City of Iqaluit

Landfill Facility Expansion

Preliminary Design Report -

Regulatory Submission

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City of Iqaluit

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Submitted by

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1.0 INTRODUCTION

1.1_ General

The existing Iqaluit landfill facility was built in 1995, and was intended as a temporary site until funding for a permanent solution could be allocated. Waste disposal techniques at the existing landfill include burning, compaction and covering with granular fill. Due to the limited size of the existing landfill, burning is necessary to reduce the volume of waste.

In October 1999, the City of Iqaluit, in conjunction with the Department of Community Government & Transportation (CG&T), commissioned a Solid Waste Management Planning Study for Iqaluit. The study was completed by JL Richards & Associates and Golder Associates Limited in September 2000. Extensive community consultations were completed as part of the study to address residents' concerns. One recommendation from this study was to develop an incinerator and ash disposal facility to address the long term solid waste management of the community.

Current estimates indicate that the existing landfill will reach its design capacity in November 2001. As a result, there was an immediate need to select the long term solid waste management system and the locations for the components of this new system. In October 2000, the City retained Dillon Consulting Limited (Dillon) to complete a solid waste facility site selection. This study was the next step in addressing the long term solid waste management issues in Iqaluit.

In January 2001, Dillon prepared a draft report for the City of Iqaluit entitled, "Solid Waste Facility Site Selection, Draft Report". Outlined in the report were a number of solid waste management (SWM) site options. These SWM site options were ranked by the SWM steering committee which was comprised of city council members and the public. The number one ranked, recommended option is an incinerator facility located at the existing municipal garage site on Federal Road with an ashfill system at the current landfill site in West 40. Further work in the development of this option is currently underway. However, until the new facility is constructed, the City needs to expand the existing landfill to meet current solid waste disposal requirements.

In June 2001, Dillon was selected to design a landfill/ashfill facility. The city's plan is to expand the existing West 40 landfill facility to accept municipal waste until the new incinerator process is in place. The expanded landfill will then become the ash disposal landfill. Due to the immediate need for the expansion of the facility, the design, approvals, and construction need to be completed in the 2001 construction field season.

1.2 Scope of Work

The purpose of this document is to outline the preliminary design for the proposed landfill system. This summary report includes the preliminary site layout, landfill liner recommendations, runoff management, and sizing calculations. The scope of work for the preliminary design included:

Background Review

This task included a complete review of the solid waste management documents developed by OMM, JL Richards/Golder, and Dillon and all available environmental assessment reports relating to the site. The intent of this task was to summarize the information directly related to the development of the landfill/ashfill facility.

Site Investigations

This task included test pitting and performing a survey to determine the location of waste mass, type of waste, and to obtain topographic information of the site.

Preliminary Design

This task focused on the following aspects:

1) Site layout including main entrance, site access roads, and waste segregation areas;
2) Stormwater management systems including ditching and sedimentation pond;
3) Composite liner systems and Cell #1 development (3 years);
4) Yard lighting and fencing.
5) Soliciting approvals required under applicable territorial and federal legislation.

The detailed landfill design and construction services will also be provided as for this project.

2.0 BACKGROUND REVIEW

The City of Iqaluit has become a capital city as well as a regional hub for business, transportation, educational facilities and institutions for the Territory of Nunavut. This has created an increase in the growth of the community population and economic activity. This increase in population and services therefore resulted in an increase in solid waste generation. There have been several solid waste management studies and many environmental studies regarding the clean-up of existing dump sites conducted in the past 10 to 15 years. The following sections summarize the results of these studies.

2.1 Previous Solid Waste Studies

The solid waste management (SWM) issues of Iqaluit have been the subject of over 30 reports in the past decade. Studies and plans for the current and future solid waste management sites for the City's short and long terms needs which have particular pertinence are:

1) Solid Waste Composition Study for Iqaluit, Pangnirtung, and Broughton Island of the Northwest Territories, September 1989, Gary W Heinke, PhD, P. Eng., Jeffrey Wong.

   The report developed waste composition through actual waste stream characterization and volume/weight measurements. To our knowledge this is the only study of waste stream composition completed in the NWT/Nunavut. The report provides comparisons of the data collected in the selected communities to studies completed in southern Canada. The results of the study are important in understanding the composition of the waste stream in Iqaluit.

2) Environmental and Geotechnical Investigation, Proposed Solid Waste Site, Iqaluit, NWT, May 1991, Hardy BBT Limited.

   This work included the investigation of the current landfill site area. There was noted concerns to the area north of the current landfill due to the presence of PCBs and other hazardous wastes. The report provides the basis for the design of the current site with respect to location, size and berm construction. This report was completed for UMA Engineering Ltd, see below.

3) Preliminary Engineering Report, Iqaluit Solid Waste Disposal Site, November 1991, UMA Engineering Ltd.

   This report included the preliminary engineering for the development of a new waste management area. This is the area now used by the City for disposal of municipal waste. The conclusions are as follows:

- An environmental assessment of the area identified the presence of contaminants at the north end of the site. The north end of the site has been set aside from the development concept for a more detailed investigation to determine the extent of the contamination and the necessary remediation.
- The preliminary engineering to develop the site on an interim basis identified that the site is suitable for a five year design horizon based upon only developing the south half of the site, using a waste generation rate of 0.017 m^3/person/day, and assuming 80% waste reduction due to burning. The site will operate with burning of combustible waste and separation of bulky waste.
- The design concept and operational plan for the site development satisfies the criteria solicited from the various regulatory agencies concerned with solid waste disposal.

4) Town of Iqaluit Landfill Operation and Maintenance Manual for Site 3 in West 40, December 1994, UMA Engineering.

   This is the O&M Manual for the City's existing landfill site.

5) Municipality of Iqaluit, Solid Waste Management Study, August 1998, Oliver Mangione and McCalla.

   This study reviewed existing and past practices of the City's waste management system. The study completed a cursory review of the options for future waste disposal. Options reviewed included landfill (with and without burning) and incineration.

6) Solid Waste Management Planning Study, Municipality of Iqaluit, September, 2000, Golder Associates Ltd & J L Richards & Associates Limited.

