Mushall.

President, WESA Technologies Inc.

Wayne Ingham, PhD Principal, WESA Inc.



NOT FOR CONSTRUCTION

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Appendix

Iqaluit Solid Waste Management Plan West 40 Landfill Decommissioning

City of Iqaluit

Iqaluit Solid Waste Management Plan West 40 Landfill Decommissioning **Technical Memorandum**

Prepared by:

AECOM 17007 – 107th Avenue 780 486 7000 tel Edmonton, AB, Canada T5S 1G3 780 486 7070 fax www.aecom.com

Project Number:

60196419

Date: January, 2014

Statement of Qualifications and Limitations

The attached Report (the "Report") has been prepared by AECOM Canada Ltd. ("Consultant") for the benefit of the client ("Client") in accordance with the agreement between Consultant and Client, including the scope of work detailed therein (the "Agreement").

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1	Septa Rundra	June 27, 2011	DRAFT
2	Septa Rundra	July 15, 2011	DRAFT REV 2
3	Jim Clare	January 30, 2014	FINAL

AECOM Signatures

Report Prepared By:

diyn Clare, R.E.T. Project Manager

R.H. SCHMIDTKE OF LICENSEE

Report Reviewed By:

Rudy Schmidtke, M.Sc., P.Eng. Associate Vice President, Environment, Canada West

PERMIT TO PRACTICE.

Signature_

Date Join 30, 2014

PERMIT NUMBER: P 639 NWT/NU Association of Professional Engineers and Geoscientists

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Appendix C. Monitoring and Inspection Forms

1. Introduction

1.1 Background

Exp. Services Inc. (exp) and AECOM were retained by City of Iqaluit (the City) to develop a Decommissioning Plan for the West 40 Landfill. This landfill is currently at capacity and the City is working towards developing a new solid waste management site. When the new solid waste management facility opens, the West 40 landfill will be decommissioned. This Decommissioning Plan is a requirement of the City's Water License.

1.2 Scope of Work

The following tasks were completed in order to assess the site:

- Confirmation between exp./AECOM and the City regarding project scope, budget, and schedule;
- Established formal lines of communication;
- Collected, requested, and assembled all necessary and available information from the City in order to conduct the site assessment:
- Reviewed existing information;
- Used existing topographical data to produce conceptual closure design; and
- Conducted a landfill site visit.

Utilizing this information, a decommissioning plan was developed to address the following components:

- Final reclamation plans providing final contours and evaluating airspace volume;
- Final contour plans will be developed to allow final grades of 5% where possible to minimize the amount of fill
 material required to establish final grades;
- Final capping material design, including the possibility of using biosolids from the sewage treatment plant and gravel if available:
- Drainage management;
- Description of final cover;
- Ground water monitoring;
- Erosion control;
- Post closure care;
- Re-vegetation;
- Operation and maintenance checklist for final cover system to protect and maintain survey bench marks; and,
- A cost estimate for this decommissioning plan and care responsibilities.

2. Site Description

2.1 Location

Iqaluit is a growing Baffin Island community and is the Capital of Nunavut. It is located at the south end of Baffin Island, on Frobisher Bay at 64° 44' N latitude and 68° 31' E longitude. Access is provided by commercial aircraft year round and sea-lift from the port of Montreal in the summer. Annual precipitation in the Iqaluit area is approximately 255 cm of snowfall and 19.2 cm of rainfall. Average annual temperatures range from a low in January of approximately -29.7°C to a high of approximately 11.4°C in July.

The landfill site is located in West 40 approximately 4 km from the City center. This site was built in 1995 and was intended as a temporary disposal site until funding for a permanent solution could be allocated.

2.2 Operational History

Existing solid waste management practices at the site consist of placement of wastes into working face, compacting the wastes and covering with granular fill and/or mulch from shredded waste. The site accepts Municipal Solid Waste (MSW) which is either collected through a municipal collection or dropped off by the public. Scrap metal, tires, white goods, wood, sewage sludge, hazardous waste and end of life vehicles are collected and stored in designated areas of the landfill.

The site is operated using area method without engineered liner and leachate collection systems.

2.3 Site Facilities

All solid waste management facilities associated with the landfill are located generally within the site. These facilities include:

- A site office and garage located near the entrance to the landfill site;
- MSW pile;
- Scrap metal areas;
- Tires collection area;
- Wood waste processing area;
- · Hazardous waste depot;
- Sewage sludge area;
- Composting; and
- Surface water management (berms, on-site and off-site retention ponds).

The site facilities are presented in Figure 1.1, Appendix A.

2.3.1 Recycling Storage Facilities

The site includes storage areas for recycling of bulky materials including:

- Scrap metals;
- Car bodies;
- Appliances/refrigerators and freezers; and
- Scrap tires.

Public sorting of waste or scavenging is not permitted within the disposal area of the landfill.

2.3.2 Hazardous Waste Depot

The site includes storage areas for hazardous waste materials. These wastes include but are not limited to:

- Automobile batteries;
- · Lead acid batteries;
- Paint; and
- Waste oils.

3. Engineering Review and Design Consideration

Based on the "Operation and Maintenance Manual, May 2005", it was estimated that the site would reach its design capacities in November 2001. However, the site expansion was implemented for continuing operation of this site.

The expansion was developed in order to optimize daily operations and efficiently use airspace, while complying with the management of the runoff in and around the site in order to keep clean surface water out of the site and manage runoff on-site.

3.1 Solid Waste Generation

The landfill currently utilizes all of the available area designated for disposal and it has exceeded its capacity. However, there is an undisturbed area adjacent to the disposal footprint that can be used to dispose of waste until a new landfill is constructed. The remaining site life of undisturbed ground in years must be determined in order to plan for the final closure and post-closure management and costs.

To estimate the waste that will be generated over the lifetime of the site operation, the population data from City of Iqaluit General Plan² was used as a base for the projection. An average increase of 2.87% growth per year was applied to represent projected population and waste generation increases. A waste generation rate of 0.03 m³/capita/day and a waste density of 100 kg/m³ were used to estimate the volume of waste generation. Projected data describing the wastes generation is presented in Table 3.1.

Table 3.1 - Projected Waste Generation

Year	Accumulated Waste Generated (m ³)	Accumulated Waste Generated (tonnes)	Note
2011	83,412	8,314	
2012	169,218	16,922	
2013	257,486	25,749	
2014	348,288	34,829	
2015	441,713	44,171	New Solid Waste Site Scheduled to be Opened (Iqaluit Solid Waste Management Plan 2014) West 40 site closes and decommissioning begins.
2016	96,107		
2017	194,972		
2018	296,674		

3.2 Site Life

In order to establish the capacity requirements of the design, the expected future waste generation was calculated in order to predict the length of time the cell can viably service the site operations. Using the data provided in Table 3.1 the site life will be calculated.

The remaining capacity at year end is calculated by subtracting the waste accumulated for that year from the previous year's remaining site capacity. It is estimated that horizontal expansion to the north and south of existing waste, where the wood wastes and metals are placed, will accommodate waste disposal until approximately 2015-2016 (see Drawing 00-C-1003, Appendix B).

¹ Darcy Reist and Ken Johnson (2006). Journal of the Northern Territories Water & Waste Association, pp. 10 – 13.

² City of Iqaluit General Plan By Law 703, October 2010.

The site life of the landfill is calculated using the following assumptions:

- Development based on existing conditions of the site topography and area fill of the proposed disposal area;
- Calculation of disposal airspace based on the final elevation of the disposal area which is still to be determined;
 and
- Compacted waste density of 700 kg/m³.

It is estimated that the new solid waste facility will be opened in 2015 and that the decommissioning of the West 40 Landfill will begin in 2015.

If the City needs to extend the lifespan of the West 40 landfill there are variations of options that can be developed. These options include:

- Increase compaction of the wastes:
 - It is estimated that current waste density at the site is approximately 400 kg/m³ based on Operation and Maintenance Manual 2005 revision 2. The current compaction can be increased to 700 kg/m³ by using new equipment and/or drive the compactor over the thin layer of the waste several times (more than 6 times over the waste). Table B.3 in Appendix B shows that increasing the waste density to 700 kg/m³ could almost double the remaining airspace capacity.
- Remove metal waste (tires as well) and fill the area:
 - The Government of Nunavut has funded a scrap metal removal program in Iqaluit which has successfully
 removed significant amounts of metal from various waste management sites around Iqaluit. Although this
 program no longer has funding, the City may be able be able initiate a new project with a similar objective
 and possibly expand the objective to include landfilled tires.
- Relocate office and garage and fill the area:
 - The office and garage area would be useable fill areas for the landfill operation but would require relocation. The buildings could be relocated to the north using the entrance to the biosolids management area. This relocation would require a significant reorganization to the entire waste management site including consideration of using the community composting area as part of the City's waste management operations.
- Fill the area further north into areas currently used for electronics, woodwaste and biosolids:
 - The landfill area may potentially expand further north than is currently delineated in the decommissioning
 plan. This area is significantly smaller than the current operating area because of the encroaching bedrock
 outcrops on either side. This expansion would require a significant reorganization to the entire waste
 management site including consideration of using the community composting area as part of the City's
 waste management operations.
 - Lateral expansion of the waste fill area may be developed by using undisturbed areas of the site or by repurposing the existing wood waste area as indicated in Drawings 00-C-1001 to 00-C-1003, Appendix A.
- Bring in incineration unit for temporary operation:
 - The application of a portable incineration unit could provide the City with significant waste reduction opportunity if required. This would be the most expensive option for increasing the operating window of the West 40 landfill site.

4. Closure Plan

4.1 General

Closure activities should be considered as part of the landfill operations and routine working practices. As the waste disposal face is filled above ground to the proposed final elevations, the perimeter slopes and surfaces are reclaimed. In this way the landfill is closed and reclaimed progressively throughout the active landfill life.

For scheduled fill development and in preparation of final landfill closure, the site should be supervised when open. Equipment will be used to reshape and compact the waste on a regular basis. In this manner, most grading and reshaping of the landfill required prior to installing the final cap may be completed by judicious placement of incoming waste over the site life, therefore, minimizing re-contouring following closure.

4.2 Final Grading Plan

The proposed final grades of the landfill maintain a minimum slope of 3% across the top of the waste fill area to allow surface water drainage off of the site. The design is based on the following:

- Steeper slopes (to meet 5% grade) at this site would require a significant amount of earthwork to construct, as well as a large quantity of soil fill which there is not available on-site;
- Settlement is expected to be a significant issue due to assumed high waste thickness with low compaction; and
- Cover maintenance is included as part of post-closure care.

4.3 Final Cover Design

The final cover design provides a protective "cap" over the waste fill area. The objectives of the final cover design are to:

- Provide a barrier layer over the waste to minimize infiltration of precipitation into the landfill to minimize leachate generation;
- Create and maintain positive drainage of precipitation off of the landfill and minimize erosion; and
- Provide a layer of soil/gravel on which to establish an acceptable level of vegetative cover.

