KIMMIRUT WASTEWATER TREATMENT FEASIBILITY STUDY

Final Report

Prepared for:

Government of Nunavut
Community and Government Services
Iqaluit, Nunavut

Prepared by:

Nunami Stantec

4370 Dominion Street
Burnaby, BC V5G 4L7
Tel: 604 436 3014

10160 112 Street
Edmonton, AB T5K 2L6
Tel: 780 917 7000

March 27, 2015

NUNAMI STANTEC

NUNAMI STANTEC

SIGN-OFF SHEET

This document entitled Kimmirut Wastewater Treatment Feasibility Study Final Report was prepared by Nunami Stantec Consulting Ltd. ("Nunami") for the account of Government of Nunavut (the "Client"). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Nunami's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Nunami and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Prepared by ______________________________

Ken Johnson, RPP, P.Eng

KENNETH JOHNSON
CANADIAN INSTITUTE OF PLANNERS
INSTITUT CANADIEN DES URBANISTES
MCIP MICU
MAR 2 7 2015

Reviewed by ______________________________

Arlen Foster, P.Eng

REGISTERED PROFESSIONAL ENGINEER
K.R. JOHNSON
NWT/NU
MAR 2 7 2015

TABLE OF CONTENTS

1 Introduction ... 1.1
1.1 Background ... 1.1
1.2 Objectives and Scope of Work ... 1.2

2 Existing Systems ... 2.1
2.1 Preliminary Treatment System ... 2.1
2.2 Alternative Un Commissioned System ... 2.1
2.3 Potential Improvements to Un Commissioned System ... 2.2

3 Physical Environment ... 3.1
3.1 Terrain and Watersheds ... 3.1
3.2 Access and Granular Material ... 3.2

4 Land Use Constraints ... 4.1
4.1 Community Land Use Plan ... 4.1
4.2 Airport Zoning Regulations ... 4.1

5 Hamlet Council Meeting Notes ... 5.1

6 Effluent Quality Standards ... 6.1

7 Waste Water Quality and Quantity ... 7.1

8 Wastewater Treatment Processes ... 8.1
8.1 Preliminary Treatment ... 8.1
8.2 Primary Treatment ... 8.1
8.3 Secondary Treatment ... 8.2
8.4 Tertiary Treatment ... 8.2

9 Area Analysis ... 9.1

10 Site Selection and Analysis ... 10.1

11 Site Accessibility ... 11.1

12 Decision Analysis and Strategic Requirements ... 12.1
12.1 Decision Analysis Framework ... 12.1
12.2 Strategic Requirements or “Must” Evaluation ... 12.1

13 Opinion of Probable Costs for Options ... 13.1
13.1 Lagoon System ... 13.1
13.2 Mechanical System (MBR) ... 13.2

14 Decision Analysis and Operational Objectives ... 14.1
14.1 Operational Objectives or “Want” Analysis ... 14.1

14.2 Outcome of Decision Analysis ... 14.2

15 Conclusions and Recommendations ... 15.1

15.1 Existing Systems ... 15.1

15.2 Site Selection and Analyses ... 15.1

15.3 Conclusions and Recommendations ... 15.2

List of Tables

Table 2.1: Capital Cost of Potential Improvements to Un Commissioned System ... 2.2

