IGLOOLIK, NU

Solid Waste Management Feasibility Study

Preliminary Draft Report

August 2020 – 19-9424

August 4th, 2020

Department of Community and Government Services
Government of Nunavut
3rd Floor, W. G. Brown Building
Iqaluit, Nunavut

Attention: Mr. Gord Marinic
Senior Municipal Planning Officer

Solid Waste Management Feasibility Study, Igloolik, NU

Dear Gord Marinic,

Dillon Consulting Limited (Dillon) is pleased to submit our draft report on the Solid Waste Management Feasibility Study completed for Igloolik, Nunavut. This report documents the current waste management system, as well as siting details and a feasibility assessment of three preferred sites for future development of a new solid waste management facility.

Upon receiving comments from the project management team and confirming required revisions, Dillon will prepare and submit the Final Report.

We thank you for the opportunity to complete this project on behalf of Igloolik, NU. If you have any questions pertaining to the enclosed information, please contact me directly at 780.664.0082, ext 4604, or jbertrand@dillon.ca.
Sincerely,

DILLON CONSULTING LIMITED

Jeannie Bertrand, P.Geol
Associate

Howard Trofanenko, P.L. (Eng.)
Partner and Officer

Our file: 19-9424

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Dillon Consulting Limited

Table of Contents

Figures

Images

Tables

Appendices

Acronyms and Abbreviations

-A-

Aboriginal Affairs and Northern Development Canada (AANDC)

-C-

Canadrill Limited Geotechnical Division (CGD)

Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC)

-D-

Department of Community and Government Services (CGS)

Dillon Consulting Limited (Dillon)

-E-

Electronic Waste (E-Waste)

-G-

Government of Nunavut (GN)

-H-

Household Hazardous Waste (HHW)

-I-

Industrial, Commercial and Institutional (ICI)

Indigenous and Northern Affairs Canada (INAC)

-L-

Local Housing organization (LHO)

-M-

Metres below grade (mbg)

Municipality of Igloolik (the Municipality)

Municipal Solid Waste (MSW)

-N-

Natural Resources Canada (NRC)

Nunavut Housing Corporation (NHC)

Nunavut Land Claims Agreement (NLCA)

Nunavut Water Board (NWB)

-S-

Senior Administrative Officer (SAO)

Solid Waste Management (SWM)

Solid Waste Management Feasibility Study (the Study)

1.0 Introduction

Dillon Consulting Limited (Dillon) was retained by the Government of Nunavut (GN), Department of Community and Government Services (CGS) to conduct a Solid Waste Management Feasibility Study (the Study) in Igloolik, NU (**Image 1**). The purpose of the study was to identify and provide a feasibility review of three different sites, and to determine the most favorable location for the development of a new solid waste management (SWM) facility.

Image 1: Municipality of Igloolik, NU

1.1 Background

Current SWM practices in the Municipality of Igloolik (the Municipality) have not changed in many years, and are quite outdated. The current practices of near shore dumping, improper segregation and uncontrolled burning do not align with the best practices as describe in the Planning and Technical Guidance Document, "Solid Waste Management for Northern and Remote Communities" (Environment and Climate Change Canada, 2017). Waste is currently disposed at an uncontrolled site, where there is no attendant, fence or berm to control and contain the waste. The location is very close to shore and there are signs of the space being inundated with Household Hazardous Waste (HHW). The location of the current dump site and disposal practices have the potential to pose hazards to the environment, the safety of those accessing the site, and the overall health of the community. Animal interactions, smoke

inhalation, unsanitary waste disposal methods, unsafe scavenging, leachate generation, and other factors all pose as significant risks. At present, there are no leachate management and no environmental protection measures in place.

1.2 Project Objectives

The objective of this project was to identify three sites which would be suitable for future development of a new SWM facility. These three locations are intended to satisfy each of the setback requirements and constraints recommendations which are considered to be best practice in Nunavut. Based on the selection of three viable site locations, an intrusive geotechnical site investigation was completed at the two accessible locations, and a preferred location identified for future development.

The preferred sites were chosen based on the following tasks:

- Desktop Siting Study;
- Site Visit and Community Consultation;
- Waste Composition Study;
- Constraints Mapping;
- Estimated Capital Costs for Site Development; and
- Comparison of preferred sites using a weighted decision matrix.

The Class D capital cost estimate for the project was completed by Altus, and was based on assumptions provided by Dillon. (To be added once changes are received).These assumptions were developed from a Dillon conceptual design and take into account waste generation rates calculated from the waste composition study and a landfill capacity analysis, both of which were performed by Dillon. The landfill siting study area is illustrated in **Figure 1**.

GOVERNMENT OF NUNAVUT

SOLID WASTE FACILITY SITE SELECTION
IGLOOLIK
NUNAVUT

FIGURE 1
LANDFILL SITING STUDY AREA

- Roadway
- Community Parcel Boundaries
- Airport
- Watercourse
- Water Body

SCALE 1:35,000

0 250 500 1,000 Meters

N W E S

MAP DRAWING INFORMATION:
DATA PROVIDED BY ESRI, DILLON, NRCAN

MAP CREATED BY: 44PH
MAP CHECKED BY: 46JB
MAP PROJECTION: NAD 1983 UTM Zone 17N

DILLON CONSULTING

PROJECT: 199424
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FILE LOCATION: G:\GIS\2019\199424 Solid Waste MFS, Hall Beach & Igloolik\MXD\Igloolik\Figure 1 - Landfill Siting Study Area.mxd

2.0 Solid Waste System Review

2.1 Community Overview

The Municipality of Igloolik is located in the Qikiqtaaluk Region in Nunavut (**Image 2**). The community is rich in culture, with all three regions of Nunavut presented; Qikitaaluk, Kitikmeot and Kivalliq. The community is home to approximately 1,920 people living in approximately 402 households.

The population of the Municipality is relatively stable throughout the year. The climate is Arctic, and average temperatures range between 11°C to -35°C. Observing the age demographics, it is clear that Igloolik is a very young community. Municipal staff had described that about 50-80 infants are born each year. This is a notable amount, and has implications on the current waste stream, as well as capacity projections.

Image 2: Site Location Map

2.2 Current Waste Management System

Municipal solid waste (MSW) is manually collected by Municipal staff using a split-body waste collection vehicle (**Image 3**). Waste collection staff try to ensure that garbage is collected from every home at least twice per week by completing difference collection routes Monday through Friday. Waste may not be

collected twice weekly due to unforeseen circumstances or issues with the waste collection vehicle. While in the community, it was noted that the current waste collection vehicle can have issues in the extreme cold weather and break lines are known to freeze and break. Waste is collected from storage boxes located at each home (**Image 4**). These waste boxes are provided by the Municipality. There are an estimated total of 292 public units, 78 staff units and 35 other units in Igloolik (Igloolik Housing Association, 2019).

Image 3: Garbage Collection Vehicle

Image 4: Household Garbage Box

The waste collected from homes is separated, with metal items taken to a metal recycling area north of the current waste site (**Image 5**). There is currently a $10 tipping fee, for self-haul disposal at the dump site; however, it is rare that the amount is paid to the Municipality. Since there is no attendant on site, the Municipality relies on an honour system for those self-hauling to pay the fee at the Municipal office.

Both community members and contractors are able to take advantage of this lack of monitoring. This is particularly problematic because of improper sorting and possible disposal of industrial grade hazardous waste. Households and businesses are charged $20/month for collection services. This fee is due monthly, regardless if waste collection is in operation (truck maintenance). Community members reported frequent disruption to pick-up services due to the waste truck breaking down or intense winter conditions limiting road accessibility.

Image 5: Scrap Metal Disposal Site North of Current Dump Site

Waste is hauled to the current dump site for disposal and burned frequently. The Municipal staff burns the waste to reduce organic material as much as possible, primarily to deter polar bears and other animals from coming to the site to scavenge for food. Animals continue to be attracted to the site, and are commonly observed searching through the burned waste material for food. Hunting waste is managed by the hunters. Carcasses and contaminated material are taken to the tundra outside of the community for disposal to avoid attracting bears near the community.

This project only addresses the SWM needs of the community. The other interest groups in the area manage their own solid waste independently, and are not anticipated to generate waste which will require management or disposal by the Hamlet.

2.3 Solid Waste Disposal Facilities

The current dump site is located north of the Municipality, along the eastern edge of the road (**Image 6** and **Image 7**)**.** Just north of the current dump site is the scrap metal waste storage area. North of the scrap metal storage area is the sewage lagoon. The disposal site is flat, and slopes beyond the dump site towards the beach. Existing solid waste management sites are shown on **Figure 2**.

GOVERNMENT OF NUNAVUT

SOLID WASTE FACILITY SITE SELECTION
IGLOOLIK
NUNAVUT

FIGURE 2
SOLID WASTE MANAGEMENT FACILITY LOCATIONS

- Solid Waste Management Facility Locations
- Roadway
- Community Parcel Boundaries
- Airport
- Watercourse
- Water Body

SCALE 1:35,000

0 250 500 1,000 Meters

N W E S

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MAP CHECKED BY: 46JB
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DILLON CONSULTING

PROJECT: 199424
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DATE: 2019-11-01

FILE LOCATION: G:\GIS\2019\199424 Solid Waste MFS, Hall Beach & Igloolik\MXD\Igloolik\Figure 2 - Solid Waste Management Facility Locations.mxd

The current dump site is not fenced, and there is no infrastructure in place (i.e. no scale house, staffed shelter or power supplies). The site is does not have a large amount of waste accumulated, in part because it is burned frequently. The waste that remains is managed with a dozer operated by Municipal staff. During the summer months cover is used whenever possible. Once an area has reached capacity for waste and the residue from burning is substantial, the area is flattened with the dozer, and covered.