For the purpose of landfill closure, the entire disposal area will require capping. If the undisturbed ground identified throughout the site (under roads, areas not surveyed, etc) is not filled prior to re-grading, it will be included within the cover design in order to ensure proper drainage off of the cap. Otherwise, areas left uncapped within the final covered footprint may collect surface water and compromise the final cover system.

The final contours of the landfill should promote drainage away from the site to discourage infiltration and leachate production while also preventing erosion. To suit these criteria, a 3H:1V slope is proposed for the side slopes with a 3% grade upwards to the crown of the landfill, directing drainage to the northeast and southwest.

The construction of final cover, or "cap", includes placement of "topsoil" and "subsoil" and needs to be constructed to satisfy the future management and integrity of the waste fill area. For "topsoil", the City may use fine granular and/or sewage sludge or composted material and for "subsoil" the City may use granular fill and/or gravel from quarry area. While the topsoil layer should be constructed as soon as possible, it is not necessary to place it immediately after the subsoil layer has been constructed. The purpose of the "cap" is to prevent erosion of the landfill and maintain the integrity of the site.

Generally accepted best practices have been employed for the decommissioning requirements, and the following final cover design is recommended:

- "Topsoil" of fine granular or compost material of 200 mm over subsoil;
- "Subsoil" of 350 mm over barrier layer;
- Barrier layer that is constructed by compacting soils or gravel to a thickness of not less than 600 mm measured perpendicular to the compacted waste surface.
- · Contoured such that no water pools on the disposal area; and
- Final cover material graded to achieve a minimum slope of 3% and not to exceed 30%.

A combined estimate of 16,146 m³ of in place material for the barrier, subsoil and topsoil layer will required to cover the landfill site.

Alternative final cover systems, such as gravel, biosolids, and compost or high density polyethylene (HDPE) may be used due to unavailability of soils in the area. However, HDPE is likely too expensive to be used as cover. If biosolids are used for the purpose of topsoil it is anticipated that the City will require approximately 3 m³ per day of biosolids or compost or a combination of biosolids and compost to be collected and stored for the period of 2014 to 2015 in order to provide the required amount of topsoil. However, if fine granular is substituted or combined with the material then less biosolids and/or compost will be required.

4.4 Drainage Restoration

The site was developed with surface water management infrastructure. The existing drainage systems include offsite and on-site surface water diversion ditches, on-site drainage pond and off-site retention pond. This drainage system can be seen in Figure 1.1, Appendix A.

Runoff and run-on surface water would be re-directed away from the cap via drainage ditching around the waste disposal area. The runoff drainage ditching will drain in a northern direction, and be further directed towards the off-site retention pond. Run-off collected in the retention pond will be tested and if found to be within acceptable parameters, can be discharged directly to the environment. If the water does not meet acceptable criteria it will be treated as required.

To maintain the integrity of the cover system, the entire fill area will be incorporated into a single cover design which will direct water toward the outer edges and off of the surface, allowing no accumulation on the surface. This translates into incorporating some undisturbed ground area into the footprint of the cover design in order to create smooth contours.

4.5 Re-vegetation

Following the completion of grading operations and the placement of final cover materials, vegetation of the surface will be required in order to prevent erosion of materials and also to integrate the area with the surrounding landscape. Vegetation of the cap should include native tundra species to ensure uptake and longevity of the plants.

A seed mix approved by the City will be selected, comprised of native species and low maintenance grasses to better acclimatize the vegetation to the natural environment and reduce the need for replacement over time.

4.6 Subsidence Remediation

The final cover design objectives include creating and maintaining positive drainage across the fill area. Areas where waste has subsided will be re-graded as part of the final cover installation.

Due to the high elevation of the landfill cell and low compaction, it is expected that future subsidence will occur. Inspection of the final cover for signs of subsidence, erosion or other damage will be performed annually by landfill operators. Should these inspections detect subsidence that interferes with the intended drainage of the site, maintenance will be performed to restore positive drainage while maintaining the final cover design over the site.

5. Post-Closure Plan

5.1 Overview

Best practise standards for decommissioned landfills suggest that, a post-closure plan should operate for a period no less than 25 years. Typically, the post-closure care period should continue until the following circumstances occur:

- Leachate quality performance standards are met at the points of compliance; and/or
- The leachate constituents are lower than the groundwater performance standard criteria concentrations.

During the post-closure care period, the City is responsible to complete the following activities:

- Protecting and maintaining the integrity of the final cover system;
- Providing repairs to the final cover system as necessary to correct settlement, subsidence, erosion, leachate break-out; and
- Monitoring surface water quality and taking corrective action where necessary.

During the post-closure care period the landfill operator should inspect the final cover system at least once per year, and complete an annual report that includes a record of:

- Annual surface water monitoring;
- Maintenance and repairs completed; and
- Any remedial or corrective action taken.

5.2 Post-Closure Care Activities

Post-closure care activities include the following:

- Final Cover Maintenance:
 - Monitoring final cover integrity
 - Prevention of erosion of cover soils
 - Maintenance of vegetation
 - Filling of low areas resulting from settlement or subsidence of the landfill
- Surface Water Monitoring:
 - Annual surface water monitoring
- Monitoring Records:
 - The post-closure care plan includes a program for maintaining records of surface water monitoring, site inspections, maintenance and repairs, and remedial actions.

Table 5.1 below summarizes the post-closure care activities and potential issues and solutions.

Table 5.1 - Post-Closure Activities and Potential Issues and Solutions

Item		Activities		Possible Issues		Response Actions
Final Cover Maintenance	•	Monitoring final cover integrity (min 1 time per year) Maintenance of vegetation (seed, cut, fertilize) as required	•	Erosion of final cover Ponding of water after precipitation in settlement areas	•	Replace top and subsoil, vegetate, and apply erosion control product such as mulch and/or erosion matting Fill settled areas with topsoil, grade to drain. and vegetate
Surface Water Monitoring	•	Conduct water sampling program as required by the City's Water License.	•	Exceed regulatory requirements		low groundwater monitoring plan response which may lude: Resample and confirm Increase monitoring frequency Expand monitoring program Identify potential risks/risk analysis Investigate possible causes and mitigate
Leachate Management	•	Monitor waste fill area for seeps or stains	•	Surface springs of leachate	•	Prevent drainage to surface water ditches Investigate cause and design and implement appropriate remediation measures Fill and grade settlement areas Maintain final cover vegetation where possible Increase frequency of site inspections until resolved

For purposes of closure, it is assumed that the entire cleared area will require capping.

6. Implementation Schedule and Cost Estimate

6.1 Closure Schedule

The closure schedule is contingent on the timing for the development of the City's new waste management facility and the waste filling option(s) selected by the City. The closure of the landfill may be initiated as early as 2015, but is subject to confirmation by additional surveying of the area.

Following closure, the landfill must be covered and seeded (it will take a couple of years to become vegetated) within the subsequent summer period. Upon completion of the closure, post-closure care will commence directly following and a closure report will be submitted to the Nunavut Water Board and Nunavut Department of Environment as required.

6.2 Post-Closure Schedule

Post-Closure monitoring will be required for a minimum of 25 years and shall include annual, surface water monitoring and management, and inspections of the final cover. Environmental remediation or cover repair activities shall be scheduled as necessary following detection of groundwater impacts or damage to the landfill cap.

6.3 Closure Cost Estimates

Closure costs for the landfill consist of the capital costs required to grade the existing site to meet minimum slope guidelines and construct the necessary final cap, installation of monitoring wells and re-vegetation. The total cost to carry out the closure plan is approximately \$894,000, in 2011 dollars excluding GST.

A representation of the cost structure has been included within Table B.5, Appendix B. The cover material cost is based on a unit cost per square metre. It has been assumed that a 600 mm barrier layer, 350 mm of "substrate", and 200 mm of "topsoil" will be used to cap the existing landfill, based on standard best practice.

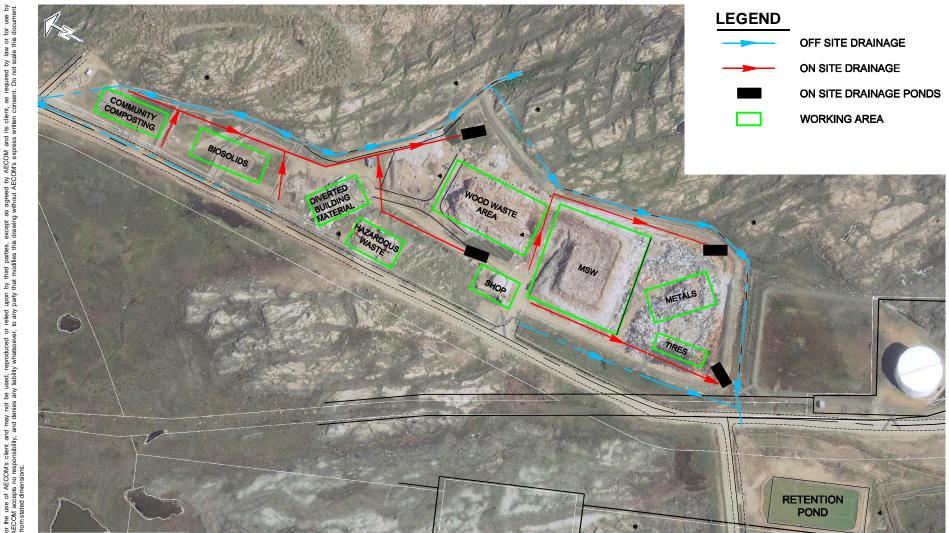
6.4 Post-Closure Cost Estimates

It is estimated that annual cost of the post-closure is approximately \$65,000 (in 2011) and total post-closure cost for 25 years is approximately \$2,820,466 (with 3% annual inflation).

A representation of the cost structure (annual and total costs) has been included within Table B.6, Appendix B.

Appendix A

Figure and Drawings



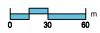
NOTES

- 1. FOUR ON SITE PONDS ARE EMPTIED BY PUMPING TO RETENTION POND; RETENTION POND IS CONTROLLED BI ANNUAL DISCHARGE AFTER LAB TESTING AND REGULATORY REVIEW.
- 2. COMMUNITY COMPOSTING IS AN AREA SET ASIDE FOR A FUTURE COMMUNITY PROGRAM.
- 3. BIOSOLID MANAGEMENT INCLUDES FREEZE THAW DE-WATERING AND COMPOSTING.