Table 10.1: Process Summary ... 10.4

Table 10.2: Lagoon Design Characteristics ... 10.5

Table 11.1: Road Accessibility to Selected Sites ... 11.1

Table 12.1: Evaluation of Strategic Requirements (Musts) ... 12.3

Table 13.1: Opinion of Probable Costs for Site 9A ... 13.2

Table 13.2: Opinion of Probable Costs for Site 10A (MBR) ... 13.3

Table 14.1: Evaluation of Operational Objectives (Wants) ... 14.3

List of Figures

Figure 1 ... Wastewater Treatment Processes – Site #7

Figure 2 ... Kimmirut Watersheds

Figure 3 ... Kimmirut Land Use Constraints

Figure 4 ... Kimmirut Land Use Plan

Figure 5 ... Kimmirut Council Meeting Notes

Figure 6 ... Coarse Terrain Analysis

Figure 7 ... Excluded Areas

Figure 8 ... Potential Areas

Figure 9 ... Selected Areas

Figure 10 ... Sites for Consideration

Figure 11 ... Wastewater Treatment Processes – Site #1

Figure 12 ... Wastewater Treatment Processes – Site #2

Figure 13 ... Wastewater Treatment Processes – Site #3

Figure 14 ... Wastewater Treatment Processes – Site #4

Figure 15 ... Wastewater Treatment Processes – Sites #5/6

Figure 16 .... Wastewater Treatment Processes – Site #8
Figure 17 .... Wastewater Treatment Processes – Site #9
Figure 18 .... Wastewater Treatment Processes – Site #10
Figure 19 .... Wastewater Treatment Processes – Site #11
Figure 20 .... Wastewater Treatment Processes – Site #12
Figure 21 .... Site 9A (Impermeable Berm)
Figure 22 ....Site 10 (MBR)

List of Appendices

Appendix A .... Initial Area Analyses and Selection
Appendix B ....Council Meeting Notes
Appendix C ....Fisheries Notes
Appendix D .... Wetland Notes
Appendix E ....Snowdrift Notes
Appendix F ....Mechanical Treatment Costs, Figures, and Notes
Appendix G .... Lagoon Costs, Figures, and Notes
Appendix H ....Effluent Quality Guidelines for Nunavut, 2000

1 INTRODUCTION

1.1 Background

Community and History

Kimmirut is located on the southern end of Baffin Island on the Meta Incognita Peninsula at 62° 5l' N latitude and 69°53'W longitude. It is located at the upper end of a drowned valley approximately 23 km from the open sea. The hamlet occupies a triangular section of land extending from sea level to the airport, which lies at an elevation of approximately 50 metres.

The current population of Kimmirut is estimated to be 473, of which 86 percent are Inuit.

Inuit have lived in the region for centuries, and first outside contact occurred in the mid-19th Century when whalers worked in the region. An Anglican Mission was established in 1900, a Hudson's Bay post opened in 1911, and the R.C.M.P. set up a detachment in 1924.

Terrain

The terrain in and around Kimmirut is generally “hilly” and steep. The terrain in the community slopes back from the ocean to the airport (elevation 50 metres) at an average grade of 10 percent; the highpoint of land near the community is at an elevation 143 metres. Travel on the land is limiting in all directions because of the steep slopes, in addition to water bodies.

Geography

The geography around Kimmirut is limiting because of water bodies in addition to the limiting terrain. To the west and northwest, the Soper River and Soper Lake are limiting to community related development. Katannilik Territorial Park is also situated to the northwest and limits community related develop.

To the southwest, Fundo Lake and its catchment area limits community related development because it is the community water supply located at Fundo Lake. To the east and southeast, Lake Harbour limits community related activity.

A narrow area of geography to the northeast provides access to Katannilik Territorial Park and Koojesse Inlet and Iqaluit beyond the park, however the access into this area is limited to snowmobiles, quads and hiking through rough terrain.

Geology

Kimmirut is situated on an uneven deposit of granular glacial soil, hemmed in by high hills of precambrian rock, with some deposits of limestone. Below the hamlet there is a stoney beach at high tide level. Bedrock is exposed extensively throughout the region and consists primarily of quartzite, schist and limestone. The area lies almost on a line separating the widespread discontinuous and continuous permafrost zones. Permafrost is present under most land areas to a depth of 60 m.