Image 6: Active Dump Site

Image 7: Close-up of Active Dump Site

There are a few areas at the current dump site where materials are segregated. This includes an area for hazardous waste (propane tanks, electronics, paint, car batteries, etc.) (**Image 8**), wood (**Image 9**), scrap metal and used oil containers.

Image 8: Close-up of Hazardous Waste Disposal Site Located North of Municipality

Image 9: Wood Disposal Site Located on the North Side of the Current Dump Site

Truck hulks were visible at the two main waste areas at the time of the site visit, and some appliances were identified as well. It is understood that no one is directly responsible for Freon removal or fluid removal, and it is understood that no one is currently providing this service. Car and truck hulks are

present throughout the Municipality, as well as along the road to the airport. Based on where the vehicles are left, it is difficult to assess which vehicles belong to whom.

2.4 Solid Waste Disposal Equipment

Igloolik has a vehicle garage near the middle of the community which houses the garbage collection vehicle. There are no heavy duty/heavy machinery mechanics in the community who are able to provide on-going maintenance for a garbage truck. Due to winter conditions, the vehicle is in constant need for repair due to broken fuel lines. When the truck is in need of repair, community members are expected to haul their waste themselves to the current dump site.

2.5 Recycling Programs

No recycling programs are currently in place. In previous years, a community member would collect bottles and cans but this practice is no longer in place.

2.6 Current Solid Waste Management Challenges

The current SWM challenges which were identified by local community members in the Municipality include:

- Animal interactions scavenging at the dump site;
- Smoke and air quality concerns resulting from burning at the dump site;
- Lack of control over use of the dump site by contractors and non-Municipal staff;
- Lack of defined and separated piles for bulky materials such as reusable wood; and
- Lack of recycling options.

3.0 Site Selection

3.1 Project Initiation Meeting

Prior to starting the desktop siting study, Dillon met with the project manager from CGS by telephone. Dillon and CGS confirmed the scope of the project, and CGS provided background documents for review and reference as part of the study.

3.2 Desktop Siting Investigation

Prior to visiting the site, a desktop siting investigation was completed to determine the constraints affecting landfill development, relevant regulations and guidelines, as well as to review the community plan.

3.2.1 Background Document Review

As part of the desktop siting investigation, Dillon reviewed the following documents to identify sites that may be suitable for development of a future SWM facility:

- Public Health Act, Consolidation of General Sanitation Regulations;
- Igloolik Airport Zoning Regulations;
- Igloolik Community Plan; and
- Igloolik Water License, 3BM-IGL1520.

3.2.2 Siting Considerations

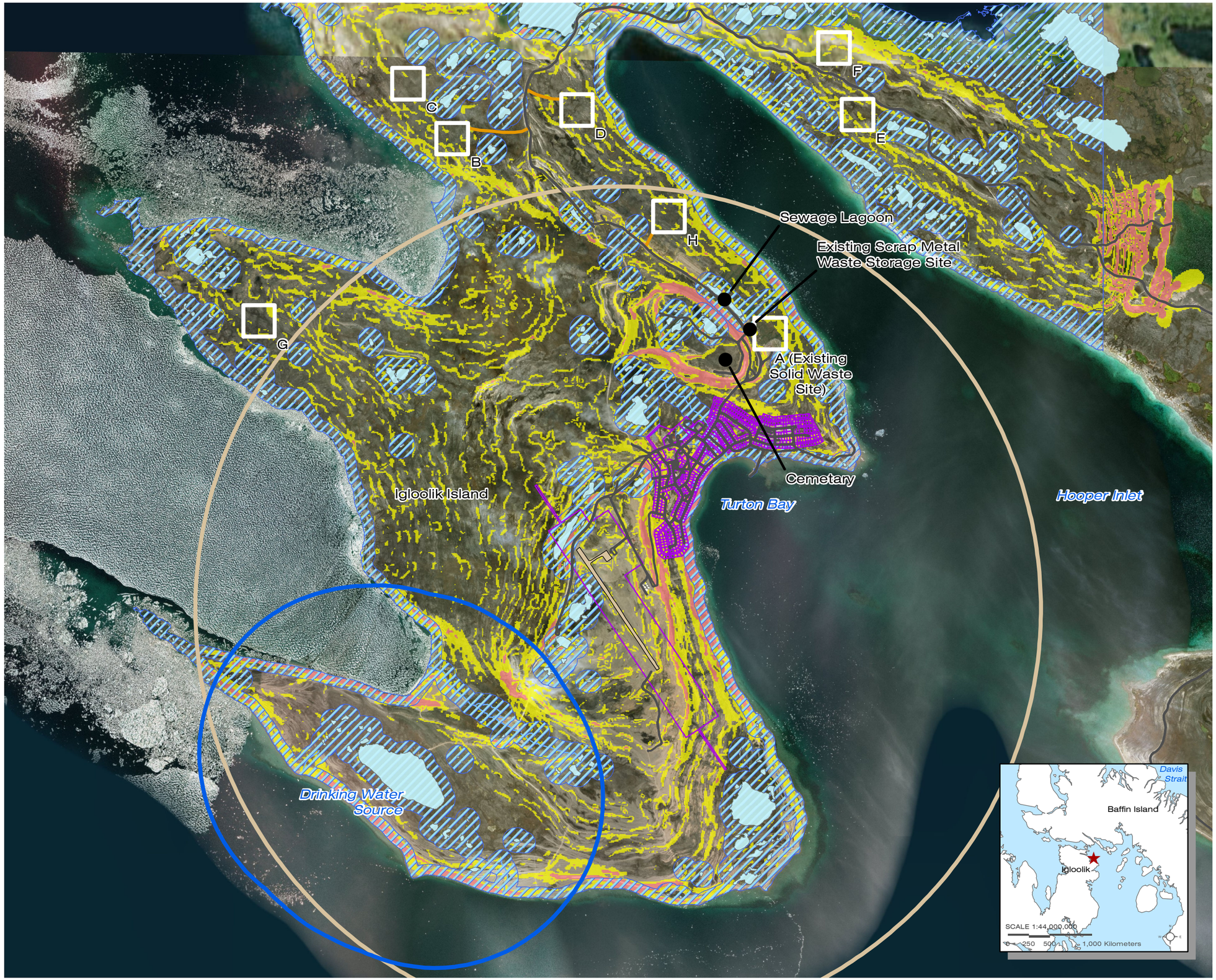
After reviewing the relevant background documents, Dillon created a map of the area surrounding the Municipality showing all known setbacks and constraints (**Figure 3**). These setback considerations were based primarily on the SWM for Northern and Remote Communities document. Considerations and setbacks took into account:

- Geology;
- Land use planning;
- Flood plains;
- Airport safety;
- Residential buildings;
- Municipality boundaries;
- Seasonal access;
- National or Territorial Parks;
- Inuit-owned lands;
- Coastal areas;
- Drinking water sources;

- Waterbodies;
- Traditional and recreational use areas;
- Proximity to existing access roads;
- Availability of daily cover material;
- Suitability for future expansion;
- Prevailing wind direction; and
- Line-of-site to public use areas.

Other constraints included the exclusion of locations with greater than 10% topographical slopes. Some constraints did not impact the study area, and so are not visible on the constraints map. Subsurface geology, prevailing wind direction, estimated capital cost and line-of-site aesthetics are site specific, and were evaluated individually for the proposed sites.

The SWM for Northern and Remote Communities document provides best practices for setback distances, which are frequently expressed in a range of distances (eg. 300 m to 1,500 m). For this study, we identified which setback distance would be used based on the relevance of each to the community, and with a priority placed on health and safety. The setback ranges are included in **Table 1**, and the setback distances used during the siting review are specifically identified.



GOVERNMENT OF NUNAVUT

SOLID WASTE FACILITY SITE SELECTION
IGLOOLIK
NUNAVUT

FIGURE 3
LANDFILL SITING CONSTRAINTS MAP

- Potential development site identified during desktop study
- Roadway
- Proposed Road Improvements
- Community Parcel Boundaries
- Airport
- Airport Setback (4 km)
- Inuit Owned Land
- Watercourse
- Water Body
- Water Feature Setback (100 m)
- Drinking Source Setback (1.5 km)

Surface Slope (degrees)

- 0 - 3
- 3 - 6
- 6 - 22

SCALE 1:35,000

0 250 500 1,000 Meters

N W E S

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FILE LOCATION: G:\GIS\2019\199424 Solid Waste MFS, Hall Beach & Igloolik\MXD\Igloolik\Figure 3 - Landfill Siting Constraints Map.mxd

3.2.3 Constraints Mapping

The relevant setback distances, siting considerations, topography, and areas of known interest to the Community were illustrated on a constraints map (section 3.2.2, **Figure 3**). This map was used to identify areas for investigation and discussion as potential sites for future development. Dillon staff discussed potential site with the Municipal Director of Public Works during the Health and Safety Training session. Their insights and comments were recorded. The Director had first-hand knowledge of collection routes and had estimates on feasible hauling distances in terms of time spent by the driver. As well, the information was more formally presented to the Mayor and the Council, and the Senior Administrative Officer (SAO), during the June 11 Council meeting. Additional information shared by the Council was subsequently added to the map for completeness, including areas of significance that were not initially identified.