City of Iqaluit Iqaluit SWMP 2011

A SIZE 8.5" x 11" (215.9mm x 279.4mm)

AECOM



SCALE 1:3000

Landfill Decommissioning Plan Existing Condition Plan Figure - 1.1

City of Iqaluit **Iqaluit SWMP 2011**

Landfill Decommisioning Plan

LIST OF PROJECT DRAWINGS

Issued for Report

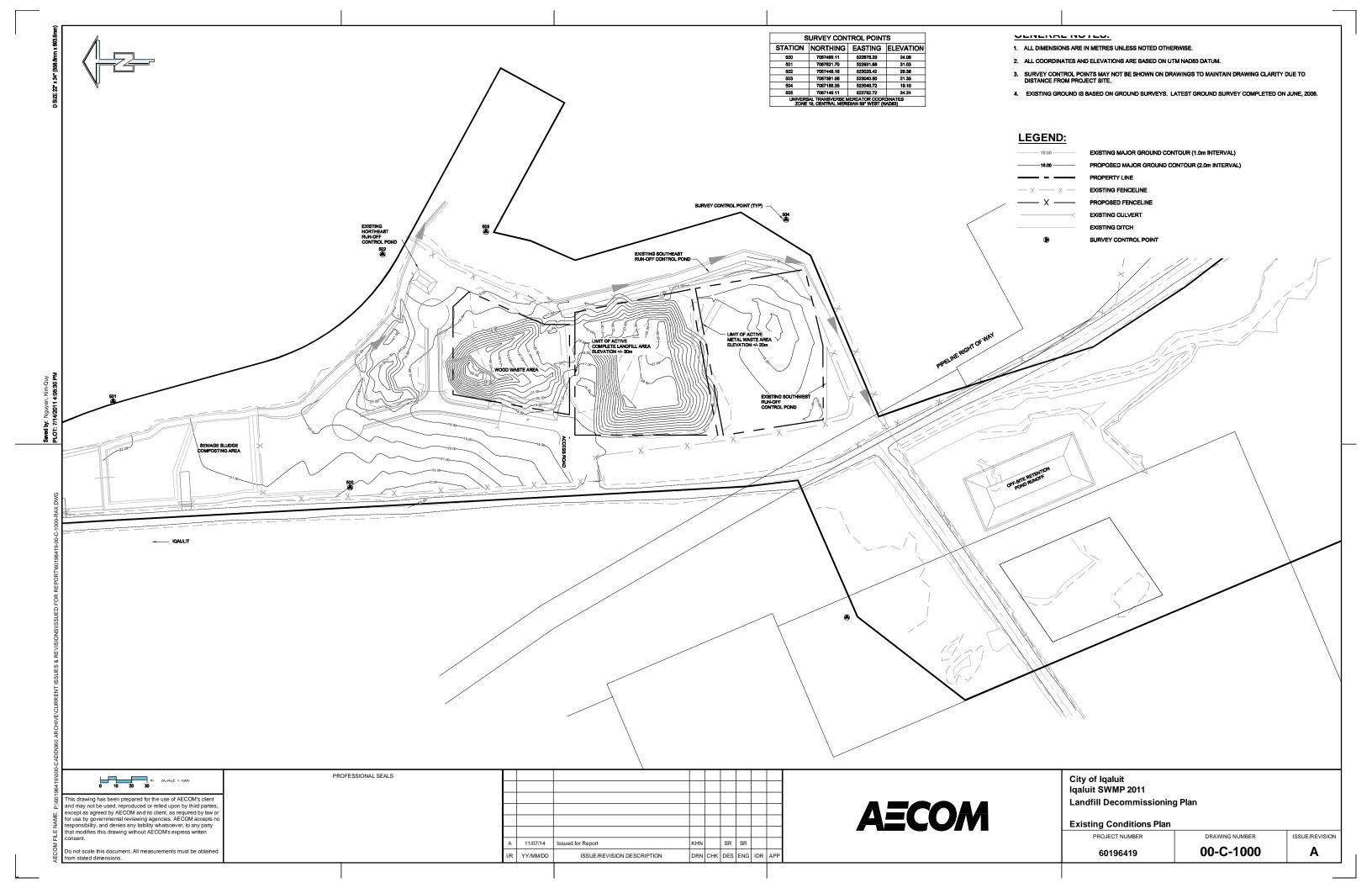
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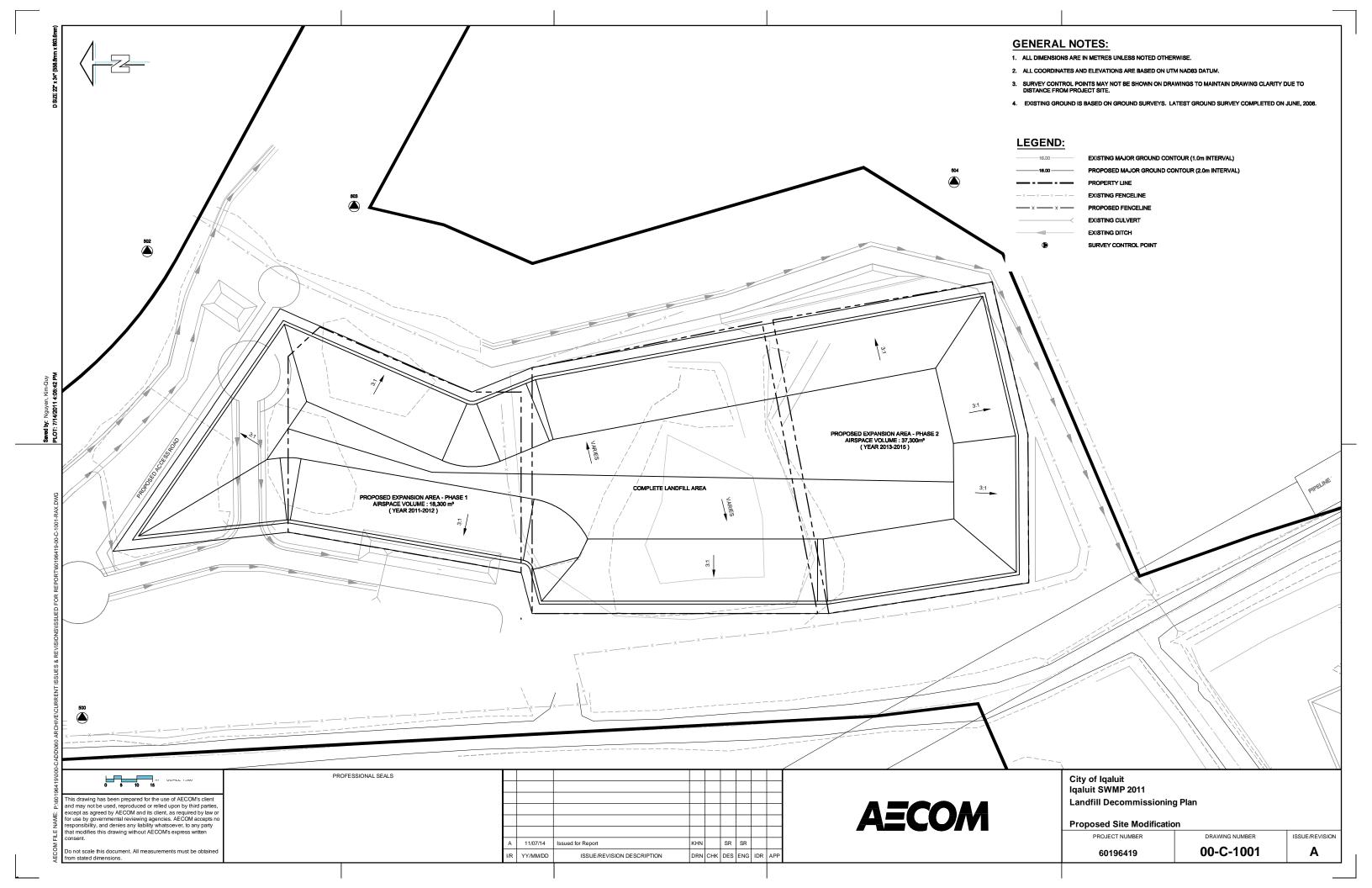