Vegetation and Climate

Vegetation is very limited in the terrain surrounding Kimmirut with the exception in of mosses, lichens, or grasses, areas of willows, and limited wetlands. Kimmirut experiences unusually high temperatures for the Arctic and its sheltered location provides relatively mild winters in comparison to the rest of the region. The mean high and low temperatures for July are 12°C and 4.0°C respectively. January's mean high and low are -20°C and -27°C. Kimmirut receives 202 mm of rain and 2100 mm of snow on average annually.

1.2 Objectives and Scope of Work

The general objective of the current assignment is to prepare a feasibility study aimed to analyze and recommend options to enable the wastewater treatment system for the Community to achieve compliance with the community’s water licence effluent discharge criteria and allow the community to create a permanent wastewater infrastructure necessary for sustainable growth. We have prepared this report with the intent of furthering four objectives as follows:

1. Reusing the “west” lagoon / wetland treatment system with appropriate upgrades;
2. Developing a new lagoon / wetland treatment system at an alternate location;
3. Developing a new mechanical wastewater treatment system; and
4. A hybrid or variation of the above options.

In support of the primary objectives, the following tasks have been carried out:

- Review available background information (including reports, maps, and other documentation) pertaining to Kimmirut’s wastewater management practices
- Assessment wastewater treatment opportunities and constraints based upon background information
- Consultation with Community Council on sewage treatment related issues
- Completion of field inspections of accessible areas, and identification of potential wastewater treatment sites, and processes based upon review and consultation
- Identification and development of conceptual wastewater treatment options for identified sites
- Assessment of wastewater treatment systems for identified sites through a decision analysis based upon “strategic” (musts) and “operational” (wants) criteria
- Recommendation of wastewater treatment option based upon of highest ranking option from decision analysis

2 EXISTING SYSTEMS

2.1 Preliminary Treatment System

The wastewater disposal system currently used by Kimmirut has been serving the community for more than 30 years, and consists of a trench at the landfill where the trucked sewage is deposited. The sewage immediately flows onto a steep embankment with an average 4 to 1 slope, dropping a total of 40 metres (170 metres horizontally) from an elevation of 65 metres to an elevation of 25 metres. The sharp drop is followed by a gradual drop of 20 metres (200 to 300 metres horizontally) at a slope of 5 to 10 percent to the ocean at Lake Harbour. The gradual drop appears to have two flow directions, either northeast or south west.

The lower portion of the discharge contains a significant grass and willow areas (35 by 130 metres to the southwest, and 20 by 180 metres to the northeast.) It is clearly evident that these areas provide some degree of treatment, but this may be limited to preliminary treatment.

The operation of the existing system is a dousing and resting process, which will maximize the potential treatment from the overland flow system through the vegetated area during the summer months. There is no available information on the effluent quality before discharge into Lake Harbour, however, upon inspection, this is no evidence of floatable material at the ocean, but evidence of the presence of nutrients with localized algae on the rocks at low tide.

The anticipated overall performance of the existing system would be preliminary treatment because of the seasonal influences. The anticipated summer performance of the system with overland flow would be primary treatment.

2.2 Alternative Un Commissioned System

An alternative wastewater system has been constructed, but it has never been commissioned. This system of two ponds, with low permeability berms, makes use of the existing terrain (See **Figure 1**). In operation, the eduction trucks would discharge into an upper pond, through which flow is controlled by the first low permeability berm. The upper pond would fill over the course of the fall and into the winter, and once this upper pond was full, the discharge point for the eduction trucks would change to allow the flow to be directed to the lower pond, through which flow is controlled by a second low permeability berm. Over the remaining course of the winter and through the spring, the lower pond would fill.

The discharge of the ponds would begin in the summer after the sewage accumulation has melted, and the seasonal biological activity in the downstream wetland has established. The discharge from both of the ponds would be controlled by an individual pumping system set up on the top of each of the low permeability berms. The flow from the lower pond would enter the biologically active wetland. The wetland ultimately discharges into a freshwater lake. A report by Kadlec and Johnson (Kimmirut Wetland Planning Study) in January 2008, estimated effluent from the two pond / wetland system would produce an effluent Total Suspended Solids (TSS) and 5 day Biological Oxygen Demand (BOD5) of less than 40 mg/l.