3.2.4 Nunavut Solid Waste Management Regulations and Standards

SWM practices in Nunavut Territory are governed by a number of overlapping regulations which are enforced by different agencies. There is no overarching regulatory body or guiding document which dictates the standards to which solid waste facilities are to be developed or maintained. The primary regulatory tool for managing solid waste sites is the water license, which is administered through the Nunavut Water Board (NWB). This is the main approval that is required for construction, operation, and decommissioning of the landfill site. Licenses must be kept current, and municipalities are required to apply for renewal. Water Board legislation prohibits the disposal of waste into water without approval. Water licenses from the NWB include conditions which apply to the maintenance and monitoring of solid waste facilities.

The three levels of government are all involved in different stages of waste management in Nunavut. The Federal Government (CIRNAC) is only responsible for waste to water as defined in the Water Licence which is how the solid waste facilities are regulated. The Government of Nunavut plans, designs and constructs solid waste sites in cooperation and on behalf of the Municipalities. Once the solid waste site is constructed, the Municipality assumes ownership and operates and maintains the facility. The municipal governments are responsible for coordinating collection and disposal services. Funding for upgrading the facilities, maintenance and operations are the responsibility of the GN and the Federal Government.

The agencies and governing bodies with input into development and operations of solid waste facilities include:

- Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC);
- Nunavut Water Board (NWB);
- Federal Government of Canada;
- Department of Fisheries and Oceans (DFO);
- Environment and Climate Change Canada (ECCC);

- Nav Canada;
- Transportation Canada;
- Nunavut Airports;
- Government of Nunavut; Department of Community and Government Services; and
- Municipalities.

The applicable Acts and Agreements are as follows which may influence the development and maintenance of Solid Waste Facilities are:

- Nunavut Land Claims Agreement (NLCA);
- Nunavut Water Board; Nunavut Waters and Nunavut Surface Rights Tribunal Act ss. 12(1) and 57(a). Renewal process required;
- Arctic Water Pollution Prevention Act, RSC, 1985;
- Environmental Protection Act, RSNWT 1988, c E-7, s.5;
- General Sanitation Regulations, RRNWT, 1990, c.P-16 Public Health Act; and
- Fisheries Act, RSC, 1985, c F-14, s. 36(3).

The following documents have been published by the Canadian and Nunavut Governments to inform communities about best practices related to management of solid waste. The following are a list of published documents which are relevant to solid waste management practices in Nunavut:

- Community Solid Waste, Technical Information Document (Public Works and Government Services Canada Real Property Services Branch, 2002);
- Environmental Guidelines for Waste Batteries (Department of Environment's Environmental Protection Division, 2011);
- Environmental Guidelines for Use Oil and Waste Fuel (Department of Environment's Environmental Protection Division, 2012);
- Environmental Guidelines for the General Management of Hazardous Waste (Department of Environment's Environmental Protection Division, 2010);
- Government of Nunavut, Nunavut Solid Waste Management Plan (exp Services Inc., 2014); and
- Solid Waste Management for Northern and Remote Communities: Planning and Technical Guidance Document (Environment and Climate Change Canada, 2017).

For the purpose of this study only two of the listed documents were used for guidance. The 'Solid Waste Management for Northern and Remote Communities' document was used as the primary guide for best practices, and the 'Nunavut Solid Waste Management Plan' was used as a secondary reference for waste generation quantities. These documents are considered to be the most comprehensive, and have the most direct relevance to this project.

In 2017, the Government of Canada published the technical information document titled "Solid Waste Management for Northern and Remote Communities". This document was intended to provide an overview of waste management planning, site selection, operations, design, monitoring, and facility

closure. The principles and guidelines discussed give a clear picture of the general components needed. Since regulations do not cover the breadth of environmental issues that a community can encounter, the guidance document provides a framework for identifying potential risks and suggests possible mitigative actions.

3.2.4.1 Airport Zoning Regulations

The airport zoning regulations apply to both land and the airspace surrounding the airport runway strip. The zone defined as the outer limit applies to construction on land and is a 4 kilometre (km) radius from the centre of the runway, as represented in **Figure 3**. The zone defined as the approach surface applies to the air space that begins at each end of the runway strip creating an inclined plane at a ratio of 1:50 m Vertical to Horizontal, that extends to a maximum of 15 km horizontally and 300 m vertically. It is typical for birds to fly to a height of 160 m and lower, the vertical height of 160 m along the plane occurs at 8 km horizontal. An 8 km radius encompasses all but Site F of the potential sites chosen for this study, requiring a bird study be conducted prior to constructing a landfill.

3.2.4.2 Nav Canada

At present an application for Igloolik has not been submitted, the application is to be submitted by the end of August 2020 and will be valid for 1 year. An approval from NAV CANADA was received for another Nunavut community, Resolute Bay, for the construction of a landfill.

3.2.4.3 Transport Canada

An email was sent to John McFee, Civil Aviation Inspector for Aerodromes and Air Navigation from Transport Canada, on July 17, 2019, requesting review and approval of the planned waste facility location Site D. A reply was received that stated “Concerning the Airport Zoning Regulations for Igloolik, the only restrictions in place are for the elevation of structures. There are no exemptions from the Aeronautics Act required for the preferred sites identified”

In previous correspondence with Mr. McFee on April 17th, 2019 regarding another landfill siting, in Resolute Bay, the following information was provided “While many airports’ zoning regulations contain clauses restricting land use related to wildlife attractions, Resolute Bay’s zoning regulations do not include any wildlife restrictions. The only restriction at Resolute Bay is for elevation of structures. There is no exemption from the Aeronautics Act required for this project.

Some thoughts:

- While there are no zoning issues, a landfill in the vicinity of an airport may pose a safety hazard due to attraction of birds and other wildlife.
- I’ve attached Transport Canada’s publication on land use in the vicinity of aerodromes. There is general information and recommendations that may be relevant to the project.
- While there is no requirement to submit anything else to Transport Canada Civil Aviation, there may be other local, territorial, or federal notifications or authorizations required.

- Obtaining a NavCanada land-use assessment and requesting input from Nunavut Airports would be prudent."

Based on this response, Dillon understands that a bird study will be required for this study location, but additional communications with Transport Canada are not required for approval.
A copy of these complete email are included in **Appendix A**.

3.2.4.4 Nunavut Airports

Correspondence with Pierre Lamothe, the Manager of Standards and Program Development for the Department of Economic Development and Transportation at the GN, took place on July 23rd. The correspondence established that approval to proceed is required from NAV Canada and Transport Canada and an airport-bird hazard risk assessment to evaluate the potential risk of the project on aviation safety is required to move on to the design phase of the project. Once the design has reached 60% completion it is to be submitted to the Department of Economic Development and transportation at the GN. Approval will be required prior to following through with construction. A copy of the correspondence can be found in **Appendix B**.

3.3 Site Visit and Community Consultation

As part of the site selection process, Dillon completed a site visit on June 10th, 2019 and a meeting with the SAO, Mayor, and Council members in the Community on June 11th, 2019. Dillon visited the existing and proposed sites to collect observations of the site. The observations can inform and more directly differentiate which sites may be best suited for future development for the new SWM Facility.

Dillon was accompanied on the site visit by the Municipal Director of Public Works, Joasai, who escorted Dillon around the Municipality and surrounding areas in a pick-up truck. As part of this tour, Dillon visited the current dump site location, and viewed the areas which were used to collect salvage metal, HHW, derelict vehicles, and scrap wood. Access to proposed sites was limited due to the presence or absence of gravel roads.

On June 11th, a meeting was facilitated by Dillon in the Municipal Council chambers with the Mayor and Councilors to discuss potential sites for development of a new solid waste facility. Proposed sites were presented on a large format map of the community and surrounding areas, and each site was discussed. Feedback was provided to Dillon on each of the locations, and comments were recorded. Council members also described additional areas which were used by the community, such as hunting and fishing areas. Known patterns of fish or migration of animals are important criteria when siting the proposed facility.

Informal interviews of community members were conducted between Jun 10th and June 12th, 2019. Dillon staff shared our reason for being in Igloolik and we described the project verbally. Some

community members expressed concerns over the lack of fencing at the existing dump site. Multiple community members stated wind direction and uncontrolled burning as a large concern which would bring in odour and raised concerns about air quality. There is also concern regarding proximity to water. The current site is near the shore, and nearby pools of water are directly adjacent to the waste piles. It is known that the pools do drain into the main water body. No leachate preventative controls exist at this time. Lastly, some community members expressed desire for recycling options as well as a need to remove stock piles of HHW, scrap metal, and derelict vehicles. At present, there are no programs in place to collect and ship recyclables, and no programs to back-haul waste materials off the island.

4.0 Data Analysis

The following subsections present the review process and analysis of the proposed solid waste management facility locations.

4.1 Site Selection

Based on guidance provided in the Solid Waste Management for Northern and Remote Communities – Planning and Technical Guidance Document, setback requirements and distances were applied to a number of features within the community.

The application of the siting constraint on the study indicated that favourable locations for site development were limited. The shape and size of the island, the location of the airport, high proximity to bodies of water, and the existing road layout meant that all possible sites were located north of the Municipality. An application was sent to the GN Department of Culture and Heritage (CH) to request access to archaeological information about Igloolik. It is our understanding that multiple archaeological sites are present within in the proposed developed areas recorded in the Nunavut Archaeological Site Database (Database). In addition, there may be more sites which have yet to be recorded and are therefore not represented in the Database.

It is the recommendation of the CH that an archaeological assessment be conducted prior to any future ground disturbance activities. During the detailed design phase, and prior to construction, a professional archaeologist that is qualified in Nunavut should be hired to conduct work within Igloolik. Project plans will need to be submitted to the Nunavut Planning Commission (NPC). These plans will be forwarded to the Nunavut Impact Review Board for a full review. Once the project is posted to the public registry, the CH will be notified, and the Database information can be released to the professional archaeologist. An archaeological application for works on site must be submitted to the CH prior to March 31st of the construction year, in order for a survey to be carried out prior to ground disturbance activities. The CH is available to assist with providing a list of professional archaeologists as well as with the archaeological application process.