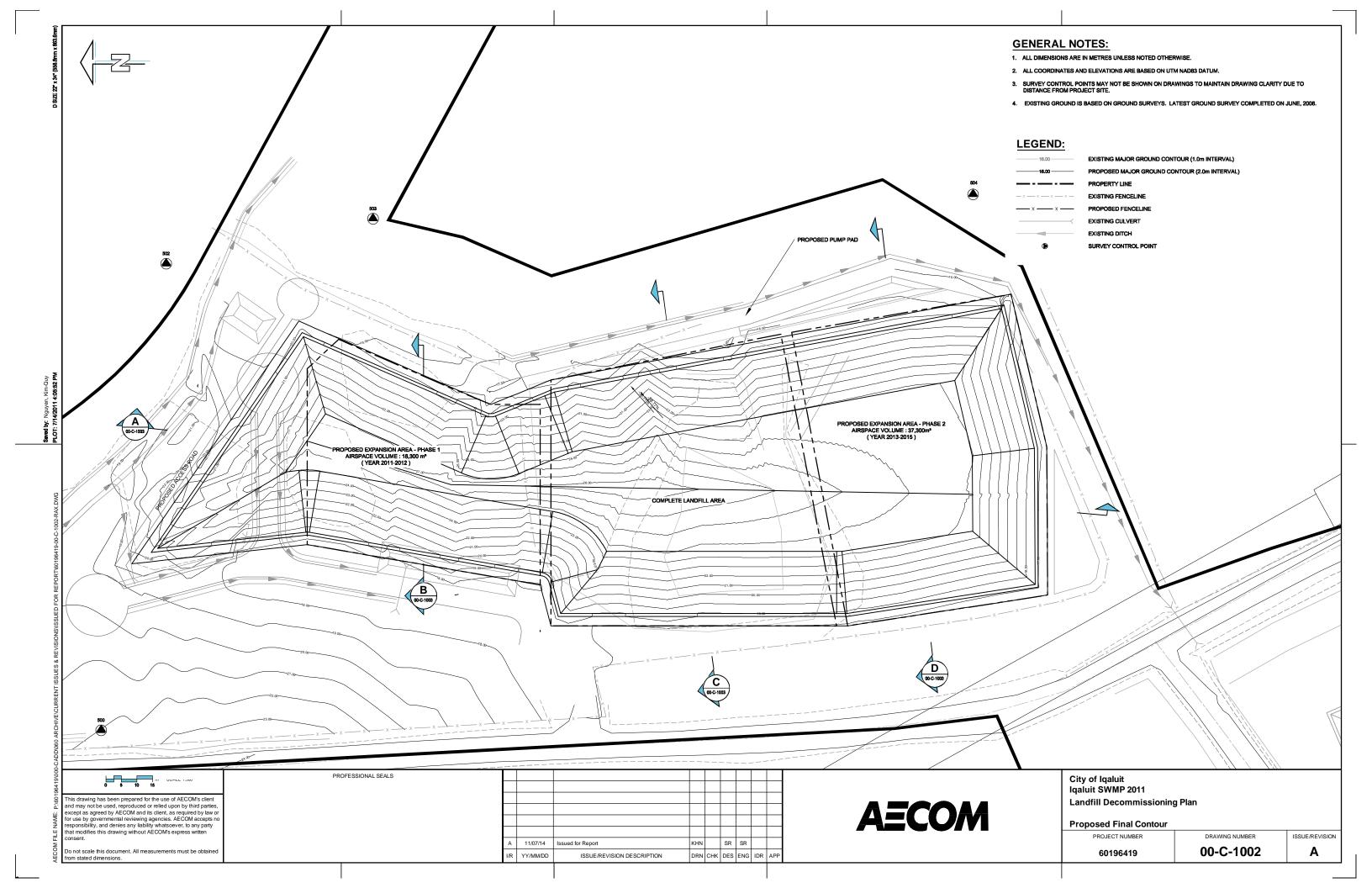
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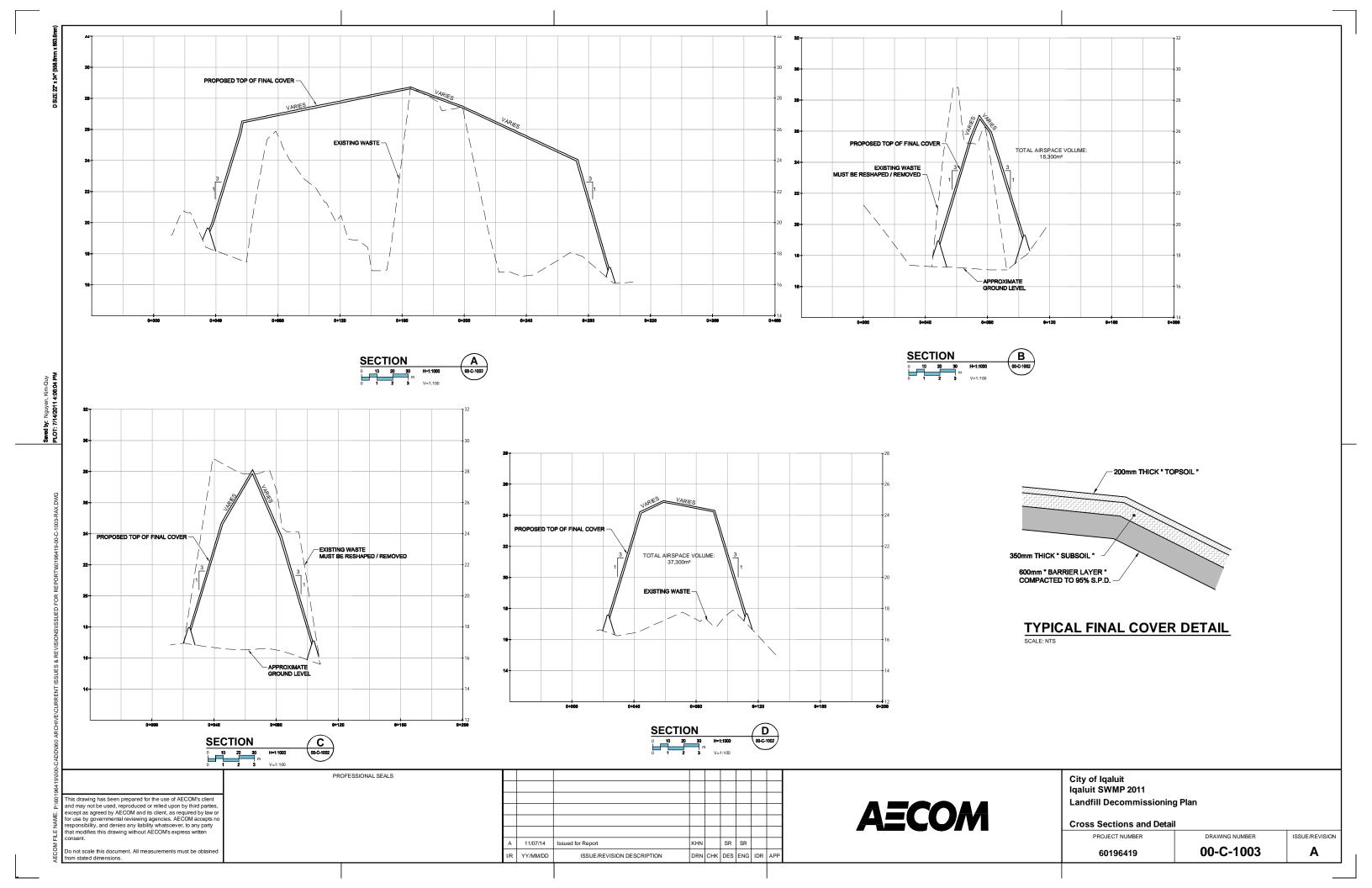
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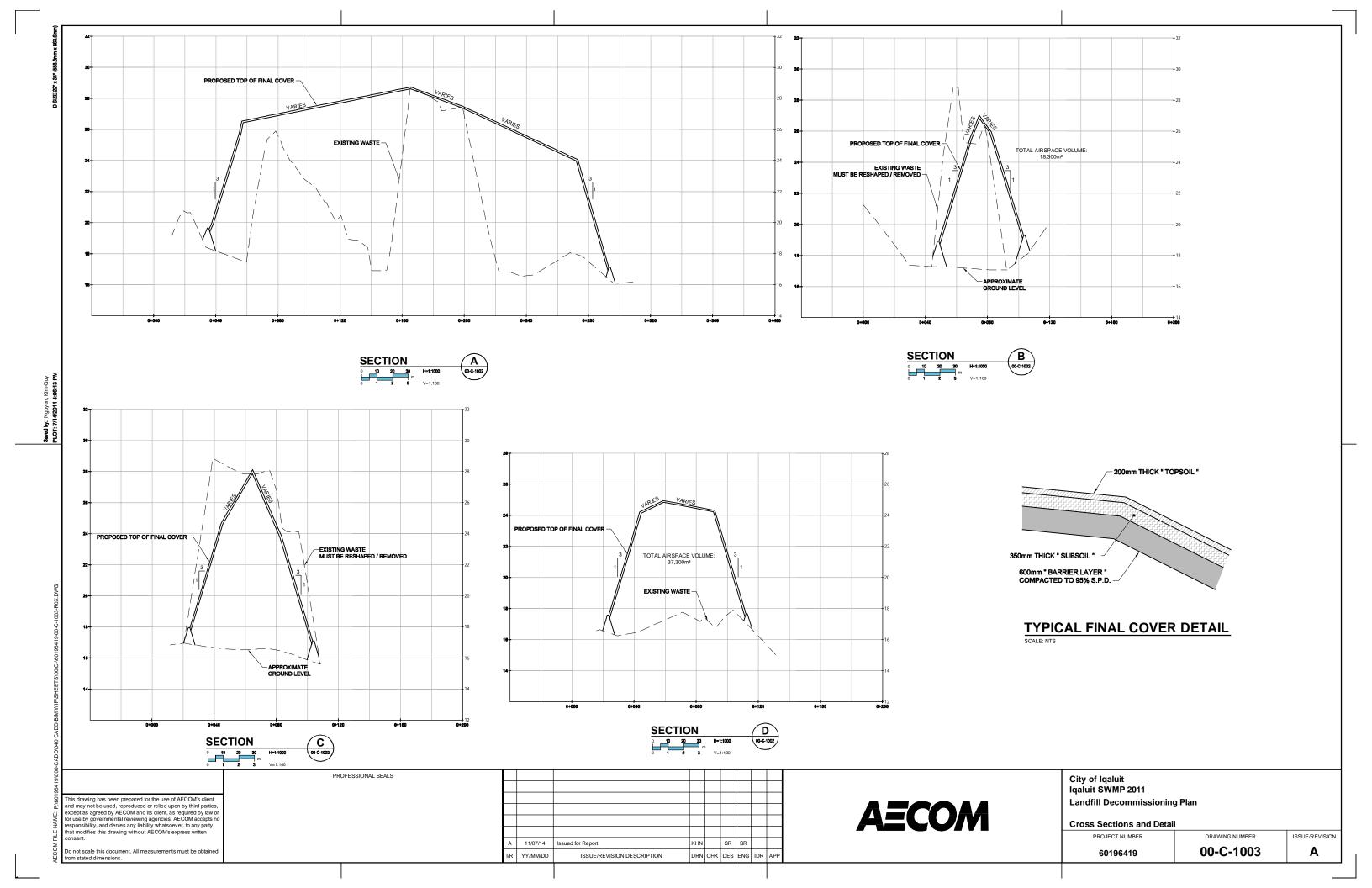
DRAWING NUMBER











Appendix B

Design Calculations and Cost Estimate



Table B.1 - Population and Waste Projections

Vacr	Donulation	Waste Generated (m³)b	Accumulated Waste (m³)	Waste Generated	Accumulated Waste
Year	Population		waste (m)	(tonnes) ^c	(tonnes)
2006 ^a	6,520	71,394		7,139	
2007 ^a	6,802	74,482		7,448	
2008	6,997	76,620		7,662	
2009 ^a	7,198	78,818		7,882	
2010 ^a	7,405	81,085	22.112	8,108	2.24
2011 ^a	7,618	83,412	83,412	8,341	8,341
2012	7,836	85,806	169,218	8,581	16,922
2013	8,061	88,268	257,486	8,827	25,749
2014	8,292	90,802	348,288	9,080	34,829
2015 ^a	8,532	93,425	441,713	9,343	44,171
2016	8,777	96,107	96,107	9,611	9,611
2017	9,029	98,865	194,972	9,886	19,497
2018	9,288	101,702	296,674	10,170	29,667
2019	9,554	104,621	401,295	10,462	40,130
2020 ^a	9,830	107,639	508,934	10,764	50,893
2021	10,112	110,728	619,662	11,073	61,966
2022	10,402	113,906	733,567	11,391	73,357
2023	10,701	117,175	850,742	11,717	85,074
2024	11,008	120,538	971,279	12,054	97,128
2025 ^a	11,326	124,020	1,095,299	12,402	109,530
2026	11,651	127,579	1,222,878	12,758	122,288
2027	11,985	131,241	1,354,119	13,124	135,412
2028	12,329	135,007	1,489,126	13,501	148,913
2029	12,683	138,882	1,628,008	13,888	162,801
2030 ^a	13,050	142,898	1,770,905	14,290	177,091
2031	13,425	146,999	1,917,904	14,700	191,790
2032	13,810	151,218	2,069,122	15,122	206,912
2033	14,206	155,557	2,224,679	15,556	222,468
2034	14,614	160,022	2,384,701	16,002	238,470
2035	15,033	164,615	2,549,316	16,461	254,932
2036	15,465	169,339	2,718,655	16,934	271,865

a Calculation based on available airspace for accepted waste, determined by design

^a Source : City of Iqaluit General Plan By Law 703, October 2010. Table 1 - Medium Projection, page 16.