   This study comprised of a large public consultation process for the development of a new solid waste management plan. The plan developed included all aspects of solid waste management including waste stream characterization, municipal waste collection, transport, disposal, hazardous waste management, recycling, waste steam diversion, site selection process, and option selection process.

   The results of this report formed the basis for the proposed options in the Dillon Solid Waste Site Selection Report. The JL Richards/Golder Study recommended two methods of solid waste disposal:

   1) Expanded waste reduction and diversion program with Increased land fill capacity which is more economical in terms of capital costs;
   2) Expanded waste reduction and diversion program with Incinerator and ashfill which has several distinct advantages such as much smaller landfill area required therefore

less impact on the environment, reduced leachate due to incineration of organics, less granular materials required for daily cover, heat recovery system, and possible to treat used oils, biomedical wastes, tires, etc..

7) Solid Waste Facility Site Selection, Dillon Consulting Limited, January 2001

The Dillon team proposed four solid waste management (SWM) options based on buffer zone constraints previously established, comments from the public, biophysical impacts, accessibility, required size, and other siting factors. These options were reviewed and validated through a steering committee meeting and a fifth option was added.

A matrix tool was used to evaluate these options to determine which site is most preferred by the community. The matrix evaluated each of the options on eight criteria which were indicated by the community as important issues for the selection of a site. The site option which ranked number one by the steering committee matrix was an incinerator on Federal Road with ash landfill on the existing West 40 landfill site.

There are many favourable elements associated with this SWM site option such as:

- capital cost is approximately $2 million cheaper than other incinerator options as the existing access road to the landfill would not need major upgrading and the site has power and an operator building;
- the West 40 site is currently considered to be the greatest environmentally impacted site therefore the ashfill is not expected to further impact the site;
- the access road to the ash landfill is fairly flat and is cleared and sanded regularly, therefore ash trucks would have much easier access to this site than the other proposed sites;
- locating the ashfill at this impacted site also does not increase the number of environmentally impacted sites in Iqaluit.

2.2 Previous Environmental Studies

Several environmental studies have been completed over the years on the West 40 Dump Site #3, which is the proposed site for the expanded landfill and future ashfill. The precise origin of the waste dump is unknown but it likely arose from military operations. The waste consists predominantly of metals which have been covered with soil and grass. There are metal outcrops over the entire site.

The following documents were reviewed for relevant information pertaining to this project:

2) Environmental and Geotechnical Investigation Proposed Solid Waste Site, Hardy BBT, 1991

Hardy BBT Limited was retained by UMA Engineering Ltd. to conduct a geotechnical investigation and environmental assessment of the current landfill site at West 40. Twenty boreholes provided information on chemical and physical makeup of the type of waste found in the metals disposal area. The waste encountered included tin cans, building materials, fuel drums, tanks, metals, glass, wood and plastic. The chemical concentrations were evaluated and compared with Quebec Guidelines. Contaminants that exceeded guidelines include: barium, chromium, copper, lead, mercury, molybdenum, nickel, zinc, and TPH. Concern was expressed for the concentrations of PAHs and PCBs encountered. The concentrations were highest in the northern portion of the site. The southern portion was recommended to be considered separately for municipal waste disposal site. Recommendations included further investigation be conducted to better determine the extent and nature of the waste in the northern part of the site and to consider designating this portion as a hazardous waste site. Recommendations were given for municipal waste containment and monitoring for the southern portion of the site.

3) Literature Review on Abandoned and Waste Disposal Sites in the Iqaluit Area, Public Works Canada, November 1992

This study documented, reviewed and summarized all available information on waste disposal and abandoned sites in the Iqaluit area. Borehole information and pictures were included from previous reports. The wastes found on site were metal and domestic waste (wood and glass), batteries, empty solvent drums and steel drums. Contaminants exceeding CCME Guidelines include PCBs, chromium, copper, lead, mercury, molybdenum, nickel, zinc and hydrocarbons.

4) Environmental Site Assessment of an Abandoned US Air Force Base and Five Waste Sites at Iqaluit NWT, Avati Ltd., August 1993

This study consisted of water and soil sampling of five contaminated sites including the West 40 Site #3. The remediation criteria adopted was CCME R/P for soil, CCME FAL for water, and Quebec B for TPH. Three soil samples and four water samples were taken at Site #3. Trace concentrations of TPH were detected, however, none of the concentrations found required remediation. Phenol and m&p cresol concentrations in surface water were recommended for remediation. No exceedances of either residential parkland criteria or the DIAND DEW Line Clean-up criteria were noted in the soil samples. The water samples were taken in the stream running through the site and the soil samples were taken between the exposed waste and the tank farm.

5) Preliminary Report on Cleanup of Waste Disposal Sites near Iqaluit, UMA Engineering, 1994

A geotechnical report by HBT/AGRA, performed for this report, suggested that there are no stability or erosion concerns for this site. The surficial materials are a mixture of sand, silt, bedrock and fill. The report recommended that data collection should include: surface soils from the north end of the site; ponded water and sediments within the central trough area; sample groundwater/leachate in stand pipes and submit for analysis. The report recommended that laboratory analysis should include pH, electroconductivity, total petroleum hydrocarbons, full metal scan, purgeable halocarbons, organochlorinated pesticides, polycyclic aromatic hydrocarbons, PCBs, PCPs, chlorinated solvents, phenols and volatile organics including benzene, toluene, ethylbenzene, and xylene. The report recommended further sampling be performed on Site #3 to determine extent of the contaminants and to provide a basis for developing an appropriate cleanup plan.

6) Environmental Study of a Military Installation and Six Waste Disposal Sites at Iqaluit, NWT, Environmental Sciences Group, Royal Roads Military College, 1995

This report provided a summary of previous reports, conducted soil and water sampling, and listed recommendations for site containment.

The sampling program performed for this report focused on sampling from drainage channels and catchment areas into which the migration of contaminants was possible. A total of seven soil samples were collected from the north (5) and south (2) ends of the site. Two samples of vegetation were collected. Three water samples were taken, two from pools of standing water in the northern half of the site and one from a borehole at the southern end. One soil sample and three water samples contained inorganic elements or PCBs in excess of the DEW Line Clean-up Criteria. The inorganic elements exceeded were cadmium, lead and zinc.