The airport is situated very close to the community, therefore the 4 km setback removes the southern portion of the western half of the island as a consideration. The small potion which is outside of the airport setback and located west of the Hamlet is only accessible by ATV or off-roading capable trucks. A road would need to be constructed and maintained to haul material. This west area is therefore not ideal for future development. Given this information, Site G was disqualified due to access concerns. An all season road (sometimes limited by weather) exists that allows travel north-east of the community. Portions of the road will be critical if development of sites B, D or H are chosen for the SWM facility.

The meeting with Mayor and Council confirmed the suggestion for development of Sites B, D or H. Site D was considered as the preferred location for the proposed site based on their understanding of the area. They shared their knowledge about their community, and mentioned accessibility to site, proximity to the community, distance from the airport, general road maintenance practices, aesthetics and cultural land use reasons for selecting Site D ahead of the other sites. Site B is similar to Site D, however it will need a slightly longer roadway constructed to access the site. Site H is within the 4 km airport setback, but is not along the flight path. These sites were accepted as possible options by Council, in the event that Site D was deemed unsuitable in the course of the study.

Sites C, F and E do not exhibit qualities which immediately eliminate these as option. However, the Sites present similar benefits to the three preferred sites with some additional complications or less favourable conditions. The sites are included in the decision matrix where the exact attributes are quantified. Further exploration through Geotechnical investigations will not be conducted at these three sites.

The current dump site (Site A) was reviewed as part of the study, and was determined to be not ideal for future development. The current site is located close to the beach, and the Council expressed concerns about leaching and future growth. The site is included in the decision matrix for comparative purposes. **Table 1** lists each siting consideration, the setback distance used as a best practice guideline, and illustrates the compliance of each site to the criteria. The information presented in **Table 1** was determined through a combination of on-site observations, in person interviews, email and phone correspondence, and a desktop study of the area.

Table 1: Siting Consideration Requirements

Siting Criteria	Setback Range (m)	Applied Setback Distance	Satisfaction of Setback Requirements								Siting Details
			Site A (current disposal site)	Site B	Site C	Site D	Site E	Site F	Site G	Site H	
Suitability of Surface and Subsurface Geology			✓	✓	✓	✓	✓	✓	✓	✓	All sites have been assessed based on aerial photos, and are considered viable for development. Additional subsurface geotechnical investigation is planned for sites B, D and H. Dillon was able to complete site visits for most sites with the exception of Sites C and G as they were not accessible by road at the time of the study.
Alignment with the Community Land use plan			✓	✓	✓	✓	✓	✓	✓	✓	All sites have been confirmed, and do not appear to conflict with current community land use plans. Site A is currently designated as a waste disposal area.
Outside of known flood areas based on local and traditional knowledge			✓	✓	✓	✓	✓	✓	✓	✓	All sites are outside of any locally known flood areas.
Airport outer limits of lands setback from centre of runway	4,000 m[(1)]	4,000 m	×	✓	✓	✓	✓	✓	✓	×	All but sites A & H are outside of the airport setback radius. Sites B, C & G are within the flight path outside of the setback radius.
Setback from homes or recreational cabins outside of the community	300-1,600 m[(2)]	500 m	✓	✓	✓	✓	×	×	✓	✓	Sites E and F are known areas for cabins.
Setback from edge of the community	300-1,600 m[(2)]	1,000 m	×	✓	✓	✓	✓	✓	✓	✓	All but site A is outside of the Community footprint.
Setback from National or Territorial Parks and other protected areas	100 m[(2)]	100 m	✓	✓	✓	✓	✓	✓	✓	✓	There are currently no National or Territorial parks, or other protected areas on Igloolik Island.
Setback from beach and coastal area	30-100 m[(2)]	100 m	✓	✓	✓	✓	✓	✓	✓	✓	All sites have been confirmed to comply with the setbacks from the ocean. Maintained a distance of 100 m from beaches and coastal areas.
Setback from Drinking water sources	300-1,500 m[(2)]	1,500 m	✓	✓	✓	✓	✓	✓	✓	✓	All sites are located outside of the most rigorous drinking water source setback. Used the maximum setback of 1,500 m from the drinking water source.
Setback from waterbodies	30-100 m[(2)]	100 m	✓	✓	✓	✓	✓	✓	✓	✓	All sites meet the waterbody setback requirements. Used the maximum setback of 100 m from waterbodies.
Setback from heritage, cultural and archeological sites and recreational use areas	100 m[(2)]	100 m	✓	✓	✓	✓	×	×	✓	✓	Sites E and F are known areas for hunting and fishing. We are still awaiting confirmation about the location of the archeological sites for Igloolik.
Proximity to existing access roads		300 m [(3)]	✓	×	×	✓	✓	✓	×	✓	Sites A, D, E, F & H are nearest existing access roads which reduce the need for road improvements. Sites B, C and G are beyond the setback and would require building access roads. Sites
Accessibility of daily cover material		1500 m [(3)]	✓	✓	✓	✓	✓	✓	✓	✓	Gravel is available and accessible, however, the exact location changes based on depth to permafrost. As a result, on average, each site will have moderate to good access to daily cover material.
Availability of land for future expansion			×	✓	✓	✓	×	✓	✓	✓	Most sites have room to expand in the future to reduce the need to site another new location. Sites A and E for not have room to expand.
Downwind of the community relative to the prevailing wind direction	Prevailing wind direction is from the North West[(4)]		✓	×	×	✓	✓	✓	×	✓	The community is downwind of Sites B, C and G are downwind from the prevailing wind direction.
Line-of-site to public roads, public use areas and aesthetics	100 m[(2)]	100 m	×	✓	✓	✓	✓	✓	✓	×	Sites A and H are within the 100 m setback from a public road, which places them within the line-of-site. All other sites are beyond the setback to a public road and are outside of the line-of-site of any public use area.
Suitable topography, preferably <10 % slope			✓	✓	✓	✓	✓	✓	✓	✓	All sites have suitable topography.
Placement outside of Inuit Owned Land			✓	✓	✓	✓	✓	✓	✓	✓	All sites and access roads are located on non-Inuit Owned land.
Seasonal Accessibility			✓	✓	✓	✓	✓	✓	×	✓	No sites affected by seasonal changes to waterways. Site G deemed unsuitable because of its inaccessibility – no current roads to this site.

[1] Igloolik Airport Zoning Regulations (Government of Canada, 2018)
[2] Solid Waste Management for Northern and Remote Communities – Planning and Technical Guidance Document (Environment and Climate Change Canada, 2017)
[3] Selected setback value based on reasonable proximity to currently developed road network.
[4] Weather of Nunavut and the Arctic (Canada, 2001)

4.2 Community Considerations

The meeting with Mayor and Council was very successful and feedback we received indicated that proposed **Site D** is the preferred location for future development. This recommendation was made by Council, based on their understanding of the area, including accessibility of the site, aesthetics, relative position to the runway and flight paths, proximity to the community and cultural land use.

During the meeting, sites A, B, C, D, E, F, G and H were discussed (**Figure 4**). Feedback and comments from the meeting with Mayor and Council are Council agreed that proposed Site D is preferred, and that sites B and H may be considered.

The following is a summary of proposed landfill locations presented by Dillon, and Council feedback:

Site A: Site A is the current dump site. This site was not favoured by Council, due to its proximity to the shoreline, as well as the current impacts on the community and the requirement for clean-up.

Site B: Supported by Council as an option for future consideration. Not currently accessible by road, but is adjacent to the road (~200 metres).

Site C: Not currently accessible by road, but is adjacent to the road (~400 metres).

Site D: Preferred Site, unanimously favoured by Mayor and Council.

Site E: Far from town, would be costly to maintain road out to this site. Community members also hunt and fish in this area.

Site F: Far from town, would be costly to maintain road out to this site. Community members also hunt and fish in this area.

Site G: Not accessible and far from town. Disqualified due to road work required to make this site a viable option.

Site H: Supported by Council as an option for future consideration. Considerations need to include the proximity to the water and coast. Site has good access for community members.

Green indicates favourable, **orange** indicates acceptable, and **red** indicates sites that have been deemed unsuitable for development.

No additional information was gained during interviews and conversations with community members but many of the comments and concerns raised during the Council meeting were repeated.

GOVERNMENT OF NUNAVUT

SOLID WASTE FACILITY SITE SELECTION
IGLOOLIK
NUNAVUT

FIGURE 4
PRELIMINARY PROPOSED LOCATIONS FOR FUTURE LANDFILL DEVELOPMENT

- Potential development site identified during desktop study
- Roadway
- Proposed Road Improvements
- Community Parcel Boundaries
- Airport
- Drinking Source Setback (1.5 km)
- Airport Setback (4 km)
- Inuit Owned Land
- Watercourse
- Water Body

SCALE 1:35,000

0 250 500 1,000 Meters

MAP DRAWING INFORMATION:
DATA PROVIDED BY ESRI, DILLON, NRCAN

MAP CREATED BY: 44PH
MAP CHECKED BY: 46JB
MAP PROJECTION: NAD 1983 UTM Zone 17N

DILLON CONSULTING

PROJECT: 199424
STATUS: DRAFT
DATE: 2020-03-16

FILE LOCATION: G:\GIS\2019\199424 Solid Waste MFS, Hall Beach & Igloolik\MXD\Igloolik\Figure 4 - Preliminary Proposed Locations for Future Landfill Development.mxd

4.3 Weighted Decision Matrix

A multi-criteria decision matrix was used to integrate the quantitative measures and qualitative feedback given during the Mayor and Council meeting. Prior to completing the decision-matrix, sites C, D, F and G were disqualified due to access limitations, and so were not included in the evaluation. Each of the factors listed in Section 3.2.2 have also been considered for all proposed sites. The criteria were satisfied for Sites B, D and H, and a weighted decision matrix (**Table 3**) were evaluated in the weighted decision matrix. The existing waste disposal site, Site A, is also included in the decision matrix for comparative purposes, though it is not being considered for development.