^a Average annual rate of 2.87% was used to estimate the population (General Plan By Law 703)

^b Assumed waste generation rate is 0.03 m³/person/day or 1,095 m³/person/year

^c Density of uncompacted waste is 100 kg/m³



Table B.2 - Estimate of Total Air Space Required

	Design of wa	aste disposal	Waste disp	osal volume	Soil cover vo	lume required	red			
	Yearly	Accumulated	(density of	[;] 700 kg/m³)	(waste to soil	cover ratio12:1)	Total air sp	ace required	Total air sp	ace required
			Yearly	Accumulated	Yearly	Accumulated	Yearly	Accumulated	Yearly	Accumulated
Year	tonnes	tonnes	m ³	m ³	m ³	m ³	m ³	m ³	Tonnes	Tonnes
2011	8,341	8,341	11,916	11,916	993	993	12,909	12,909	9,036	9,036
2012	8,581	16,922	12,258	24,174	1,021	2,014	13,279	26,188	9,296	18,332
2013	8,827	25,749	12,610	36,784	1,051	3,065	13,661	39,849	9,562	27,894
2014	9,080	34,829	12,972	49,755	1,081	4,146	14,053	53,902	9,837	37,731
2015	9,343	44,171	13,346	63,102	1,112	5,258	14,459	68,360	10,121	47,852
2016 ^a	9,611	9,611	13,730	13,730	1,144	1,144	14,874	14,874	10,412	10,412
2017	9,886	19,497	14,124	27,853	1,177	2,321	15,301	30,174	10,710	21,122
2018	10,170	29,667	14,529	42,382	1,211	3,532	15,740	45,914	11,018	32,140
2019	10,462	40,130	14,946	57,328	1,245	4,777	16,191	62,105	11,334	43,474
2020	10,764	50,893	15,377	72,705	1,281	6,059	16,658	78,764	11,661	55,134
2021	11,073	61,966	15,818	88,523	1,318	7,377	17,136	95,900	11,996	67,130
2022	11,391	73,357	16,272	104,795	1,356	8,733	17,628	113,528	12,340	79,470
2023	11,717	85,074	16,739	121,535	1,395	10,128	18,134	131,662	12,694	92,164
2024	12,054	97,128	17,220	138,754	1,435	11,563	18,655	150,317	13,058	105,222
2025	12,402	109,530	17,717	156,471	1,476	13,039	19,194	169,511	13,435	118,657
2026	12,758	122,288	18,226	174,697	1,519	14,558	19,744	189,255	13,821	132,478
2027	13,124	135,412	18,749	193,446	1,562	16,120	20,311	209,566	14,218	146,696
2028	13,501	148,913	19,287	212,732	1,607	17,728	20,894	230,460	14,626	161,322
2029	13,888	162,801	19,840	232,573	1,653	19,381	21,494	251,954	15,046	176,368
2030	14,290	177,091	20,414	252,986	1,701	21,082	22,115	274,069	15,481	191,848
2031	14,700	191,790	21,000	273,986	1,750	22,832	22,750	296,818	15,925	207,773
2032	15,122	206,912	21,603	295,589	1,800	24,632	23,403	320,221	16,382	224,155
2033	15,556	222,468	22,222	317,811	1,852	26,484	24,074	344,296	16,852	241,007
2034	16,002	238,470	22,860	340,672	1,905	28,389	24,765	369,061	17,336	258,343
2035	16,461	254,932	23,516	364,188	1,960	30,349	25,476	394,537	17,833	276,176
2036	16,934	271,865	24,191	388,379	2,016	32,365	26,207	420,744	18,345	294,521

^a New landfill is expected to be constructed in 2015. Thus, waste generated in 2016 will be disposed at the new landfill.



Table B.3 - Area Required

Description	Quantity	Quantity	Unit
Total waste generation 2016 to 2036 (20 years)	2,718,655		m ³
Total waste generation until 2036 with the density of 100 kg/m ³	271,865		tonnes
Airspace requirement until 2036 with a density of 400 and 700 kg/m ³	Der	sity	l .
for future landfill	700	400	kg/m ³
Total airspace for requirement for accepted waste	388,379	679,664	m ³
Total "soil" requirement for cover material (waste to soil ratio of 12:1)	32,365	56,639	m ³
Total airspace for the future landfill (in m ³)	420,744	736,302	m^3
Total airspace for the future landfill (in tonnes)	294,521	294,521	tonnes
Area requirement for the future landfill with average height of 15 m			
Determined by design; H =	15	15	m
Determined by design; L =	400	500	m
Calculated; W =	220	350	m
Landfill Cell Area =	88,000	175,000	m²
Additional space for utilities, road, temporary recycle compound, etc.			
is assumed 30% of the area required			
Additional Area =	26,400	52,500	m²
Total Area required =	114,400	227,500	m²
L=	500	500	m
W =	229	455	m
Area requirement determined by design for 20 years lifespan:			
L=	500	500	m
W =	250	500	m
A =	125,000	250,000	m ²

Table B.4 - Construction Sequence and Site Utilization

	Waste disposed ^{a)}	Accumulated Waste	Created Airspace Capacity	Accumulated Airspace Capacity	Capacity Remaining	Estimated Airspace Remaining at year	
Year	(tonnes)	(tonnes)	(tonnes)	(tonnes)	at year end ^{b)} (tonnes)	end ^{c)} (m³)	Note
2011	9,036	9,036					Utilized Stage 1
2012	9,296	18,332					Utilized Stage 1
2013	9,562	27,894					Utilized Stage 2
2014	9,837	37,731					Utilized Stage 2
2015	10,121	47,852					Utilized Stage 2 and closed entire West 40 landfill; and Construct New Landfill in New Site
2016	10,412	10,412	294,521	284,109	284,109	405,871	Open and Operate New Landfill
2017	10,710	21,122		284,109	273,399	390,570	
2018	11,018	32,140		273,399	262,381	374,830	
2019	11,334	43,474		262,381	251,047	358,639	
2020	11,661	55,134		251,047	239,386	341,981	
2021	11,996	67,130		239,386	227,391	324,844	
2022	12,340	79,470		227,391	215,051	307,216	
2023	12,694	92,164		215,051	202,357	289,082	
2024	13,058	105,222		202,357	189,299	270,427	
2025	13,435	118,657		189,299	175,864	251,234	
2026	13,821	132,478		175,864	162,042	231,489	
2027	14,218	146,696		162,042	147,825	211,178	
2028	14,626	161,322		147,825	133,199	190,284	
2029	15,046	176,368		133,199	118,153	168,791	
2030	15,481	191,848		118,153	102,673	146,675	
2031	15,925	207,773		102,673	86,748	123,926	
2032	16,382	224,155		86,748	70,366	100,523	
2033	16,852	241,007		70,366	53,514	76,449	
2034	17,336	258,343		53,514	36,178	51,683	
2035	17,833	276,176		36,178	18,345	26,207	
2036	18,345	294,521		18,345	0	(0)	Landfill Closed

a) Waste to be disposed include soil cover
b) Calculation based on airspace for accepted waste determined by design
c) Conversion from metric tonnes to cubic meters using a compacted waste density of 700 kg/m²

Table B.5 - Estimated Cost of West 40 Landfill Decommissioning Plan

No	Description	Unit	Approx. Quantity	Unit Price	Amount
Α	DECOMMISSIONIONG (CLOSURE) COST				
1	Reporting: closure and post-closure plan	Lump Sum	1	\$50,000	\$50,000
2	General Requirements Includes:	Lump Sum	1	\$200,000	\$200,000
	Mobilization and demobilization All other works for construction intent				
3	Surveying	Cash Allowance	1	\$50,000	\$50,000
4	Final Cover Construction				
a)	Barrier Layer: 600 mm gravel/shales from nearest quary - Not Available onsite	m²	5.382	\$20	\$107,640
	- Not Available offsite - QA/QC	day	30	\$20 \$1.200	\$107,640 \$36.000
b)	Subsoil 350 mm thick mulch: supply and placement	m ²	5,382	\$10	\$53,820
	Topsoil 200 mm thick biosolid: supply, placement and seeding	m²	5,382	\$10	\$53,820
5	Monitoring Wells Construction - six wells	Lump Sump	6	\$1,000	\$6,000
6	Miscellaneous Activities				
	Removal of:	1		#00.000	#00.000
	- Site Building - Recycle area	Lump Sum Lump Sum	1	\$20,000 \$10,000	\$20,000 \$10,000
	- Tire, Wood, Metal, and Appliance Piles	Lump Sum	1	\$50,000	\$50,000 \$50,000
	Sub Total Closure Cost				\$637,280
	Professional Service (Design and Construction)			10%	\$63,728
	Contingency Plan			20%	\$127,456
	TOTAL CLOSURE COST				\$828,464
В	POST-CLOSURE COST				
1	Annual Groundwater Monitoring include inspection of: - Inspection of Cover, Vegetation, Site Security, and Surface Drainage - Lab Analysis - Reporting	Times/Year	2	\$20,000	\$40,000
_				040.000	040.000
2	Annual Report	Lump Sump	1	\$10,000	\$10,000
	Sub Total Post Closure Cost				\$50,000
	Professional Service			10%	\$5,000
	Contingency Plan			20%	\$10,000
	TOTAL POST-CLOSURE COST PER YEAR Note:				\$65,000

Note: Assumed inflation rate of 3%. Calculated in July 14, 2011



Table B6 - Estimated Maintenance Cost for 25 Years Post-Closure

Year	Initial Cost	Years	Annual Cost	Accumulated Cost	Note
2011	\$65,000	0	\$65,000		
2012		1	\$66,950		
2013		2	\$68,959		
2014		3	\$71,027		
2015		4	\$73,158	\$73,158	Landfill Closed
2016		5	\$75,353	\$148,511	
2017		6	\$77,613	\$226,124	
2018		7	\$79,942	\$306,066	
2019		8	\$82,340	\$388,406	
2020		9	\$84,810	\$473,216	
2021		10	\$87,355	\$560,571	
2022		11	\$89,975	\$650,546	
2023		12	\$92,674	\$743,221	
2024		13	\$95,455	\$838,675	
2025		14	\$98,318	\$936,994	
2026		15	\$101,268	\$1,038,262	
2027		16	\$104,306	\$1,142,567	
2028		17	\$107,435	\$1,250,003	
2029		18	\$110,658	\$1,360,661	
2030		19	\$113,978	\$1,474,639	
2031		20	\$117,397	\$1,592,036	
2032		21	\$120,919	\$1,712,955	
2033		22	\$124,547	\$1,837,502	
2034		23	\$128,283	\$1,965,785	
2035		24	\$132,132	\$2,097,916	
2036		25	\$136,096	\$2,234,012	
2037		26	\$140,178	\$2,374,190	
2038		27	\$144,384	\$2,518,574	
2039		28	\$148,715	\$2,667,290	
2040		29	\$153,177	\$2,820,466	

Note:

Assumed inflation rate of 3%. Calculated in June 20, 2011

Appendix C

Monitoring and Inspection Forms

Closed Landfill Inspection Report

Section 1:

Facility:		
Owner:		
Location:		
Legal Land Description:		
Approximate closure date:	Approximate size	
Inspector:	Inspection date:	
Other people present:		

Section 2 Vegetation:

T () (11	
Type(s) of growth	Remarks:
(check all that apply):	
1137	
□ grasses	
= 9.0.000	
□ herbaceous plants	
la ricibaccous plants	
- moss	
□ moss	
Condition of succession	Damandra
Condition of growth:	Remarks:
_ , , , , , , ,	
□ Excellent (thick	
growth)	
,	
□ Good	
□ Poor (thin growth,	
bare soil, mosses)	
	<u> </u>
Invasive plants	Remarks:
present?	
□ Yes □ No	
Dead spots present?	Remarks:
Bedd opoto present:	Tromano.
□ Yes	
□ No	
LINU	

Section 3 Final Cover Condition:

Is there subsidence (depressions in the cap)?	Remarks:
□ Yes	
□ No	
Is there any evidence of water ponding on the cap?	Remarks:
□ Yes	
□ No	
Are there colored leachate seeps through the cap?	Remarks:
□ Yes	
□ No	
Are there colored leachate seeps at toe slope?	Remarks:
□ Yes	
□ No	
Are there signs of burrowing animals?	Remarks:
□ Yes	
□ No	
Is there any waste pushing through the cap?	Remarks:
□ Yes	
□ No	
Does the cap cover all of the solid waste?	Remarks:
□ Yes	
□ No	
Is there evidence of erosion?	Remarks:
□ Yes	
□ No	
Is there ATV damage to the cap or vegetation?	Remarks:
□ Yes	
□ No	

Section 4 Drainage and Surface Water:

Conditions/Stability of streams/swales/ditches etc.	Remarks:
□ Excellent (unobstructed)	
□ Good	
□ Poor (overgrown or sediment filled)	
Is there evidence of colored leachate in surface waters?	Remarks:
□ Yes	
□ No	
Is there surface water monitoring?	Remarks:
□ Yes	
□ No	
Section 5 Other Facility Cond	litions:
Access road condition:	Remarks:
□ Excellent	
□ Good	
□ Poor	
Gates and fences:	Remarks:
□ Present	
□ Not present	
Gate and fence condition:	Remarks:
□ Excellent	
□ Good	
□ Poor	
Section 6 Structures:	
Are there man made structures on the cover?	Remarks
□ Yes	
□ No	

Section 7 General cleanliness of the site:

Is there litter present?	Remarks:
□ Yes	
□ No	
Is there evidence of unauthorized dumping?	Remarks
□ Yes	
□ No	
Section 8 Maintenance:	
Section 8 Maintenance: Is there an ongoing maintenance program?	Remarks:
Is there an ongoing	
Is there an ongoing maintenance program?	

Section 9 Other Information:

- Attach a hand drawn site sketch made on plain paper 8 1/2" x 11"
- Attach labeled photographs of landfill conditions and any nearby development

 Describe any corrective actions planned or taken as a result of conditions noted during the inspection (attached additional pages if necessary): 				

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Appendix G

Solid Waste By-law 341 and By-law 544

BY-LAW 341 - SOLID WASTE BY-LAW

INDEX

Clause		Page N0#
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THE CORPORATION OF THE TOWN OF IQALUIT, N.W.T.

BY-LAW 341

BEING A BY-LAW of the incorporated Town of Iqaluit in the Northwest Territories to provide for the regulation, collection and disposal of solid waste.

WHEREAS the <u>Cities, Towns and Villages Act</u>, R.S.N.W.T., 1988,c.C-8, Sections 85 through 88, 169, 173 and 182 through 187 provides that Municipalities may; regulate, establish and operate garbage facilities, provide for the collection, removal and disposal of garbage, provide for sale or reuse of any waste by-product, levi and collect fees for garbage services and impose punishment for offenses.

NOW, THEREFORE PURSUANT to the provisions of the <u>Cities</u>, <u>Towns and Villages Act</u>, and notwithstanding any by-laws, sections thereof, resolutions or prior enactments,

THE COUNCIL OF THE TOWN OF IQALUIT, in regular session duly assembled, enacts as follows:

PART I, INTERPRETATION

101. Short Title

This by-law may be cited as the Solid Waste By-Law.

102. Severability

If any provision of this by-law is declared invalid because of any word, phrase, clause, sentence, paragraph or section of this By-Law or any documents which form part of this By-Law or an application thereof to any person or circumstance is declared invalid, the remaining provisions shall not be affected thereby but shall remain in force.

103. Definitions

In this by-law, unless the content otherwise requires;

"at cost"

means the posted equipment and manpower rates of the Town, as adjusted from time to time, and any administrative overhead costs plus 15%.

"authorized contractor"

means a contractor, authorized by By-Law, to perform solid waste services, on behalf of the Town of Iqaluit in accordance with specified terms, conditions and fees.

"bulky waste"

means waste which will not normally fit into a garbage box.

"combustible waste"

means waste suitable for burning that can be readily burned without appreciably endangering operations or the environment.

"commercial"

means a single premise used for the purpose of carrying on a business for profit and represented by the owner(s) and/or tenant(s).

"commercial/government/industrial

hazardous waste"

means solid waste generated by commercial, government or industrial organizations which could be flammable, toxic, corrosive, explosive, or otherwise has the potential for endangering municipal operations, the community or the surrounding environment.

"construction debris"

means unwanted, useless, abandoned, discarded or rejected goods or materials of every kind that are normally generated on a construction site but, excluding sewage and/or commercial, government and industrial hazardous waste.

"Council"

means the Council of the Town of Iqaluit.

"covered"

means secured in such a fashion that wind, animals or birds cannot scatter.

"covered conveyance"

means a vehicle used to transport solid waste to the waste facility where the waste is contained so that it cannot fall out, be blown out or otherwise scattered.

"garbage"

means the same as "solid waste".

"garbage room/building"

means a locked room or building, as per any specifications relating to this by-law, used exclusively for the temporary holding of garbage in readiness for scheduled collection.

"government"

means a single premise used for the purpose of government and represented by senior official(s) and/or elected representative(s).

"honey bag"

means bagged raw sewage.

"household hazardous waste"

means solid wastes generated only in residential domiciles which are flammable, toxic, corrosive, explosive, or otherwise has the potential for endangering municipal operations, the community or the environment.

"household waste"

means solid waste normally generated in or from residential domiciles but, excluding hazardous waste.

"industrial"

means a single premise used for manufacturing and represented by the owner(s) and/or tenant(s).

"land fill"

means a duly licensed site used for the disposal of municipal type solid waste.

"littering"

means disposing of garbage in any area other than prescribed by this by-law.

"Manager"

means the Senior Administrative Officer of the Town of Iqaluit or their designate.

"municipal type solid waste"

means garbage which can be hand placed in garbage truck but, does not include sewage or hazardous waste.

"residential"

means a single domicile represented by the owner(s) or tenant(s). This also includes "not for profit" premises. "segregate"

means the separation of solid waste into combustible, salvageable, recyclable, bulky, metal or hazardous waste.

"solid waste"

means unwanted, useless, abandoned, discarded or rejected goods or materials of every kind but, excluding sewage and or commercial, government and industrial hazardous waste.

"solid waste facility"

refers to the Town operated modified sanitary land fill, which is clearly marked with signs, which is located in the West 40 between an old abandoned waste site and fuel tank #22. The site is referred to as site #3 in the Town Waste Management Plan.

"Town"

means the Town of Iqaluit or its duly authorized contractor(s).

"waste container"

means a covered garbage box, locked garbage room or house and dumpsters as specified in any specifications relating to this by-law.

"waste generator"

means one who produces waste of any nature which relates to and is under

the control of this by-law.

PART II, GENERAL PROVISIONS

201. Authority to Provide Municipal Services

No person or contractor, except those authorized by By-Law, shall directly or indirectly engage in the provision of municipal solid waste services within the Town.

202. Authority and Duties of the Manager

- The Manager is authorized and directed to; (1)
 - supervise, control and administer the provisions and regulations and to do all things necessary to fulfil their responsibilities and duties under this by-law;

- (b) control all contracting, construction, operation, maintenance and regulatory compliance related to the provision of solid waste services;
- (c) perform all acts that may be necessary for the efficient management, operation and protection of the municipality;
- (d) enter upon private property for the purpose of this bylaw; and
- (e) levy tariffs, fines and penalties as well as take any other legal actions necessary to enforce this by-law.
- (2) The Manager may prescribe;
 - (a) orders,
 - (b) specifications for
 - (i) waste containers
 - (ii) segregation of waste
 - (iii) and other specifications,
 - (c) waste collection days, and
 - (d) hours of operation and service.
- (3) The Manager may prescribe forms for;
 - (a) application for service,
 - (b) termination of service,
 - (c) receipt of service,
 - (d) charges for service,
 - (e) description, volume and type of waste,
 - (f) violations,
 - (g) any other forms and information sheets necessary to carry out the provisions of this by-law.

203. Financing and Accounting

(1) All costs for the provision of solid waste services shall be financed through tariffs, service charges, fees, (as per Schedule "C") loans, and grants, subsidies or other funding provided to the Town by the Government of the Northwest Territories and/or others.

- (2) All monies collected for solid waste services shall only be used to provide waste services to customers including administration, operation, maintenance, training, extension, repair, capital improvements and regulatory compliance.
- (3) All monies collected for the provision of solid waste services shall be separately accounted for and disbursed by action of the Council.
- (4) Bills for tariffs, service charges, fees and all other penalties and/or charges levied under this by-law are due and payable not later than thirty (30) days after the date of mailing.
- (5) Overdue accounts shall have interest charged at the same rates that are charged for overdue taxes as established by the prevailing Town Taxation By-Law.

204. Service Area

- (1) The Town shall provide municipal type solid waste collection services to premises within the built up areas of the Town.
- (2) Collection of municipal type solid waste outside the service area will only be provided at cost and when such services will not impede the provision of this service within the designated service area.

205. Description of Service

- (1) The Town shall collect municipal type solid waste, within the service area, from residences, commercial establishments, industrial establishments and government locations on a scheduled basis.
- (2) The Town shall operate and maintain a solid waste facility, known as the Town Land Fill, for municipal type waste, household hazardous waste and bulky waste, which is located at site 3 in the West 40. All solid waste, with the exception of raw sewage and/or commercial, government and industrial generated hazardous waste, shall be disposed of at the Town Land Fill.
- (3) Notwithstanding subsections (1) and (2), when in the opinion of the manager, or regulatory agencies, the environment or public health and safety are seriously impaired, the manager may;
 - (a) restrict or terminate municipal type solid waste collection,

- (b) restrict or terminate operation of the solid waste facility.
- (4) The Town shall make every reasonable effort to provide safe, continuous and efficient solid waste services; nevertheless, the Town shall not be liable for damages, including business losses,
 - (a) caused by restriction or termination of municipal type solid waste collection,
 - (b) caused by restriction or termination of operation of the solid waste facility,
 - (c) caused through noncompliance with specifications,
 - (d) caused by impeded access to waste containers,
 - (e) caused by the interference or cessation of solid waste services in connection with the repair, expansion, replacement, or proper operation and maintenance of the solid waste collection system or solid waste disposal facility,
 - (f) caused by the interference or cessation of service due to adverse weather conditions, road conditions or vehicle mechanical problems,
 - (g) caused by improper segregation of waste,
 - (h) generally for any accident due to the operation of the municipal system, unless such action has been shown to be directly due to the negligence of the Town or its employees,
 - (i) caused by the interference or cessation of service due to any contravention of this by-law.
- (5) The Town shall conduct a mass participation annual spring clean-up of litter and unsightly bulky waste.
- (6) The Town shall conduct a household hazardous waste round up four (4) times per year.
- (7) The Town shall not collect, transport, handle, store nor dispose of commercial, government or industrial generated hazardous waste.
- (8) Collection, transportation, handling, storage and disposal of commercial, government or industrial generated hazardous waste is the sole responsibility of the generator and must be done in accordance with all applicable legislation.