This report suggests that the waste and contaminants can be contained by adding granular material until the level of permafrost is raised above the buried waste, thus locking in the contaminants. This recommendation is based on an excerpt from the DEW Line Cleanup Protocol which states “landfills that are located in stable areas which are not subject to erosion but are identified as potential sources of contaminated leachate must be fully contained to prevent leachate migration.”

After adding granular material, they recommended regrading the site to reduce infiltration and the water that is rerouted should be monitored. If chronic leaching of contaminants is detected then a sedimentation pond with organic absorbent booms should be established.

In summary, the contaminants noted in the above reports for West 40 Site #3 include: PCBs, chromium, copper, lead mercury, molybdenum, nickel, zinc, hydrocarbons, cresol and PAHs. The waste is a mixture of domestic and militaristic waste and includes wood, cans, barrels and other metal debris.

The suggestions for remediation/containment of the site include:

- Covering exposed waste with granular material and reseeding (Hardy BBT)
- Excavating waste and shipping south to a disposal facility (Avati 1993)
- Adding granular material until the level of permafrost is raised above the buried waste, regrading to prevent water infiltration in the contaminated area, and monitor leachate discharging into Frobisher Bay (Environmental Sciences Group, 1995)

3.0 SITE INVESTIGATIONS

The proposed location for the long term landfill/ashfill facility is the West 40 Site #3 which is the current municipal landfill site. In 1995 an interim municipal landfill was constructed on the southern half of the metals dump site. This landfill is enclosed with soil berms and fencing and has a culvert which can be opened and closed to control leachate discharge into the drainage ditch. This ditch discharges into Frobisher Bay approximately 600 m from the landfill site.

Due to a recent labour dispute, there was a 3 month period in which there was no burning of waste which has resulted in massive mounds of waste at the landfill site. This waste is currently being burned and spread. It is suspected that this landfill will meet its design limit by November 2001.

The northern half of the metals dump which is adjacent to the current landfill consists of metal debris which has been partially covered with soil and then revegetated however metals are visible throughout the site as there are many mounds of metals with little cover. Visible debris includes metal drums, cans, vehicle parts, batteries and various scrap metal. The site is drained by a ditch located through the site which connects to the ditch surrounding the current landfill.

Photographs of the existing site conditions are presented in Appendix A.

The site investigation program consisted of developing a topographic survey of the site and excavating test pits to determine the type and extent of metals wastes. The following describes the results of these investigations.

3.1 Topographic Survey

A topographic survey was conducted using a total station and based on UTM coordinates. The survey located:

- Rock outcrops
- Roads
- Fences and other site features
- Elevations to provide contour information
- Ditching and drainage features
- Location of existing waste mass.

This information was imported into AutoCAD and overlaid with existing mapping of the area. The existing site plan is presented in Drawing 1.

Fig 3-1

3.2 Test Pits

Fourteen test pits were excavated throughout the northern metals site to determine:

- Type of buried material
- Depth to permafrost
- Density of waste

Test pits were excavated to the depth of the permafrost zone. Permafrost was encountered at depths ranging from 0.3 m to 1.0 m. Two test pits did not encounter permafrost and were stopped at depths of 1.7 m and 2.0 m. There were no signs of free product however water did flow into three of the test pits. All test pits revealed metal wastes mixed with soil which was loosely compacted. The types of waste observed in the test pits was very similar to the material visible at the surface and included empty oil drums, cans, automobile and furniture frames, crate strappings, and miscellaneous metals. Photographs of the test pits are presented in Appendix B.

4.0 PRELIMINARY DESIGN

The existing landfill facility in West 40 is planned to be expanded to accept municipal waste until the new incinerator process is in place. The site will then be expanded again to become the 20 year ash disposal landfill. The facility is proposed to be constructed in stages, commonly referred to as cells. Cell #1 of the facility is the municipal landfill which will be constructed in the 2001 season. This cell is expected to be in operation for approximately 3 years while the incinerator is being designed, constructed, and commissioned. Cells #2 & #3 of the facility make up the ash landfill which are expected to operate for a total life of 20 years.

The preliminary design details of the landfill/ashfill facility including facility location, requirements, sizing, layout, liner details, and runoff management are described in this section.

4.1 Facility Location

The proposed location of the landfill and ashfill is the West 40 metals and landfill site. This site was recommended from the Solid Waste Site Selection Study completed by Dillon in 2001. Some of the reasons why this site achieved a higher ranking than other locations by the steering committee include:

- Capital cost is approximately $2 million lower than other site options as the existing access road to the landfill would not need major upgrading and the site has power and an operator building;
- The West 40 site is currently considered to be the greatest environmentally impacted site therefore the ashfill is not expected to further impact the site;
- The access road to the ash landfill is fairly flat and is cleared and sanded regularly therefore ash trucks would have much easier access to this site than the other proposed sites;
- Locating the ashfill at this impacted site also does not increase the number of environmentally impacted sites in Iqaluit;
- Using the existing landfill site for the ashfill also significantly reduces the cost of closing/capping dump sites as there would only be the cost to close the West 40 site in 20 years time rather than the West 40 site in next couple of years and a new ashfill site in 20 years.

The JL Richards/Golder report contained landfill location constraint maps. These maps identified the areas where a landfill/ashfill can not be located. These buffer zones include: residential/commercial areas, industrial areas, transportation zones, major aquatic habitat areas, City water reservoir catchment area, and the 3 Km airport buffer zone. The location of the ashfill is required to follow all buffer zone requirements, however, the 3 Km airport buffer zone may be excluded on a case by case basis. The airport authority have indicated acceptance of locating the ashfill within the 3 km buffer zone at this West 40 site, however this is subject to final approval.

4.2 Facility Requirements

The landfill/ashfill facility will be an engineered facility which will have controlled access, posted hours of operation, operations and maintenance guidelines, hazardous waste collection area, designated waste areas, covered and compacted waste, and controlled runoff. The following describe the proposed physical elements and operations of the proposed municipal landfill/ashfill facility.