The evaluation consisted of a number of site options, a defined set of evaluation criteria and corresponding weights for the criteria. Inputs to the decision matrix were the degree to which each site option satisfied the criteria. The output was an overall ranking of site options. The site locations are scored with a ranking index which indicates the degree to which each site satisfies all the weighted criteria. The ranking index is a relative comparison of one site to the other alternatives rather than an absolute measure. The option with the highest ranking index suggests that it is a better option compared to an alternative with a lower ranking index.

Weighting was applied based on the understanding that all sites meet the minimum setback criteria laid out in the Solid Waste Management for Northern and Remote Communities, Planning and Technical Guidance Document. This allowed the weighting for Council approval to be weighted with the most significant influence, since it was understood that safety and environmental setbacks were met. Additional setback distances for environmental and safety related considerations are weighted, but with less overall influence. The weighted values are intended to compare the proposed options to each other, and not to rate them on a universal basis. A description of the ranking criteria parameters and scoring application can be found in **Table 2**.

Table 2: Ranking Criteria Details

Criteria	Parameters of Criteria	Scoring Application	Weighting
Drinking Water Source	The proximity to the communities drinking water source	If outside of the designated setback the site would receive the best rank.	1 - 3
Airport	The proximity to the airport and the flight path.	The best rank is given to one that is outside of the airport setback and not along the flight path.	1 - 15
Access Road	The length of access road that would be required for the given site.	The best rank is given to the site with the shortest access road as it would require less road upgrades.	1 - 3
Traditional and Recreational Areas	The proximity to traditional and recreational areas.	The best rank is given to the sites that are the furthest from the traditional and recreational areas.	1 - 5

Criteria	Parameters of Criteria	Scoring Application	Weighting
Availability of Granular Material	The proximity to available granular material	The best rank is given to the site that is nearest a source of granular material.	1 - 3
Hauling Distance	The distance required to transport waste from the community to the site.	The best rank is given to the site that is required to haul waste the shortest distance.	1 - 3
Community Setbacks	The proximity to the community setback.	The best rank is given to the sites that our outside of the community setback.	1 - 3
Visibility from Community Use Areas	The visibility of the site from community use areas.	The best rank is given to the site that is furthest from community use areas, including roadways. 1 - 3	1 - 3
Area for Future Expansion	The amount of area available for future expansion	The best rank is given to the site with the ability to double its current footprint.	1 - 3
Council Approval	Council's approval of the site.	The best rank is given to the site that the council considers to be most favourable.	1 - 15
All-Season Road Access	Accessibility of the site in all seasons.	The best rank is given to sites that are accessible in all seasons and conditions.	1 - 3
Prevailing Winds	The location of the site relative to the prevailing winds	The best rank is given to the sites that are downwind from the community.	1 - 3
Slope of Selected Sites	The slope of the selected site relative to the other considered sites.	The best rank is given to the site that is less than 3% slope, and the site with the least amount of slope relative to the other considered sites.	1 - 3
Capital Cost (includes relevant infrastructure)	The cost of the site relative to the other considered sites.	The best rank is given to the site with the lowest cost.	1 - 10

Table 3: Weighted Decision Matrix

Site	A	B	D	H
Location	Existing, .5 km N of Community	3.5 km NW of Community	4 km N of Community	2.5 km N of Community
Distance From				
Drinking Water Source *(1=Close, 3=Far)*	3	3	3	3
Airport *(1=Close, 10=Far)*	1	7	10	1
Access Road *(3=Close, 1=Far)*	3	1	2	2
Traditional and Recreational Areas *(1=Close, 5=Far)*	3	5	4	4
Availability of Granular Materials *(3=Close, 1=Far)*	3	3	3	3
Hauling Distance *(3=Close, 1=Far)*	3	2	1	2
Community Setbacks *(1=Close, 3=Adequate)*	2	3	3	3
Community Considerations				
Visibility from Community Use Areas *(1=Visible, 3=Not Visible)*	1	3	2	2
Area for Future Expansion *(1=None, 3=Considerable)*	1	2	3	2
Council Approval *(1=Against, 15=In Favour)*	1	12	15	10
Land Features				
Seasonal Road Access *(1=Inaccessible, 8=Accessible)*	8	5	6	7
Prevailing Winds *(3=Favourable, 1=Unfavourable)*	1	3	3	2
Slope of Selected Site *(3=<3%, 1=>10%)*	2	2	3	1
Cost (Data Pending)				
Capital Cost *(3=Low Cost, 1=High Cost)*	-	-	-	
Overall Scoring	**32**	**51**	**57**	**42**

Total scores for each of the proposed sites is presented in **Table 4**.

Table 4: Overall Decision Scores for Proposed Sites

Proposed Site	Site A	Site B	Site D	Site H
Location	Existing, .5 km N of Community	3.5 km NW of Community	4 km N of Community	2.5 km N of Community
Overall Score	**32**	**51**	**57**	**42**

Based on the weighted decision matrix, **Site D** ranks as the preferred site for development, and Site B ranks as the second preferred site. Site H could be too close to either water setback. The small parcel of acceptable land could encroach on the coastline, or move inland where there are pools that often collect water. This removes the possibility of scaling the operation up when needed. And it put the surrounding environment at risk of leachate generation. Site A is too close to the community. As well, the predominantly southern wind direction negatively affects the community with noticeable amounts of foul odours coming from the landfill pile.

5.0 Waste Composition Study

5.1 Methodology

Dillon staff completed a waste composition study at on June 11th, 2019. Waste was audited from both the household and industrial, commercial and institutional (ICI) sectors.

The primary objectives of the waste composition study were to:

- Determine the amount of waste generated by Igloolik's residential and ICI sectors;
- Estimate the potential diversion rates with the introduction of new programs (e.g., recycling) that could be implemented by Igloolik; and
- Capacity analysis for a future landfill facility, based a 20-year planning horizon.

Household waste was collected by public works staff, dropped at the Public Works truck storage bay. A sub-sample of the material provided was weighed, sorted and categorized for a comprehensive look at household waste generation and composition. The sample was collected by Public Works staff on June 10th, 2019 from approximately 20 households. It was assumed this sample represented two days' worth of waste generation. This estimate was based on the assumption that materials are collected twice, weekly from each household and based on the staff's assumptions on when the houses last had waste collected. The collected waste was delivered to the sorting area. Dillon staff recorded information on the inbound load. This included the number of households that the waste was collected from, and the number of days that waste was generated. After the waste was unloaded, Dillon staff weighed a portion of the waste to determine the total sample weight. Waste was sorted by Dillon staff, and supported by temporary staff hired from the community. The temporary staff sorted waste, and helped with weighing samples and taking pictures. The audited sample was sorted into a total of 12 primary categories, and 16 sub-categories (**Table 5**).

ICI waste was visually audited and was not physically sorted. Significant waste generating ICI facilities in Igloolik were evaluated as a part of the waste study using an on-site assessment and interviews with staff regarding waste generation and disposal trends.

Dillon provided the necessary equipment to conduct the waste composition study including scales, containers for sorting, data sheets and a camera. Everyone participating in the waste sort wore the appropriate personal safety equipment, provided by Dillon. The Municipality provided tables for the waste composition study.

Table 5: Waste Composition Study Categories

Primary Category	Sub-Category
Paper/Fibre	Paper, Cardboard and Boxboard
	Polycoat Containers
Metal	Aluminum and Steel Food and Beverage Containers
Glass	Glass Food and Beverage Containers
Plastics	Plastic Containers (#1, 3, 5 and 7)
	Low, Medium and High Density Polyethylene (#2 and 4)
	Laminated Plastics
	Polystyrene
Organics	Food Scraps and Tissue/Towelling
Wood Scraps	Wood Scraps
Electronics	Electronics and Household Appliances
Hazardous Waste	Hazardous Waste
Toys	Toys
Textiles	Textiles
Diapers	Diapers and Sanitary Waste
Other	All Other Waste "Garbage"

Health and safety training and waste sorter training were provided to the temporary local staff on June 10th to prepare them for participation in the waste composition study. All personal protective equipment was provided by Dillon, and the staff were instructed on safe handling procedures, as well as how to use the safety equipment provided. The sorting team began and completed their audit on June 11th after reviewing the tasks and addressing safety considerations.

Image 10: Community Members Assisting in Waste Sort

Image 11: Waste Composition Study Set-Up

5.2 Results

5.2.1 Household Waste Composition

The two days' worth of collection provided a waste sample representing household garbage from approximately 20 households, and weighed a combined total of 368.80 kg. The two days' worth of waste collected does not consider seasonal variances in the waste stream, but is considered to be statistically representative for this project based on the intended use of the data.

Image 12: Tipped Waste Audit Sample

Image 13: Waste Audit Material

Diagram 1 illustrates the overall composition of residential household waste. The largest portion of the composition of residential waste was the organics representing 27.0%. Diapers were the second highest category (25.5%) followed by paper/fibre (16.4%) and plastics (12%).