- (9) Stockpiling of any commercial, government or industrial generated hazardous waste must not be left to accumulate, within Town boundaries, for over four (4) years.
- (10) No-one shall indiscriminately dispose of hazardous waste.
- (11) The Town shall not collect, handle nor dispose of honey bags.
- (12) Anyone who litters must clean up their litter immediately upon notification by the manager and/or be liable to a fine as specified in schedule "A".
- (13) Should a building or structure have been damaged by fire or other means, the owner must, within one hundred and twenty (120) days, apply to the Town for the necessary permits to restore, repair, or demolish the structure or the building may be deemed to be construction debris under the terms of this by-law.

206. Authority to Restrict Service

- (1) The Manager may, without notice, cease or restrict service to any customer or part of Town should he decide that an emergency makes such action necessary.
- (2) The Manager may, in a non-emergency situation, including adverse weather conditions, scheduled repairs, or alteration of the collection or disposal system, restrict service to any customer or part of the Town, provided that the Manager shall, when it is practical to do so, provide public notice of such intended cessation or restriction of service to all affected customers.
- (3) The Manager may discontinue service for any of the following reasons;
 - (a) failure to establish service,
 - (b) fraud in establishing service,
 - (c) non-payment of charges or fees levied pursuant to this by-law,
 - (d) failure to provide a deposit, if required,
 - (e) failure to provide unimpeded access; or
 - (f) contravention of any other section of this by-law.
- (4) When service is discontinued, neither the Town nor its employees or any municipal officials shall be liable for any costs or damages resulting from the discontinuance of service.

(5) Where this by-law authorises service to be discontinued, the Manager shall, when it is practical to do so, give notice prior to service being discontinued. Such notice shall indicate the infraction, remedy, and the date that service will be discontinued unless remedy is made. When service is discontinued, service shall not be reinstated until such time as there is no longer a contravention of this by-law or any outstanding service charges and fees, and a specified reinstatement service fee is paid to the Town.

207. Notification

- (1) Notice from the Town to a customer or owner for bills due, contravention of any provisions of this by-law, or for any other reasons, shall be in writing to the last known address.
- (2) Notice to the Town shall be made in writing to the Municipal Office, except that notice of complaint may be made by telephone or in person.

208. Effective Date

(1) This by-law shall come into effect April 1, 1995 and shall remain in effect until it is repealed.

PART III, ESTABLISHMENT AND TERMINATION OF SERVICE

301. To Establish Waste Collection Service

- (1) Subject to subsection (2), every person requiring establishment of service, shall submit to the Manager an application for service form and the appropriate fees specified in Schedule C.
- (2) Where premises are occupied by a tenant or lessee, the Manager may require that the application for service be submitted by the owner of the premises.
- (3) Where a premise has multiple occupancies the application for service shall be submitted, along with detailed drawings and specifications for waste containment, by the owner of the premise.
- (4) An application for service must allow a minimum of five (5) working days prior to date when service is expected.

(5) An application for service will not be required for units which were already obtaining service at the effective date of this by-law.

302. Content of Application for Waste Collection Service

The application for service shall include such particulars as the following;

- (a) location of the premise,
- (b) date applicant will be ready for service,
- (c) type of waste storage erected or intended for erection,
- (d) whether the premise had been previously serviced,
- (e) name and mailing address to which notices and bills are to be sent,
- (f) whether the applicant is owner or tenant of, or agent for the premises,
- (g) category of customer and applicable rate,
- (h) agreement to abide by and accept all the provisions of this by-law,
- (i) any other fees or service charges,
- (j) detailed drawings and specifications for garbage rooms or buildings, and
- (h) any other information in such detail and form the Manager deems appropriate.

303. Deposit

As a condition of providing services the Manager may require a deposit from the applicant provided that;

- (a) the amount of the deposit shall be determined by the Manager based on the expected service charge for a ninety (90) day period,
- (b) the deposit shall be refunded after it has been held for a twelve consecutive month period during which all bills for service have been paid within the time allowed,

- (c) the deposit, less the amount of any unpaid balance due to the Town, shall be refunded upon discontinuance of service, and
- (d) interest of six (6) percent per year will be paid on any deposit.

304. Application to Terminate Service

- (1) In order to terminate service, the customer shall submit to the Manager a written request stating the date the applicant desires to terminate service and any other information and in such form as may be prescribed by the Manager.
- (2) All applications for termination of service must allow a minimum of five (5) working days prior to the date termination of service is required.
- (3) The Town may continue to levy service charges in accordance with this by-law until services are terminated.

PART IV, RESPONSIBILITIES OF THE WASTE GENERATOR

401. Residential Waste

- (1) Every residential generator of municipal type waste shall maintain, in good condition, sufficient covered or enclosed waste containers as per Town specifications.
- (2) All waste placed in a waste container must first be placed in a garbage bag.
- (3) All waste containers shall be kept within the property boundaries of the lot or parcel of land on which the serviced premises are located and be positioned adjacent to the public roadway.
- (4) Every waste generator shall maintain, at his own expense, unimpeded access to their waste containers, including the removal of ice, snow, mud, vehicles, pets and yard materials and, the sanding of icy patches.
- (5) Any person having garbage upon their premise or lands shall dispose of it in the manner prescribed by the Manager.
- (6) No person shall dispose of hot ashes, burning matter or loose waste in any waste container.

- (7) No person shall dispose of any explosive, inflammable, dangerous or hazardous waste in any waste container or any other place without the express authority of the Manager who shall designate the manner and place it shall be disposed of.
- (8) Household hazardous waste shall be stored by the residential waste generator until the Town holds a "Household Hazardous Waste Round-up" when these wastes shall be brought to an area prescribed by the Manager for disposal.
- (9) Subject to subsections (15) and (16) of this section, no person shall burn any waste of any nature within the boundaries of the Town. This excludes barbecues or cooking fires.
- (10) Any construction or building material being used or stored on private property must be stored on the said property, in a neat and orderly fashion or it may be defined as construction debris under the terms of this by-law.
- (11) Subject to subsection (12) of this section, all debris on a construction or work site must be segregated and placed in covered containers, on a daily basis, then hauled in a covered conveyance to the Town Land Fill site.
- (12) Where a waste container is not available, all debris on a construction or demolition site shall be segregated, hauled in a covered conveyance and disposed of at the Town Land Fill site on a daily basis.
- (13) Notwithstanding section 205. subsection (5) and (6), and subsections (8), (10), (11) and (12) of this section, no person other than the Town or its authorized contractor shall directly or indirectly remove and/or dispose of any residential waste within the boundaries of the Town.
- (14) Bulky wastes, generated by residential generators, must be segregated, removed and disposed of at the Town Landfill.
- (15) The Town may carry out controlled burning of waste for volume reduction and/or training.
- (16) The Fire Department may grant permission for the supervised burning of bon-fires on special occasions.
- (17) All premises which utilize a garbage room or building shall ensure that all waste is stored in secured and segregated waste containers.
- (18) Conditions of the operations and maintenance manual for the Town Land Fill site and directions of the Waste Facility Operator are to be strictly observed by all residential users.

402. Commercial/Government/Industrial Waste

- (1) Every commercial, government or industrial generator of municipal type waste shall maintain, in good condition, sufficient covered or enclosed waste containers as per Town specifications.
- (2) All waste placed in a waste container must first be segregated then placed in garbage bags or baled.
- (3) All waste containers shall be kept within the property boundaries of the lot or parcel of land on which the serviced premises are located and be positioned adjacent to the public roadway.
- (4) Every commercial, government or industrial waste generator shall maintain, at his own expense, unimpeded access to their waste containers, including the removal of ice, snow, mud, vehicles, pets and yard materials and, the sanding of icy patches.
- (5) Any commercial, government or industrial establishment having litter or unsightly garbage upon their premise or lands shall dispose of it in the manner prescribed by the Manager.
- (6) No commercial, government or industrial establishment shall dispose of hot ashes, burning matter or loose waste in any waste container.
- (7) Subject to subsection (8) and (9) of this section, no commercial, government or industrial establishment shall dispose of any explosive, inflammable, dangerous or hazardous waste in any waste container or any other place without the express authority of the Manager who shall designate the manner and place it shall be disposed of.
- (8) Collection, transportation, handling, storage and disposal of commercially, governmentally or industrially generated hazardous waste is the sole responsibility of the generator and must be done in accordance with all applicable legislation.
- (9) Stockpiling of any commercially, governmentally or industrially generated hazardous waste must not be left to accumulate, within Town boundaries, for over four (4) years.
- (10) Subject to subsections (17) and (18) of this section, no commercial, government or industrial establishment shall burn any waste of any nature within the boundaries of the Town. This excludes barbecues or cooking fires.

- (11) Any construction or building material being used or stored on private property must be stored on the said property, in a neat and orderly fashion or it may be defined as construction debris under the terms of this by-law.
- (12) Subject to subsection (8) and (13) of this section, all construction debris on a construction or work site must be segregated and placed in covered containers, on a daily basis, then hauled in a covered conveyance to the Town Land Fill site.
- (13) Subject to subsection (8) of this section, where a waste container is not available, all debris on a construction or demolition site shall be segregated, hauled in a covered conveyance and disposed of at the Town Land Fill site on a daily basis.
- (14) Commercial establishments shall segregate, remove and dispose of all bulky wastes, generated by them, at the Town land fill.
- (15) The Town may dispose of construction debris and/or bulky wastes if it has not been properly disposed of within twenty four (24) hours of notification to do so, and the premise owner charged "at cost" for work performed by or on behalf of the Town.
- (16) Notwithstanding section 205. subsection (5) and (6), and subsections (7), (8), (12), (13) and (14) of this section, no person other than the Town or its authorized contractor shall directly or indirectly remove and/or dispose of any commercial, government or industrial municipal type waste within the boundaries of the Town.
- (17) The Town may carry out controlled burning of waste for volume reduction and/or training.
- (18) The Fire Department may grant permission for the supervised burning of bon-fires on special occasions.
- (19) All premises which utilize a garbage room or building shall ensure that all waste is stored in secured and segregated waste containers.
- (20) Conditions of the operations and maintenance manual for the Town Land Fill site and directions of the Waste Facility Operator are to be strictly observed by all commercial, government or industrial users.