Cell #1 - Municipal landfill

This landfill cell will be engineered to ensure disposal areas are identified, cover materials are stock piled, access roads constructed, drainage ditching and berms constructed, and fencing and gates erected. The area method of disposal will be used in combination with open burning of waste. The area method involves disposing of waste in a planned sequence by spreading the burned waste in layers, compacting, and then covering with soil. Burning will be contained in an isolated area of the landfill and will be conducted only when wind conditions prevent smoke and odour from being directed towards the city. Burning of waste is used to reduce the volume by 40 to 70%, reduce the windblown material, and renders the waste less accessible to birds. Non-combustible wastes will be removed from the waste stream through recycling. The City of Iqaluit is in the process of commissioning an extensive recycling program for paper, plastics, and metals. The commercial paper recycling program is currently underway.

The facility will be continuously supervised and will have dedicated equipment used for spreading and compacting the waste.

The landfill cell will consist of:

- soil berms which enclose the waste and liquid runoff,
- debris fencing and locked gate to reduce the scattering of waste and to control access to the site,
- yard lighting for operation and security,
- metals storage area,
- household hazardous waste storage area,
- construction and demolition debris storage area,
- existing operator building,
- stock piled cover material,

- access road,
- culvert which can open and close to control runoff from the site.

Cells #2 & 3 - Ashfill

The ashfill process is very similar to landfilling however the berm and liner design and runoff management is more involved. The ashfill cells will be engineered to ensure disposal areas are identified, cover materials are stock piled, access roads constructed, drainage ditching, lined berms, and sedimentation pond constructed, and fencing and gates erected. The area method of disposal of ash will be used which involves disposing in a planned sequence by spreading the ash in layers, and then covering with soil to reduce air borne particles. An ashfill uses a much smaller area of land than a landfill as the total waste volume is reduced by approximately 71% (84% of waste stream is combustible which is reduced in volume by approximately 85%).

The ashfill cells will consist of:

- soil berms, lined with a membrane, which enclose the ash and liquid runoff,
- debris fencing and locked gate to reduce the scattering of ash and to control access to the site,
- metals storage area,
- household hazardous waste storage area,
- existing operator building,
- stock piled cover material,
- access road,
- culvert which can open and close to control runoff from the site,
- sedimentation pond.

4.3 Facility Sizing

In order to determine the size of the facility, the 23 year population projection and the average quantity of waste produced per person was required. The size of the landfill cell is based on a 3 year life and ashfill cells are based on a 20 year life which would be to the year 2024.

The following sections provide a detailed description of the process used to size the facility.

4.3.1 Population

The 23 year population projection for Iqaluit was required in order to estimate the size of the disposal facility. The population projection was determined using the yearly percentage population increase found from the 1991 to 1996 census. Although the 2001 census data has not yet been released, informal discussions with the Nunavut Bureau of Statistics indicate that they are expecting the yearly percentage increase from the 1996 to 2001 census to be similar. Table 4-1 presents the census data for Iqaluit:

Table 4-1 Population Census Data

1991 Census	3552
1996 Census	4220
Yearly % Increase	3.51%

The current population of Iqaluit is unknown at this point as the 2001 census information has not been released. The latest Nunavut Bureau of Statistics population projection for year 2000 is 4897. However, this figure does not include the population who own property in another province or who live here for short periods of time. Therefore Dillon used a base population of 5500 for year 2000. Using the population growth of 3.51% from the census, the resulting population for 2024 is 12,577. Table 4.2 presents the yearly population projections.

Table 4.2 - Population Projection

Year	Population Projection[1]
2000	55002
2001	5,693
2002	5,892
2003	6,099
2004	6,313
Waste which will be considered for incineration:	
2005	6534
2006	6,763
2007	7,001
2008	7,246
2009	7,500
2010	7,763
2011	8,035
2012	8,317
2013	8,609
2014	8,911
2015	9,223
2016	9,547
2017	9,881
2018	10,228
2019	10,587
2020	10,958
2021	11,342
2022	11,740
2023	12,151
2024	12,577

21) Population projection based on yearly increase of 3.51% which was determined from census increase for 1991 to 1996.

22) Year 2000 population of 5500 was determined from conversations with the Nunavut Bureau of Statistics and the City of Iqaluit. This figure is believed to be a more realistic representation of actual Iqaluit population as it includes short term residents and residents who pay taxes on properties in other provinces.

4.3.2 Waste Quantity

The average waste generation rate per capita was required in order to determine the size of the disposal facility.

An equation based on population was developed by the Department of Municipal and Community Affairs (MACA) of GNWT to estimate average waste quantities generated in northern communities. Dillon used this method to determine average waste quantities which would be produced in Iqaluit over the next 23 years based on the above mentioned population projection.

In the summer of 2000, the City completed a waste stream analysis at the existing landfill to determine the quantity and types of waste which is currently produced by the City. This waste analysis was used as a comparison to the MACA waste projection for the existing population.

From the waste stream analysis it was determined that the average waste quantity produced in 2000 in Iqaluit is 113 m^3/day or 16.9 tonne/day. This waste is produced five days per week therefore over 260 days per year for a total yearly waste volume of 29,300 m^3/year or 4400 tonne/year.

Using a population of 5500 for year 2000, the MACA equation indicated that the total quantity of municipal waste produced per day is approximately 98 m^3 or 14.7 tonne. For the purposes of this waste projection it was assumed that this quantity would be produced 365 days per year for total of 35,800 m^3/year or 5400 tonne/year.

The yearly waste quantity estimated by the MACA equation is approximately 20% higher than the volumes estimated at the existing landfill site. Based on this comparison, the MACA equation waste volumes are considered reliable as the quantities estimated by the municipality are approximate.

Based on the MACA formula, the volume of waste used for facility design is approximately 0.018 to 0.02 m^3/capita/day. This figure includes residential, commercial, and industrial wastes. It also includes recyclable materials such as plastics, paper, and metals.

The population projection and estimated volume of waste per year are presented in Table 4-3.

The uncompacted volume of waste estimated to accumulate over the next three years (November 2001 to November 2004) is approximately 121,000 m^3. The volume of uncompacted waste which is expected to accumulate from 2004 to 2024 is approximately 1.3 million m^3 which will be incinerated.