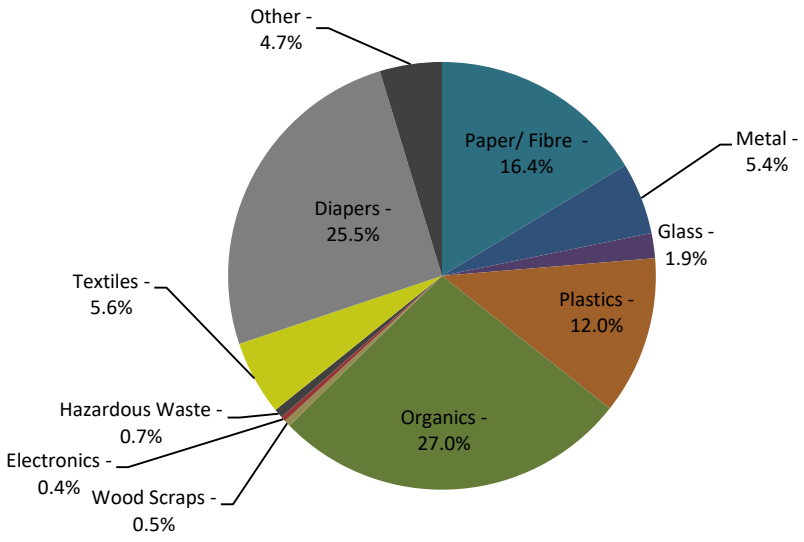

Diagram 1: Waste Composition Study Results - By Primary Category

Diagram 2 represents all sub-categories waste was sorted into during the study. In the sub-categories, the highest portion was food scraps, and tissue /towelling (27.0%). The next highest sub-categories were diapers and sanitary waste (25.5%) and paper, cardboard and boxboard (14.6%).

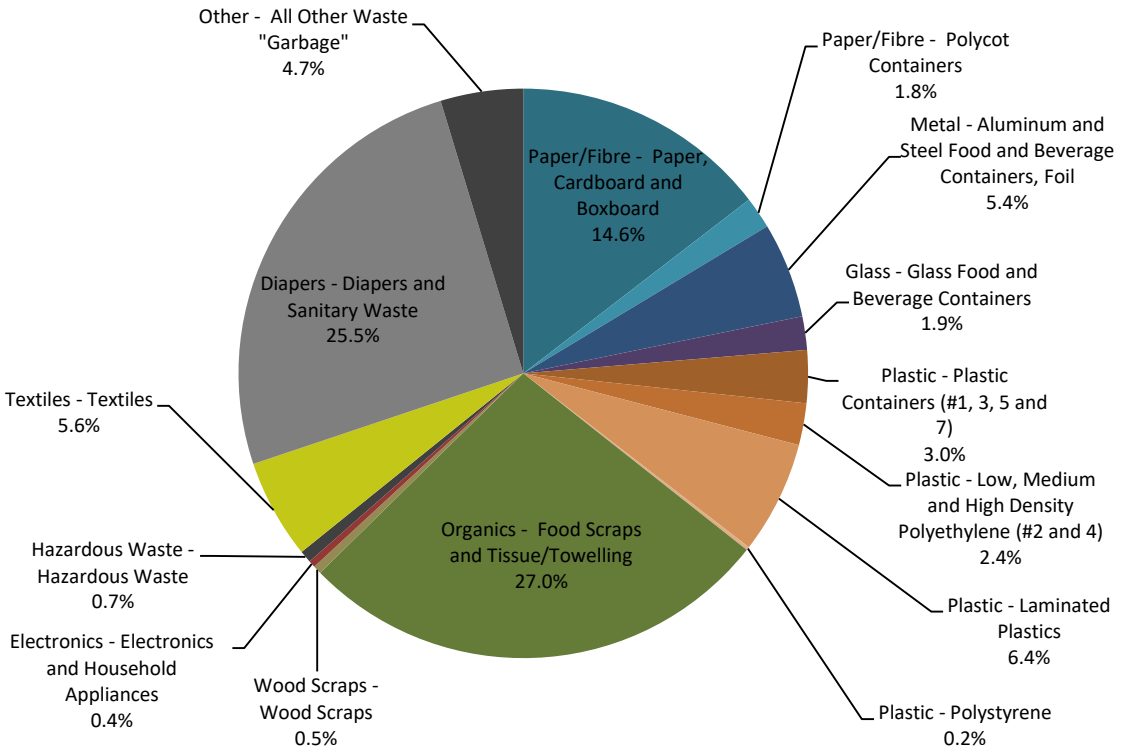

Diagram 2: Waste Composition Study Results - By Sub-Categories

5.2.2 ICI Results

Igloolik is a small community with a small number of significant ICI waste generators. Businesses and significant ICI waste generators include:

- Grocery Stores (2)
- Hotels (2)
- Public Services Buildings (6)
- Restaurants (1)
- Schools (4)

Supplies are shipped to the community every summer on the sealift, which comprises a number of deliveries to the community by boat. These boats visit Igloolik as part of a northern delivery circuit. Supplies delivered include fuel, building materials, food, equipment, and any other materials ordered in advance for delivery. The number of sealifts per year varies, but typically is around two per year and is dependent on what materials and quantities are required for the upcoming year. Additional supplies are brought to the community by air, either as mail, or supplies ordered by local individuals or businesses, and shipped by the distributors.

To assess the amount of waste generated in the ICI sector of Igloolik assumptions and external references were required to calculate the values. A comprehensive list of the assumptions or references are listed in **Table 6**.

Table 6: ICI Waste Assumptions

	Assumption/Reference
Visual Assessment of Truck Load Composition	65% MSW, 30% OCC and 5% Other
Density of MSW (65% of Waste)[5]	**187 kg/m^3**
Density of OCC (30% of Waste)[6]	63 kg/m^3
Density of Other (5% of Waste)[7]	80 kg/m^3
Combined Average Load Density	145 kg/m^3

[5] 2014 Generator Based Characterization of Commercial Sector Disposal and Diversion in California (P.41)
[6] Volume to weight conversion factors U.S Environmental Protection Agency Office of Resource Conservation and Recovery April 2016 (P.4)
[7] Volume to weight conversion factors U.S Environmental Protection Agency Office of Resource Conservation and Recovery April 2016 (P.5)

6.0 Conceptual Design

Based on the site selection process, and initial knowledge of the three preferred sites for future development of a solid waste facility, Dillon developed a conceptual design for a solid waste management facility. This process has taken into account the estimated waste generation rates of the community, the geology and topography of the region, the climate and associated challenges with road access and leachate management.

6.1 Capacity Analysis

A capacity analysis was conducted to project the current and future (20-year) needs of the proposed landfill site. The capacity analysis used waste generation data from the results of the waste composition study discussed in **Section 4.0** and supplemented that data for specific materials with the Nunavut Solid Waste Management Plan (exp Services Inc., 2014). The permanent population growth rate of 2.9%, which is the same value applied to each community in the Qikiqtaaluk region, was found in the Nunavut, Regional and Community Population Projections 2009-2036 (Nunavut Bureau of Statistics, 2010), it was used to project the future population of the Municipality and is represented in **Table 7**.

Table 7: Projected Community Population Based on Historic Growth

Year	Total Population, Igloolik
2021	2,033
2026	2,345
2031	2,706
2036	3,121
2041	3,601

The results of the waste composition study provided the annual waste disposed per community member, these values were used in conjunction with the population growth to forecast future waste generation. The landfill cell analysis used waste generation values from the completed waste composition study. This study determined that the current waste generation is approximately 810 kg/year/capita.

Following meetings with the Government of Nunavut as well as other stakeholders, a standardized generation rate for the Municipality was decided to be 1,075 kg/year/capita. Based on research completed by Dillon, it is assumed that 962 kg/year/capita of the waste generated will be disposed. This standard will be used for all communities completing this study in Nunavut going forward. This rate was applied to developing a 20 year waste generation forecast, based on anticipated population growth, to project the total waste capacity for a new landfill design. This standardized generation rate is an average of several studies completed in Nunavut and Northern Canada and is assumed tor reflect waste

generated in residential, ICI, construction and demolition as well as bulky waste. This rate was applied to developing a 20 year waste generation forecast, based on anticipated population growth, to project the total waste capacity for a new landfill design (**Table 8**).

Table 8: Waste Generation Forecast, 2021-2041

Waste Generation Sector	Annual Waste Disposed, 2021 (Tonnes)	20-year Accumulation projection, 2041 (Tonnes)
All Generating Sectors	1,956	55,484

To determine the size of area required for each of the segregated materials, values were used from the following sources:

- Nunavut Solid Waste Management Plan (NSWMP 14) (exp Services Inc., 2014),
- Statistics Canada (Stats Canada) waste diversion values (Government of Canada, 2016), and
- Conversations with local maintenance managers at the Local Housing Organization (LHO), an affiliation of Nunavut Housing Corporation (NHC).

The NSWMP 14 reported generation rates broken out into the three regions of Nunavut, the values provided for the Qikiqtaaluk region were applied to the Municipality.

Stats Canada only reports on diversion values for E-waste. Reported diversion values only account for material which is diverted away from the landfill, thus generation values would be higher than diversion values. Dillon calculated the rate by dividing the generation value by the population of the given year and assumed that Nunavut has a lower E-waste generation rate relative to the national average reported by Stats Canada. It is acceptable to utilize the national E-waste diversion rate as Nunavut's generation rate, as a conservative estimate.