PART V, ENFORCEMENT

501. Penalty Provisions

- (1) A By-law Officer employed by the Town is authorized to issue a violation Ticket to any person who the By-law Officer has reasonable and probable grounds to believe and has contravened any provision in this By-law.
- (2) Any person who contravenes any provision of the By-law is guilty of an offence and is liable on summary conviction to a fine as set out in Schedule "A" of this By-law.
- (3) Any Commercial Business, Government or Industry who contravenes any provision of the By-law is guilty of an offence and is liable on summary conviction to a fine as set out in Schedule "B" of this By-law.
- (4) Every person who contravenes any of the provisions of this Bylaw is guilty of an offence, punishable on summary conviction and is liable to a fine of not less than One Hundred (\$100.00) Dollars or more than Two Thousand (\$2,000.00) Dollars and in default of fine imposed, a period of imprisonment not exceeding six (6) months.
- (5) Every Commercial Business, Government or Industry who contravenes any of the provisions of this By-law is guilty of an offence, punishable on summary conviction and is liable to a fine of not less than One Thousand (\$1000.00) Dollars or more than Ten Thousand (\$10,000.00) Dollars and in default of fine imposed, a period of imprisonment not exceeding six (6) months.
- (6) A By-law Officer who has reasonable and probable grounds to believe that a person, business, government or industry is violating or has violated any provision of this By-law may give such person written notice of intention to prosecute in the form of a ticket as defined in the Summary Convictions Act and amendments thereto, setting forth the date, and place of the offence; briefly stating the nature of the offence; stating that payment may be made under section __V_ of this By-law.
- (7) A person, business, government or industry who has received a ticket pursuant to section V in respect of an alleged offence under this By-law may after receipt of such ticket in lieu of prosecution under this By-law, pay to the Town such penalty as is set out in the appropriate Schedule "A" or "B" attached hereto and which forms part of this By-law.

PART VI, REPEAL

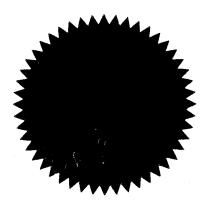
601.	Repeal
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(1) On the effective date this by-law repeals by-laws 169 and 333.

THIS BY-LAW NUMBER 341 IS READ A FIRST TIME this ______, day of ______, 1995 A.D. by the Council of the Town of Iqaluit, N.W.T.

THIS BY-LAW NUMBER 341 IS READ A SECOND TIME this 13 day of Market, 1995 A.D. by the Council of the Town of Iqaluit, N.W.T.

THIS BY-LAW NUMBER 341 IS READ A THIRD AND FINAL TIME this 27^{*2} day of March, 1995 A.D. by the Council of the Town of Iqaluit, N.W.T.



MAYOR

OFFICE OF THE OF

SCHEDULE "A" OF BY-LAW 341

FINES FOR INDIVIDUALS

<u>Sections</u>		Amount
205(4)10	indiscriminate disposal of hazardous waste	\$500.00
205(12)	littering	\$500.00
401(1)	failing to provide a waste container	\$100.00
401(2)	failing to place garbage in proper container	\$100.00
401(5)	failing to dispose as directed	\$250.00
401(6)	placing burning items in waste container	\$500.00
401(7)	placing hazardous waste in unsuitable container	\$500.00
401(9)	burning waste within town boundaries without permission of Fire department	\$500.00
401(10)	storing garbage on property in untidy manner	\$200.00
401(11)	unsegregated garbage	\$500.00
401(11)	uncontained construction debris	\$500.00
401(12)	hauling waste in uncovered conveyance	\$500.00
401(17)	unsecured waste storage container	\$200.00
401 (18)	non-observation of directions	\$300.00

SCHEDULE "B" OF BY-LAW 341

FINES FOR CORPORATIONS

<u>Sections</u>		AMOUNT
205(4)10	indiscriminate disposal of hazardous waste	\$10,000.00
205(12)	littering	\$ 5,000.00
402(1)	failing to provide a waste container	\$ 1,000.00
402(2)	failing to properly put garbage in container	\$ 1,000.00
402(5)	failing to dispose as directed	\$ 2,500.00
402(6)	placing burning items in waste container	\$ 2,500.00
402(7)	unsuitable hazardous waste storage	\$10,000.00
402(8)	improper hazardous waste procedures	\$10,000.00
402(9)	stockpiling hazardous waste for over 4 yrs.	\$10,000.00
402(10)	burning waste within town boundaries without permission of Fire department	\$ 5,000.00
402(11)	storing garbage on property in untidy manner	\$ 2,000.00
402(12)	unsegregated garbage uncontained construction debris	\$ 3,000.00 \$ 5,000.00
402(12)& (13)	hauling garbage in uncovered conveyance	\$ 5,000.00
402(19)	unsecured or segregated waste storage	\$ 2,500.00
402(20)	non-observation of directions	\$ 3,000.00

SCHEDULE "C" OF BY-LAW 341

TARIFFS AND FEES

(1) Subject to subsection II, the rates payable by customers for collection and disposal of municipal type solid waste are as follows:

CATEGORY OF CUSTOMER;

Residential and Non-Profit; (based on collections twice per week excluding Statutory Holidays)

(Das	sed on corrections twice per week excluding Statutor	ry Holidays)
1.	 single and duplex units (separate storage) (under 35 cubic feet) 	\$27.50/M/U
2.	- triplex to six-plex units (separate storage) (under 35 cubic feet)	\$27.50/M/U
3.	- triplex to six-plex units (combined storage) (35 cubic feet up to 200 cubic feet)	\$25.00/M/U
4.	- Larger than six-plex (separate storage) (under 35 cubic feet)	\$27.50/M/U
5.	 larger than six-plex (combined storage) (200 cubic feet and over) 	\$22.50/M/U
	mercial; sed on five collections per week excluding Statutor	ry Holidays)
6.	 single business (separate storage of 35 cubic ft. or under) 	\$60.00/M/B
7.	 single business (separate storage of over 35 cubic ft. and under 200 cubic ft.) 	\$75.00/M/B
8.	- single business (200 cubic ft. & over)	\$100.00/M/B
9.	 multiple businesses (combined storage of under 200 cubic ft.) 	\$70.00/M/B
10.	 multiple businesses (combined storage of 200 cubic ft. & over) 	\$65.00/M/B
	Government/Industrial; (based on five collections per week excluding Holidays)	g Statutory
11.	- separate storage of 35 cubic ft. or under	\$60.00/M/U
12.	- separate storage of over 35 cubic ft. and under 200 cubic ft.	\$75.00/M/U
13.	- separate storage of 200 cubic ft. & over	\$100.00/M/U

SCHEDULE "C" By-Law 341 continued

(2)	Unscheduled garbage collection fee/collection	stion \$125.00
(3)	Application for service fee	\$ 15.00
(4)	Reinstatement of service fee	\$ 15.00
(5)	Tipping fees at Town Land Fill;	
	- up to 1/2 ton pick-up truck	\$ 5.00/load
	- over 1/2 ton to 1 ton pick-up truc	k \$10.00/load
	- over 1 ton to 15 ton truck	\$25.00/load
	- over 15 ton truck	\$35.00/load
	- car body	\$10.00/car
	- pick-up truck body	\$15.00/truck
	- bulky items larger than pu truck b	oody \$25.00/item
	- designated contractor fee	\$150.00/load
(6)	Wood salvage	\$1.00/cubic ft.
(7)	Other miscellaneous salvage Nominal fee	to be determined
(8)	Recyclable materials Market valu	e at time of sale
(9)	at the charge as es	est will be charged a same rate as that d for overdue taxes stablished by the ling Town Taxation
(10)	Disposal of construction debris or bulky	waste "at cost"
NOTE;	; M = month B = business U = unit (single)	

THE CORPORATION OF THE CITY OF IQALUIT, NU

BY-LAW #544

AMENDMENT TO SOLID WASTE BY-LAW

A By-law of the City of Iqaluit, a municipal corporation in Nunavut to waive municipal service charges for collection of waste, pursuant to the provisions of the Cities, Towns and Villages Act, R.S.N.W.T. 1988, c. C-8, s.65(1) and 85 (1)(d)

A by-law is necessary to waive municipal service charges for collection of waste due to non-collection during the labour dispute f5om April 17 to July 31, 2001 as it was not included in the Essential Service Agreement.

NOW THEREFORE, the Council fo the City of Iqaluit in a session duly assembled, enacts as follows:

1. For a period of April 17, 2001 to July 31, 2001, only that Council waive municipal services collection charges for Residential, Commercial, Government and Industrial waste.

Government and Industrial waste.	Tor Residential, Commercial,
This By-law amends By-law 341 for a period of	April 17, 2001 to July 31, 2001.
THIS BY-LAW READ A FIRST TIME this 14	4 day of <u>August</u> , 2001. A.D.
	MAYOR
	CHIEF ADMINISTRATIVE OFFICER
THIS BY-LAW READ A SECOND TIME this_	<u>14</u> day of <u>August</u> , 2001. A.D.
	MAYOR
	CHIEF ADMINISTRATIVE OFFICER
THIS BY-LAW READ A THIRD AND FINAL	TIME this 28 day August, 2001.A.D
	MAYOR

CHIEF ADMINISTRATIVE OFFICER



Appendix

Nunavut Water Board – Type "A" Water Licence No. 3AM-IQA1626



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NUNAVUT WATER BOARD TYPE "A" WATER LICENCE NO. 3AM-IQA1626

Nunavut Water Board | Type "A" Water Licence No: 3AM-IQA1626

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Licence No. 3AM-IQA1626

Pursuant to the Nunavut Waters and Nunavut Surface Rights Tribunal Act and the Agreement Between the Inuit of the Nunavut Settlement Area and Her Majesty the Queen in Right of Canada, the Nunavut Water Board, hereinafter referred to as the Board, hereby grants to the

CITY OF IQALUIT

(Licensee)	OV 460 10 41 111T N	III VAA OHO	
P.O. E	BOX 460 IQALUIT, N	OU AUA OHO	
(Mailing Address)			
		vert or otherwise use Water or deposit ns contained within this Licence:	
Licence Number / Type:	3AM-IQA1626 / TYPE "A"		
Water Management Area:	FROBISHER BAY WATERSHED (53)		
Location:	WITHIN CITY OF IQALUIT'S MUNICIPAL BOUNDARIES, QIKIQTANI REGION, NUNAVUT		
Classification: MUNICIPAL UNDERTAKING			
Purpose:	USE OF WATERS AND DEPOSIT OF WASTE		
Quantity of Water not to be Exceeded:	1,100,000 CUBIC METRES ANNUALLY		
Date Licence Issuance:	JUNE 17, 2016		
Expiry of Licence:	JUNE 16, 2026		
This Licence issued (Motion Number: 2016-02-P6-14) and recorded at Goji Haven, Nunavut, includes and is subject to the annexed conditions.			
NIE		*	
Norman Mike Nunavut Water Board, Hearing Chair	APPROVED BY:	Minister of Indigenous and Northern Affairs Canada	
	APPROVAL DATE:		