Table 4-3 Projected Population and Solid Waste Volumes

Year	Population	Annual Volume Solid Waste[1] (m^3)	Cumulative Waste Volume[2] (m^3)
2000	5500		
2001	5,693		
2002	5,892	38,802	38,802
2003	6,099	40,410	79,212
2004	6,313	42,084	**121,296**
Waste which will be considered for incineration:			
2005	6,534	43,825	43,825
2006	6,763	45,637	89,462
2007	7,001	47,521	136,983
2008	7,246	49,482	186,465
2009	7,500	51,522	237,987
2010	7,763	53,644	291,631
2011	8,035	55,852	347,483
2012	8,317	58,148	405,631
2013	8,609	60,537	466,168
2014	8,911	63,022	529,189
2015	9,223	65,606	594,796
2016	9,547	68,295	663,091
2017	9,881	71,091	734,182
2018	10,228	74,000	808,181
2019	10,587	77,025	885,206
2020	10,958	80,171	965,376
2021	11,342	83,443	1,048,819
2022	11,740	86,846	1,135,665
2023	12,151	90,385	1,226,050
2024	12,577	94,065	**1,320,115**

Notes:

23) Waste volumes based on MACA equation.
24) Volume of uncompacted solid waste includes residential, commercial, industrial wastes, recyclables, large metals, etc.

A portion of this solid waste is non-combustible such as metals, glass & ceramics, and soil. The waste stream composition for the City presented by MACA for Iqaluit is shown in Table 4-4. Based on this waste stream breakdown, 84% of the solid waste generated in the community is combustible. The remaining 16%, including cans, other metals, glass and ceramics, and dirt, can not be reduced in volume by open burning or incineration. The percentage of waste which is combustible is required to determine the volumes of waste which will be deposited in the facility.

Table 4-4 Waste Composition

Waste Component	Percentage by Weight (%)
Food	21.4
Cardboard	14.4
Newsprint	5
Other Paper Products	18.5
Cans	5.4
Other Metal products	4
Plastic, Rubber, Leather	13.3
Glass, Ceramics	3.1
Textiles	3.5
Wood	4.5
Dirt	3.4
Diapers	3.5
Total:	100

4.3.3 Facility Cell Sizing

Municipal Landfill Size - Cell #1

Based on the population growth rate of 3.51% per year and the MACA waste generation rate, the volume of waste to be landfilled over the 3 year period is estimated to be 121,000 m^3 uncompacted as shown in Table 4.3. A portion of this waste is non-combustible such as metals, glass & ceramics, and soil. To determine the design volume required for this three year landfill cell (Cell #1) the following assumptions were used:

- soil berm height of 1.5 metres with 3:1 slopes,
- municipal waste height of 4 metres with 4:1 slopes,
- 84% combustible waste stream,
- open burning of waste volume reduction of 50%,
- ratio of waste to soil cover of 5:1, and
- compacted waste density of 500 kg/m^3 (moderate compaction).

Table 4.5 presents the uncompacted waste volumes, volumes of waste after open burning, and cumulative volume of uncompacted waste.

Table 4-5 - Projected Waste Volume Utilizing Open Burning - Cell #1

Year	Annual Volume Solid Waste (m^3)	Annual Volume of Burnable Solid Waste[1] (m^3)	Annual Volume of Waste after burning[2] (m^3)	Volume of burned & nonburned Waste (m^3)	**Cumulative Volume of Uncompacted Waste[3] (m^3)**
2002	38,802	32,594	16,297	22,505	22,505
2003	40,410	33,945	16,972	23,438	45,943
2004	42,084	35,350	17,675	24,409	**70,352**

1) Approximately 84% of the waste stream is combustible.
2) Open burning reduces volume of waste by approximately 50%.
3) Uncompacted waste density of 150 kg/m^3.

The total volume of waste of 70,350 m^3 is then converted to a compacted waste volume by using a compacted waste density of 500 kg/m^3. The resulting compacted volume of waste for Cell #1 is approximately 21,000 m^3. The soil cover volume based on a 5:1 ratio is approximately 4000 m^3. **The resulting Cell #1 active landfill volume is approximately 25,000 cubic metres**.

Ashfill Size - Cells #2 & #3

The ashfill facility is designed for a 20 year life consisting of two cells, one constructed in 2004 when the proposed incinerator is commissioned and one constructed in 2015. To determine the size of these cells, the quantity of ash and non-combustible wastes are required. The volume of solid waste produced over the 20 year period is estimated to be 1.3 million m^3 uncompacted. Approximately 16% of this waste is non-combustible such as metals, glass & ceramics, and soil and therefore are not reduced in volume by incineration. Typically an incinerator reduces the volume of combustible waste by approximately 85 to 90% (85% was used for the design).

Table 4-6 presents the projected quantities of ash and non-combustibles produced over the 20 year period. The quantity of ash to be landfilled over 20 years was determined to be approximately 166,000 m^3. The remaining waste which could not be incinerated would be placed in designated areas within the ashfill. The volume of this waste is approximately 211,000 m^3 uncompacted.

To determine the area required to house an ashfill the following assumptions were utilized:

- soil berm height of 1.5 metres with 3:1 slopes,
- ash height of 10 metres with 4:1 slopes,
- 84% of waste stream combustible,
- Incinerator waste volume reduction of 85%
- ratio of ash to cover of 5:1,
- ash density of 1200 kg/m^3, and
- compacted waste density of 500 kg/m^3 (moderate compaction of the non-combustible waste).

The volume of ash for Cells #2 & #3 is 166,000 m^3. The volume of non-combustible waste of 211,000 m^3 is then converted to a compacted waste volume by using a compacted waste density of 500 kg/m^3. The resulting compacted volume of non-combustible waste for Cells #2 & #3 is approximately 63,000 m^3. The soil cover volume for the ash and non-combustibles based on a 5:1 ratio is approximately 46,000 m^3. **The resulting active ashfill volume is approximately 275,000 cubic metres which is broken into two cells**.