We spoke with LHO maintenance managers from five communities, they provided estimated quantities of appliances and fuel tanks sent to the landfill annually. An average volume for each appliance type was applied to the quantity in conjunction with the population, to estimate the generation rate. The calculated quantities, projections and assumptions are provided in **Table 9.** To determine the estimated volumes of material generated for HHW, E-Waste, Tires and Clean Wood, density values were applied from the Waste Materials – Density Data sheet (Australia Environment Protection Authority Victoria, n.d.). Information provided by NSWMP, Stats Canada and LHO's contributed to the calculations in this section. Derived calculations and example calculations from provided data are provided in **Appendix D.**

Table 9: Segregated Materials

Material	Segregation Method	Annual Generation Rate	20 Year Projection	Source	Assumptions
Appliances	Sea Can	140 m^3/yr	4,300 m^3	LHO	Combination of washers, dryers, fridges and stoves
HHW	Sea Can	0.8 tonnes/yr	20 tonnes	NSWMP 14	Only reported on automotive batteries
E-Waste	Sea Can	0.4 tonnes/yr	10 tonnes	Stats Canada	Diversion rates were applied to the population from Statistics Canada for that year
Tires	Sea Can	1.5 tonnes/yr	40 tonnes	NSWMP 14	
ELV	Separated Pile	27 tonnes/yr	810 tonnes	NSWMP 14	
Oil/ Fuel Tanks	Separated Pile	70 m^3/yr	2100 m^3	LHO	Switching from metal to fibreglass as an initiative for longevity, likely to see a decrease in the coming years
Wood Waste	Separated Pile	720 m^3/yr	22,000 m^3	NSWMP 14	

Community specific details were provided by a LHO representative for that community. Based on the 84 units the LHO manages, it was estimated that eight to ten appliances are disposed of annually. In Igloolik, the LHO reduces waste by tendering out vehicles at the end of their life, old appliances are kept for parts, and mattresses are donated to the community after approximately five years of use.

6.2 Schematic Layout

Using the results of the capacity analysis, as well as our understanding of the solid waste disposal needs of the community, a schematic site layout (**Appendix C**) was developed and applied to each of the three preferred sites. For Igloolik each site layout is similar, and also includes a site specific draft access route for future road development, as well as a landfill and solid waste diversion facility designed for a 20 year lifespan.

The proposed facilities include features as described below in **Table 10**.

Table 10: Facility Features

Site Feature	Description	Dimensions (Where Applicable)
20 Year Lifespan MSW Cell	MSW landfill cell complete with geomembrane liner and leachate collection system.	• Interior Dimensions: 210 x 210 m
Leachate Evaporation Pond	Evaporation pond complete with geomembrane liner sized to accommodate leachate produced by the MSW cell.	• Interior Dimensions: 56 x 56 m
Driving Surface	Gravel roadway complete with subgrade, granular base, and granular surface course.	• Approximately 9,000 m^2 • 2% Crossfall • 10 m wide
Gravel Pad for End-of-Life Vehicle Decommissioning	Gravel pad complete with geomembrane liner.	• 10 x 20 m
Gravel Pad for Used Oil Storage Tanks	Gravel pad, underlain with geomembrane liner.	• 10 x 20 m
End-of-Life Vehicle Storage	Allotted area for ELOV storage. Required to provide positive drainage.	• 38 x 60 m
Empty Fuel Tank Storage	Allotted area for empty fuel tank storage. Necessary to provide positive drainage.	• 25 x 38 m
Surface Water Run-on Control Ditching	For purposes of conveying surface water away from new development. Hydroseed or seed blanket typical to prevent erosion.	• Approx. 2,000 lin.m • 1 m deep (typical) • 1m wide (typical) • 3:1 slopes (typical)
Perimeter Chain Linked Fence	Galvanized steel.	• 1,650 lin.m • 2 m high
Chain Linked Fence Gates	Galvanized steel.	• 10 m length • 2 m height
Site Lighting	Concrete supported steel posts with light fixture.	• N/A
Sea-Cans	For the collection and storage of diverted waste prior to shipping	• 3 x 3 x 12 m
ATCO Office Trailer	Custom-built office trailer available from numerous suppliers.	• 7 x 13 m
Contaminated Soil Treatment and Storage	Gravel pad(s) complete with oil-water separator.	• 12 x 65 m (treatment) • 12 x 65 m (storage)
Truck Storage Building	Pre-fabricated membrane-type structure for storage of dump truck and dozer	• 9 x 20 m
Signage	As required.	N/A

The conceptual design layout includes all of the required waste storage areas and waste sorting areas in one location, which will significantly decrease the labour requirements to maintain the site. The

prevailing wind direction is from the Northwest and will be considered for the layout of the site and the placement of the chain-link fence, debris will need to be monitored once the site is operational.

6.2.1 Landfill Cell Design Basis

The conceptual approach to development of the Igloolik Landfill is to design an engineered site facility. This approach relies on the combination of synthetic protection in conjunction with the natural environment to mitigate impacts through the use of a synthetic geomembrane, an engineered slope, freeze back, and other factors.

Environment and Climate Change Canada published the *Solid Waste Management for Northern and Remote Communities- Planning and Technical Guidance Document* (Guidance Document), dated March 2017. This document is intended to provide guidance on best practices rather than act as a regulation, this allows for qualified professionals to make recommendations based on specific local conditions. The document classifies 2 types of facilities as either Class 1 for larger landfills (e.g. > 5,000 tonnes per year) that do not support natural attenuation and Class 2 for smaller landfills, < 5,000 tonnes per year, that support natural attenuation. The best practices (e.g. Table 5-1, ECCC 2017) for Class 1 facilities recommend a highly engineered containment liner system as Igloolik does not support natural attenuation. However, the conditions at the preferred site in Igloolik support an alternative approach. Key considerations for the proposed design include:

- Landfill is located in a semi-arid region and measures can be developed/ implemented to prevent the infiltration of precipitation into the waste mass;
- Landfill is located on bedrock that will allow for granular material to be placed to create a slope with the geomembrane liner, to slope away from surrounding water bodies;
- Landfill is placed to allow for the bedrock and groundwater to run parallel to surrounding water bodies, when possible;
- Landfill is located in a permafrost region where biodegradation of solid waste is considered negligible and supports freeze back to prevent leaks through the single geomembrane layer; and
- Low waste generation rates and small landfill footprint.

Based on the following key factors specific to Igloolik, this conceptual design has been based on a engineered system design concept:

- Igloolik has an arid climate, with an approximate annual precipitation rate of 274.3 mm (10.8 in) per year[8]. Most of the precipitation falls in the summer months, the following two methods can be considered to mitigate the amount of precipitation reaching the waste mass.
    - A reusable human applied landfill tarp applied daily to mitigate the impacts of rain, and
    - Placement of stormwater barriers in the landfill to subdivide the cells into smaller sections to reduce the impact should precipitation reach the waste mass.
- The Igloolik landfill is anticipated to receive less than 1000 tonnes per year of waste, which places it at the low end of the Class 2 Facility classification;

[8]https://www.weatherbase.com/weather/weather-summary.php3?s=710813&cityname=Igloolik%2C+Nunavut%2C+Canada&units=

- Igloolik is located in a permafrost region which supports the following:
    - Biodegradation of waste is anticipated to be negligible,
    - Over time the waste mass will act as an insulation barrier for liquid collected at the bottom of the cell; and
    - Freeze back, the freezing of surrounding soil that will impeded the movement of liquid material, will occur should the geomembrane liner be punctured; and
- The desired slope can be achieved by grading the granular material above the bedrock while maintaining a minimum depth of 1 foot of material at the shallowest point, additional material can be imported if required;

The intent of the design is for leachate to drain out of the active landfill cell during the summer months, and accumulate in the leachate pond. This leachate is anticipated to partially evaporate during the summer months, and the remainder pumped over the waste mass near the end of the summer, until the capacity of the waste mass to absorb leachate is reached. Some of the leachate may remain in the leachate pond at the end of the summer. The leachate that is absorbed by the waste mass, should freeze to create a frozen core within the waste mass. As the landfill develops the surface portion of the frozen waste mass will annually thaw and this volume along with the annual leachate generation may exceed the storage capacity of the leachate pond, after evaporation. As such, the ability of the waste mass to absorb leachate, the capacity of the leachate pond and surface evaporation should be investigated during the detailed design phase of a new landfill site.

In the event that permafrost does begin to deplete, there should be a general increase in temperature which would allow for increased evaporation from the waste mass and leachate pond. As a proactive approach, the following two methods should be considered in the design phase:

- Installing temperature probes under the landfill to receive advanced warning of warming; and
- Installing an interceptor trench or pipe to collect and mechanically or gravitationally pump to the leachate pond, additionally begin collecting semi-annual leachate samples as a database for potential future leachate treatment options.

The leachate that is already being diverted to a leachate pond can begin to be captured and treated by the most appropriate process determined at that time.

6.3 Class D Cost Estimate

The schematic layout for a new landfill facility and waste diversion area, including access road requirements were provided to Altus Group, who prepared a Class D cost estimate for the development of each of the three preferred sites. Conceptual designs and corresponding quantities estimates were provided to Altus, as well as estimated road upgrades required for development of each site. Select design assumptions were also provided to Altus, based on the outcomes from the consultant design meeting held in Iqaluit in June 2019.

The following table will include the Class D cost estimates for landfill development at each of the three proposed sites upon receiving the final estimate.

Table 11: Class D Cost Estimate Summary (To be updated)

The conceptual design was based on an engineered liner system as per the landfill design basis described in **Section 5.2.1.**

The material quantity estimate and detailed cost estimate provided by Altus is included in **Appendix E**, noting this is a draft copy and presently does not include the full details**.**

These cost estimates were used as part of the decision matrix, and influence the outcome of that process, and the recommendation for a preferred site for future development. These costs are intended for use in future budgeting applications, specifically in planning for the development of a new SWM facility.