Table 4-6 Projected Ash and Non-combustible Waste Quantities - Cells #2 & #3

Year	Annual Volume Solid Waste[1] (m^3)	Annual Volume of Incineratorable Solid Waste[2] (m^3)	Annual Volume of Ash produced[3] (m^3)	**Cummulative Volume of Ash (m^3)**	**Cummulative Volume of Non-combustible Uncompacted Waste (m^3)**
2005	43,825	36813	5,522	5,522	7,012
2006	45,637	38335	5,750	11,272	14,314
2007	47,521	39,918	5,988	17,260	21,917
2008	49,482	41,565	6,235	23,495	29,834
2009	51,522	43,278	6,492	29,986	38078
2010	53,644	45,061	6,759	36,746	46,661
2011	55,852	46,915	7,037	43,783	55,597
2012	58,148	48,844	7,327	51,109	64,901
2013	60,537	50,851	7,628	58,737	74,587
2014	63,022	52,938	7,941	66,678	84,670
2015	65,606	55,109	8,266	74,944	95,167
2016	68,295	57,368	8,605	83,549	106,095
2017	71,091	59,717	8,957	92,507	117,469
2018	74,000	62,160	9,324	101,831	129,309
2019	77,025	64,701	9,705	111,536	141,633
2020	80,171	67,343	10,102	121,637	154,460
2021	83,443	70,092	10,514	132,151	167,811
2022	86,846	72,950	10,943	143,094	181,706
2023	90,385	75,923	11,388	154,482	196168
2024	94,065	79,015	11,852	**166,335**	**211,218**

Notes:
1) Municipal waste volumes from MACA equation.
2) Approximately 84% of waste stream can be incinerated.
3) Incinerator reduces the volume of waste by approximately 85%.

4.3.4 Cell Design Volume Summary

The following Table 4.7 summarizes the design sizes of the proposed 3 year solid waste landfill and 20 year ashfill cells. Detailed sizing spreadsheets are presented in Appendix C.

Table 4.7 Cell Design Volume Summary

Cell #	Volume of compacted solid waste (D=500 kg/m^3) (m^3)	Volume of ash (m^3)	Volume of soil Cover 5:1 ratio (m^3)	**Total Cell Volume (m^3)**
Cell #1 - Municipal Landfill (3 year life)	21,000	na	4,000	**25,000**
Cell #2 - Ash Landfill (11 year life)	32,000	83,500	23,000	**138,500**
Cell #3 - Ash Landfill (9 year life)	31,500	82,800	22,800	**137,100**
Total	84,500	166,300	49,800	**300,600**

4.4 Facility Layout

4.4.1 Site Constraints

The proposed facility location is the West 40 site, which is the location of the existing municipal landfill and abandoned metals dump. The size of the proposed landfill/ashfill facility is limited due to existing site constraints. Some of the constraints of the West 40 site include:

1) The site area is limited by:
   - Rock ridges along the **east** side of the site, which separates the site from Frobisher Bay. The ridge elevation ranges from approximately 16 m in the northeast of the site to 24 m in the south east.
   - Rock ridge along the **north** side of the site which has an elevation of approximately 25 to 32 m.
   - Existing gravel access road along the **west** side of the site.
   - Existing tank farm to the **south** of the site.

   Due to these existing features, the site is limited to an area of approximately 3.5 hectares.

2) The north end of the site is an abandoned metals dump which contains a mixture of domestic and militaristic waste such as wood, cans, barrels and other metal debris. Several environmental assessments of this site have been conducted over the past 10 years as discussed in Section 2.2. The contaminants noted in the reports for this site include: PCBs, chromium, copper, lead mercury, molybdenum, nickel, zinc, hydrocarbons, cresol and PAHs. Recommendations for clean-up of this site include covering the site with granular material until the level of permafrost is raised above the buried waste, regrading to prevent water infiltration in the contaminated area, and monitor leachate discharging into Frobisher Bay.

   Therefore site preparation would include compacting of existing metals dump, covering with granular material to provide a uniform surface and to raise the level of permafrost above the existing contaminated site to seal in contaminants preventing further leaching into the environment.

3) The existing municipal landfill site is approximately 1.5 hectares and is surrounded by chain link fencing, soil berms, and ditching. This site consists of designated areas for municipal solid waste, metals, construction debris, and tires. The municipal solid waste is open burned to reduce volume and bird attractions.

Therefore site preparation would include compacting of the existing landfill, covering with granular material to provide a uniform surface and to raise the level of permafrost above the existing waste to seal in contaminants preventing further leaching into the environment.

4.4.2 Proposed Layout

The proposed facility is to be constructed in three phases. Cell #1 being a municipal landfill and Cells #2 & #3 being ashfill cells.

Cell #1

Cell #1 is a three year municipal landfill site which will accept solid waste until the proposed incinerator is constructed and commissioned. Cell #1 is proposed to be located on the north end of the site in the area of the existing metals dump. Construction of this cell is to begin in September 2001 and to be completed by November 1, 2001. This cell is proposed to accept all municipal waste until November 2004.

A gravel access road will be constructed within the cell. Soil berms will be constructed on the east and northwest sides of site to contain the waste and runoff. The average elevation of the existing metals dump site is approximately 17 m. The proposed finished elevation of Cell #1 is 22 m resulting in an average waste thickness of 5 m. The layout of Cell #1 is presented in Drawing 2.

Cell #2

Cell #2 is an 11 year ashfill which is proposed to be located on the south end of the site in the area of the existing municipal landfill. It is expected that this cell will be in operation from November 2004 to November 2015.

This cell is proposed to extend east of the existing site into the rock ridges. A gravel access road will be constructed within the cell. Soil berms will be constructed along all sides of the site to contain the waste and runoff. The average elevation of the existing landfill site is approximately 16 m. The proposed finished elevation of Cell #2 is 25 m resulting in an average waste thickness of 9 m. The layout of Cell #2 is presented in Drawing 3.

Cell #3

Cell #3 is a 9 year ashfill which is proposed to be located over the entire site area. It is expected that this cell will be in operation from November 2015 to November 2024.

This cell is proposed to fill in the entire area between the tank farm fence, access road, and crest of the rock ridges. Upon site closure, the facility will be a large, gently sloping mound. A gravel access road will be constructed within the cell. Soil berms will be extended along all sides of the site to contain the waste and runoff. The proposed finished elevation of Cell #3 is 30 m resulting in an average waste thickness of 13.5 m. The layout of Cell #3 is presented in Drawing 4. Typical sections through the cells are presented in Drawing 5.

Figure 4-1.cell1

Figure 4-2cell2

Figure 4-3***cell 3***

Figure 4-4 sections

Other Site Features

The following describes the overall site features:

- The access road entrance will remain in the same location as the current entrance to the site.
- The existing operator building will remain in its current location and will continue to serve as the operator office building.
- The site drainage will not be significantly altered. The landfill and metals dump currently drain by site ditching which leads into the main access road ditch which drains into Frobisher Bay. As the site develops and elevations of waste and ash increase, the ditching may be raised however will continue to discharge in the existing access road ditch.
- A hazardous waste storage area will be constructed as a separate storage area within this site and will have a designated access road. This site will have sea lift containers and areas for storing/treating hazardous wastes.
- The landfill/ashfill facility will have designated areas for disposing metals, tires, and construction & demolition waste. These disposal areas will be located on the far north end of the site.
- The existing elevations of the metals dump and current landfill range from 16 m in low areas to 24 m on high points of the rock ridges. A finished elevation of 30 m is required to achieve the 23 year design volumes. Therefore the ashfill final contours will be 6 m to 14 m above the existing site topography.
- The proposed location for a sedimentation pond is on the opposite side of the main gravel access road. This location has not been finalized. Runoff management is further discussed in Section 4.6.
- Liner requirements for the landfill and ashfill cells are discussed in Sections 4.5.

Standard details associated with the landfill construction are presented in Drawing 6.

Figure 4-5 misc details

4.5 Liner Requirements

A liner design implies a constructed layer forming part of the landfill base design. Typically, the base is designed to provide two functions:

- Leachate containment within the fill area or cell.

- Leachate collection facilities or geometry to allow extraction or level control.

Base design elements are derived through an evaluation of the sensitivity of the local environment and the types of waste to be contained. Consideration is given to the constituents that may leave the landfill through the base, usually in the form of leachate, transported by water or through chemical diffusion. Therefore, an engineered liner system as part of a landfill base would be incorporated into design of a facility if the following conditions are met:

- Leachable or migrating constituents are harmful to the environment.

- The potentially affected or impacted environment may be detrimentally affected by this migration "off-site."

In addition to this rationale to support the need for an engineered liner system, a degree of conservatism is built into decisions to support landfill base design and regulatory approval. This conservatism is observed as a result of uncertainty in the outcome of release of leachate, or as a result of a desire to set a "minimum" standard. Liner designs are site-specific, based on the containment properties of the native materials and the availability of specific imported materials for liner construction. Regardless, the liner must be designed to meet the "minimum" standard.

The following sections discuss the liner recommendations for the landfill cell and for the ashfill cells.

4.5.1 Municipal Landfill Liner

For landfills where waste is covered in place, liner materials are required that prevent wastes (solid and liquid) from migrating into the liner layer. The extended rationale from this requirement to a geosynthetic membrane liner is based on the stated assumption that soil liners cannot prevent migration of liquid waste into the soil. It is, however, possible to prevent migration of waste by identifying a liner as a layer, or zone, which is frozen. A permafrost layer would meet the criteria as an impermeable liner. An engineered liner is not normally used for municipal solid waste landfills in northern climates as the permafrost layer acts as an impermeable barrier.

Therefore the 3 year solid waste landfill cell will not require an engineered liner system. Site preparation will be required due to the existing conditions of the metals dump site. The test pit program indicated light to moderate compaction of the existing metals wastes. The review of the environmental assessment reports indicated that remediation of this site should include covering the waste with soil so the contaminants become embedded in permafrost.

The recommended site preparation for Cell #1 includes:

- levelling of several existing mounds of metal waste;
- compacting the entire metals site;
- covering the site with a 0.5 metre thick layer of granular material and compacting;
- constructing soil berms;
- re-constructing the drainage ditch from the site to the existing landfill ditch system;
- installing a culvert which may be opened to discharge runoff from the cell.

The typical landfill cross section is presented on Drawing 7.

4.5.2 Ashfill Liner

As discussed above, a permafrost layer meets the criteria as an impermeable liner. The determination of a liner thickness becomes somewhat irrelevant in this case where a liner zone may be declared at some nominal thickness. This could be in the order of 1 to 2 m to provide a dimension or a margin of security, for example, in the event of the need to protect a permanently frozen liner zone from surface or adjacent activities that could thaw a portion of the defined permafrost liner cross section.

U.S. EPA/625/6-88/018 Guide to Technical Resources for the Design of Landfills provides guidance for municipal ash landfill design, liner systems. In addition, the US EPA identifies municipal waste ash current acceptable practice including co-disposal with municipal waste (not incinerated) or by a dedicated ash landfill (monofills).

In the case of a municipal waste/ash co-disposal landfill or an ashfill site, the permafrost liner principal is applied. If constructed on permanently frozen waste or frozen bedrock/soil, these materials would form the liner on the base of the new ash landfill. Side berm or perimeter containment would also require an impermeable liner to prevent horizontal seeps or leachate escape in above freezing seasonal periods. This can be accomplished on above grade side berms by keying a synthetic or a “frozen liner” layer into the underlying frozen liner zone. During operations, it is not possible/practical to maintain a frozen berm liner, however, containment could be accomplished in two ways:

- **Case One** - Side berm constructed with a synthetic liner during the operating life of the facility through to closure.

- **Case Two** - Soil berm liner with interior leachate toe drains to maintain any internal leachate at the top of the frozen soil horizon, preventing the build-up of a hydraulic head against the

Figure 4-6

perimeter berm during operations. On closure of the active use, it would be covered and allowed to freeze, assisted by heat sinks or "thermopiles" to maintain the berms in a frozen state.

Recommended Ashfill Liner Design Concept

The chosen site at the existing landfill consists of uneven, fractured granite bedrock, overlain in areas by native soils. The optimum liner design for a new ash landfill would meet the requirements for liner containment by designation of the frozen base layer of waste as the liner, complete with the use of perimeter soil berms with a synthetic membrane liner, keyed into the frozen base layer.

Drawing 7 shows the proposed ashfill liner system. Detail A shows the liner configuration where the bedrock does not extend to the ground surface. A slightly different design, as shown in Detail B, would be used where the bedrock does extend to the ground surface. A combination of these two designs would likely be required at this site.