6.4 Geotechnical Intrusive Investigation

An intrusive geotechnical investigation was completed by Canadrill Limited Geotechnical Division (CDG) between September 6th to 11, 2019. The purpose of this geotechnical investigation program was to determine the geotechnical suitability of sites B, D and H for landfill development including assessing the surface and subsurface conditions at the sites and provide geotechnical recommendations to support the design and construction of the facility, including associated buildings, roadway/parking areas and general site grading. The findings presented in this section are derived from the Geotechnical Investigation Final Report, prepared and presented to Dillon by CGD. Facts and inferences are that of CGD, as described in their assessment of the area. The report in full can be found in **Appendix F**.

The scope of the geotechnical program consisted of:

- Compilation and Review of Available Information;
- Geotechnical Field Program;
- Laboratory Testing; and
- Geotechnical Reporting.

A geotechnical field program consisting of drilling six boreholes at Site D and excavating six test pits at Site B and H. CDG attempted to access all three site with a drill, however substantial amounts of wet/soft superficial soils impeded the movement of the drill to sites B and H. The investigation was therefore switch to test pits in consultation with Dillon.

At each of the investigated sites, the geotechnical program determined the depth to bedrock, developed a geotechnical profile of overburden material, confirmed the presence and depth of permafrost, and confirmed the depth of the groundwater table. Samples were collected and analyzed for moisture content, gradation, pore water salinity, and electrical resistivity. A thermistor was installed at each proposed site location to monitor subsurface temperatures, specifically permafrost conditions.

Four test pits excavated at Site B showed a subsurface conditions consisting of a thin veneer of organics intermixed and underlain by sand, gravel and cobbles. These were overlying soft to firm clay to refusal. The remaining two test pits were observed to be much softer at surface, consisting primarily of fine-grained sand and clay from surface to refusal. The depth to bedrock is expected to be variable throughout the site. The investigation encountered bedrock once, at 1.5 below grade (mbg). In the remaining five test pits, the bedrock was beyond the depth of excavation (greater than 1.8 to 2.3 mbg).

Site D consisted of a thin veneer of tundra organics mixed with sand, gravel and cobble. There were no areas with visible bedrock or ponds in or around the site. The majority of the overburden appeared to be thawed at the time of investigation. Bedrock was encountered in all boreholes at inferred depths ranging from 1.2 to 2.7 mbg. The upper portion of the bedrock was observed to be severely fractured. The depth to sound bedrock was inferred at depths ranging from 1.8 to 3.4 mbg. The depth to bedrock is expected to be variable throughout the site.On the surface, areas with exposed bedrock or ponds in or around the site were not observed.

Site H consisted of a tundra organics and predominantly coarse-grained sand, gravel and cobbles down to bedrock. Zones of predominantly fine-grained sand and clay to bedrock were observed in testpits TPH05 & TPH06. The overburden was thawed through the full depth explored at the time of the investigation. Practical refusal on bedrock was encountered in all test pits at depths ranging from 0.8 to 1.6 mbg.

Seepage was was not observed during the investigation on any of the three sites. Seasonal changes in groundwater would be expected due to changes in weather trends, precipitation events and significant site disturbances. In addition, the overburden soils are considered to be non-liquefiable.

Based on the geotechnical investigation conducted, Site D is understood to be the most favourable for development and construction of a Solid Waste Management facility. The geotechnical report provides recommendations for geothermal considerations, building foundation design and solid waste cell and leachate pond design and construction as well as Roadway, Gravel Pads and General Site Grading/Drainage. The report also indicates that Site D, based on the anticipated subsurface conditions, can be classified as a "Class C" for seismic site response in accordance with the requirements of Section 4.1.8.4 if the National Building Code of Canada (NBCC), 2015. The final geotechnical report included in **Appendix F** provides geotechnical recommendations.

7.0 Conclusions and Recommendations

7.1 Recommended Future Solid Waste Facility Site Location

Based on desktop review, a total of eight potential sites were identified for discussion and evaluation (**Figure 4**). After meeting with the Mayor and Council and discussions with members of the community and public works department, three of the eight sites were confirmed as suitable for additional investigation. These were sites B, D and H. The remainder of the sites (A, C, E, F and G) were identified as unsuitable for further investigation. Each of the three preferred sites (B, D and H) were included in a weighted decision matrix analysis, which indicated that Site D was most favorable for development of a new solid waste management facility. This preferred site also aligned with the preferences expressed during the consultation meeting with the Mayor and Council.

Based on our review of all of the potential locations, and based on our understanding of the community and its solid waste management needs, Dillon recommends that Site D be chosen for the development of a new solid waste management facility. This area of Igloolik is currently limited to other development options as it is on the northern end of the island. Site D, based on our current understanding of the community, has been shown to meet the setback requirements of the airport and drinking water sources.

7.1.1 Final Location Assessment

Prior to detailed design, it is recommended that an in-person site assessment be completed to decide on the specific location and layout of the facility. Current review has been based on aerial photos, topographic maps, and a drilling program carried out during the winter months. It is recommended that the site be visited in person to 'field fit' the final site footprint to the actual site conditions. It is also recommended that a professional archaeologist with experience in Nunavut be present during this phase to rule out any potential for disturbances of historically significant sites.

In the case that Site D, the preferred site location, can't be considered for development, it is recommended that additional on-site evaluation be completed at Site B ideally during summer months when the site will be most accessible.

7.1.2 Nunavut Airports Consultation and Bird Study

Dillon recommends that an aviation-bird hazard risk assessment is conducted for Site D to adhere to the requirements set out by the GN Transportation department. Upon receiving the report it will need to be submitted to the GN Transportation department for review to allow the project to proceed to the design phase. Once in the design phase the 60% detailed design will need to be submitted to the GN transportation department for review to gain approval to complete the design and construct the facility.

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IGLOOLIK
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FIGURE 5
PREFERRED LOCATIONS FOR FUTURE DEVELOPMENT

- Existing Location
- Preferred Location
- Roadway
- Proposed Road Improvements
- Community Parcel Boundaries
- Airport
- Airport Setback (4 km)
- Inuit Owned Land
- Watercourse
- Water Body
- Drinking Source Setback (1.5 km)

SCALE 1:35,000

0 250 500 1,000 Meters

N W E S

MAP DRAWING INFORMATION:
DATA PROVIDED BY ESRI, DILLON, NRCAN

MAP CREATED BY: 44PH
MAP CHECKED BY: 46JB
MAP PROJECTION: NAD 1983 UTM Zone 17N

DILLON CONSULTING

PROJECT: 199424
STATUS: DRAFT
DATE: 2020-03-16

FILE LOCATION: G:\GIS\2019\199424 Solid Waste MFS, Hall Beach & Igloolik\MXD\Igloolik\Figure 5 - Preferred Locations for Future Development.mxd

7.2 Recommended Next Steps

7.2.1 Comprehensive Waste Generation Study

In order to gain a comprehensive understanding of the solid waste generation rates in Igloolik, a comprehensive multi-week waste generation study is recommended. This study should be completed at the active site, and would monitor all inbound material, including residential, ICI, C&D and Bulky waste disposal over several weeks. This study would allow for a more detailed understanding of the generation and composition of waste from each generating sector, and would provide a representative view of waste generation across seasons, as well as during sea-lift events. The data collected could be used to support the detailed design of a new solid waste facility, including and planning for waste diversion and recycling programs.

7.2.2 Northern Infrastructure Standardization Initiative

The Nunavut Climate Change Centre has been focusing on the impacts of climate change to infrastructure in the Canadian arctic. As part of their focus they are working with the Standards Council of Canada (CSA) to address the issues associated with climate change. CSA has established the Northern Infrastructure Standardization Initiative (NISI) to create standards that are specific to Northern infrastructure. A Standard for Solid waste management is currently being developed to be released in 2020. It is recommended that the standard is followed once the document is available.

7.3 Diversion Options

7.3.1 Segregation of Household Hazardous Waste

To mitigate the highest risks to the environment, proper segregation of HHW should be in place at the disposal site. Industrial waste from commercial waste generators should not be accepted at municipal landfills because they often contain materials and contaminants which are not within the technical specifications of municipal landfills. Household hazardous waste, including fuel tanks, should be stored in a location with a liner system in place, and should be protected from snow and rainfall to minimize leaching into soil and groundwater.

7.3.2 Re-Use of Household Goods and Building Materials

Due to the logistical challenges associated with waste management in Igloolik, it is also recommended that re-use of household goods and building materials be encouraged, and that these activities be supported through the design of a safe waste transfer area. Community members can drop off or pick up goods for reuse, while remaining outside of the active landfill area.

7.3.3 Backhauling of Divertible Waste Materials

It is recommended that Municipality consider the feasibility of back hauling hazardous waste, as well as items managed under extended producer responsibility programs, on an as needed basis, ideally at a minimum of every 5 years. HHW would be a high priority for back hauling to avoid future leakage, improper handling of materials, and reactive cross contamination with other waste materials. Other items recommended for backhaul include E-waste, white goods, and tires. This can be conducted similar to what is outlined in the Northern Waste Diversion Program Details (**Appendix G**).

8.0 Closing

This report was prepared exclusively for the purposes, project and site locations outlined in the report. The report is based on information provided to, or obtained by Dillon Consulting Limited ("Dillon") as indicated in the report, and applies solely to site conditions existing at the time of the site investigation(s). Although a reasonable investigation was conducted by Dillon, Dillon's investigation was by no means exhaustive. Rather, Dillon's report represents a reasonable review of available information within an agreed work scope, schedule and budget. Further review and updating of the report may be required as conditions and the regulatory and planning frameworks, change over time.

This report was prepared by Dillon for the sole benefit of our Client. The material in it reflects Dillon's best judgment in light of the information available to it at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibilities of such third parties. Dillon accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

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