The Town of Churchill in northern Manitoba has an old/existing municipal landfill that received incinerator ash and non-combusted waste. A recent closure plan has been developed for PWGSC (owners of the land) to close the active portion utilizing the freezing berm methodology and constructing a new landfill in this same manner immediately adjacent to it. Although the Town may decide to locate a new landfill at a new site, the methodology of permanently freezing in the old landfill has been advanced.

4.6 Runoff Management

4.6.1 General Runoff Management Plan

The objective of the runoff plan is to control the discharge of water from the site to the receiving environment. The water leaving the site will be comprised of melt water from the spring freshet, runoff from precipitation, and leachate from the waste mass. The collection of the runoff and controlled release will be achieved through the development of the following components:

- Perimeter and internal ditching to collect the spring melt and precipitation water from the site and transport the water to a sedimentation pond.
- The sedimentation pond which provides two functions. First it will provide for the removal of suspended solids through natural settling processes. Second it provides for the operator of the landfill to monitor the surface of the water to verify that there is no noticeable contaminants prior to the discharge of the water to the environment. Noticeable contaminants would be oily substances, discoloration of the water, or floating debris.
- The water from the sedimentation pond would be discharged through a control structure (weir and culvert) to a ditch that will transport the water off site.

During the development and operation of the 3 year municipal waste cell, there will not be a sedimentation pond. The water collected from outside the waste mass, will be directed, via ditches, directly off site. This water should not have been in contact with the waste mass, and therefore is not contaminated by the landfill operation.

Water that comes in contact with the waste mass, will be colleted within the waste cell. This is similar to the current situation, where water collected in the waste cell is monitored, and then discharged to the environment through the use of the control valve on a culvert that is located in the downstream cell wall. The water will be monitored prior to discharge.

4.6.2 Surface Water and Leachate Monitoring

Collection of leachate from northern landfills can be problematic. Due to the presence of permafrost, and a short active layer season, the installation of monitoring wells, sample recovery, and development of a meaningful data set is difficult. It is proposed to use the sedimentation pond as a collection basin for both surface water and leachate water collection and sampling. The ditching system installed will be an effective cut off system to collect subsurface water movements during the active layer season. Water collected from the sedimentation pond will reflect the quality of the water leaving the landfill site to the receiving environment.

Representative water samples will be recovered from the sedimentation pond using dedicated sampling equipment. Sampling will entail:

- Recording the presence of any oil sheen on the water surface and where necessary, samples of the product will be recovered and placed in laboratory prepared sample jars;
- Recovered water samples will be preserved as required and chilled during transport to the analytical laboratory.

Field QA/QC programs will be implemented for sampling.

The laboratory contracted to perform the analysis will be accredited by the Canadian Association for Environmental Analytical Laboratories (CAEAL).

A total of 5 samples per year from the sedimentation pond will be recovered. The sampling will be completed on a monthly basis during the non freezing months. Based on the significant costs of some of the analysis, a screening approach is proposed to be undertaken with a limited number of samples analyzed for unusual constituents such as dioxins and furans. If these constituents are detected in the screening samples, additional samples may be analyzed to determine the full extent of the contamination.

Target parameters for the analytical program are identified below in Table 4-8. However; the proposed analytical program will be discussed with the regulators prior to implementation.

Table 4-8 Proposed Analytical Program Groundwater/Surface Water/Leachate

Constituent	# of Samples to be analyzed	Rationale
pH	5 landfill	effective screening tool; may identify presence of acids, bases, glycols, will identify potential for dissolution / mobilization of metals
Electrical Conductivity	5 landfill	effective screening tool
Metal Scan (including Hydride Metals)	5 landfill	metal contaminants anticipated, screen selected samples analyze others as required
Benzene, Toluene, Ethyl benzene, Xylene (BTEX) range)	5 landfill	Determination of hydrocarbon contamination and for comparison toe CCME discharge values
Total Purgeable Hydrocarbons (C_3 - C_{10}	5 landfill	Determination of hydrocarbon contamination and for comparison toe CCME discharge values
Total Extractable Hydrocarbons (C_{10} - C_{32} range)	5 landfill	Determination of hydrocarbon contamination and for comparison toe CCME discharge values
Phenol	1 landfill	screen samples
PAH’s	1 landfill	analyze limited number of samples, identify target samples as above and based on staining
PCB’s	1 landfill	screen a limited number of samples, analyze additional samples as required

4.6.3 Sedimentation Pond Sizing & Location

The sedimentation pond is required to be located downstream of the site. The preliminary site recommendation is across the road from the existing landfill site in the path of the existing drainage route. This location will minimize the cost of the construction for the sedimentation pond, and reduce the cost of the ditch construction required to transport the surface water to the pond. The pond will be constructed with the following components:

- Retention for a peak flow condition based on the actual drainage area for the pond.
- A discharge culvert with a control valve to allow for the complete discharge of the pond for inspection and maintenance purposes.
- An overflow culvert to be used under normal operation.
- An emergency overflow weir to allow for discharge should the culverts become blocked or frozen.

5.0 SUMMARY

Table 5-1 provides a summary of the proposed SMW facility.

Table 5-1 Facility Summary

	Cell #1	Cell #2	Cell #3
Location	Existing metals dump site at West 40.	Existing landfill site at West 40.	Entire West 40 site covering cells 1 & 2.
Years of Operation	Nov 2001 - 2004 (3 years)	Nov 2004 - 2015 (11 years)	Nov 2015 - 2024 (9 years)
Size (m3)	Waste - 21,000 Soil Cover - 4,000 TOTAL - 25,000	Ash - 83,500 Non-combustible waste - 32,000 Soil Cover - 23,000 TOTAL - 138,500	Ash - 82,800 Non-combustible waste - 31,500 Soil Cover - 22,800 TOTAL - 137,100
Finished Elevation (m)	22	25	30
Liner System	0.5 m thick soil base layer with permafrost liner. Soil Berms.	Permafrost liner with geomembrane lined soil berms.	Permafrost liner with geomembrane lined soil berms.

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APPENDIX A
Site Photographs

APPENDIX B
Test Pit Photographs

APPENDIX C
Cell Sizing Spreadsheets