The pond / wetland system was developed to respond to the Nunavut Water Board's (NWB's) standards, however the pond / wetland has not operated nor has it been licensed through the NWB. Following the construction of the pond system, concerns were raised by regulatory agencies and local community members. A fish study was conducted to assess the downstream freshwater system which would ultimately accept the discharge from the system. Through community consultations and site visits, it was determined that the area was fish bearing and that diversion or revisions to the wastewater treatment system may be necessary.

2.3 Potential Improvements to Un Commissioned System

The limiting terrain around Kimmirut in general, and around the un commissioned system specifically limits any improvements that may be undertake to improve the effluent quality anticipated from the process. There are no areas available for additional ponds, and the wetland is not accessible for completing improvements such as berms to reduce channeling of the flow through the wetland.

An alternative to improving the process performance and hence the effluent quality would be changing the discharge area of the system from the Pleasant Inlet catchment area to the Soper River catchment area. This would change the receiving water from freshwater to an estuary (brackish water). The opinion of probable cost of this improvement would be $500,000, and would include improvements to the existing pumped discharge system for the lower pond by increasing the pumping capacity (head) and increasing the discharge piping to convey the effluent into the Soper River Catchment area.

Table 2.1: Capital Cost of Potential Improvements to Un Commissioned System

Description	Total
Portable pumping system	$150,000
Surface pipeline	$100,000
Access for pumping system and pipeline	$100,000
Contingency 40%	$140,000
Total	**$500,000**

3 PHYSICAL ENVIRONMENT

3.1 Terrain and Watersheds

The terrain around Kimmirut is generally “hilly” and steep, as previously discussed; the highpoint of land near the community is at an elevation 143 metres. Travel on the land is limiting in all directions because of the steep slopes.

The water bodies around Kimmirut have unique characteristics that are marine, fresh water and brackish water (estuary). The brackish water occurs in Soper Lake as a result of the “reversing falls” which push salt water into the lake when the tide is high.

The immediate area around Kimmirut contains 6 distinct watersheds (See **Figure 2**). These watershed catchments draining to Soper Lake, Soper River (downstream of Soper Lake), Lake Harbour, Glasgow Inlet, Pleasant Inlet, and North Bay. The water supply is taken from Fundo Lake, which lies in the Pleasant Inlet watershed.

Soper Lake water shed encompasses the area north of the community and includes many lakes in addtion to Soper Lake which is an estuary because of the salt water intrusion that occurs with the reversing falls at the south end of the lake. Soper Lake drains into the Soper River. The Soper River watershed encompasses the area west of the community, and includes several minor lakes on the east edge.

The Lake Harbour watershed is a minor watershed that encompasses the area to the east and south of the community on both sides of Lake Harbour. The watershed extends less than 500 metres on the west side of Lake Harbour but extends a significant distant south from the community. The watershed extends approximately 1500 metres on the east side of Lake Harbour.

The Glasgow Inlet watershed is the watershed east of the community and southeast of both the Lake Harbour and Soper Lake watersheds.

The Pleasant Inlet watershed that encompasses an area south of the community including the community’s water supply lake, which is called Fundo Lake. Fundo Lake and the adjacent contributing connected lakes extend approximately 5 kilometres in a southeasterly direction from the community.

The North Bay watershed encompassess an area south from the Pleasant Inlet watershed and Fundo Lake.

Sewage from Kimmirut currently discharges in the Lake Harbour watershed area (marine environment), and the new sewage area would discharge into the Pleasant Inlet catchment area (freshwater) downstream of Fundo Lake, which is the community’s water supply.

3.2 Access and Granular Material

The road system around Kimmirut provides access into the Soper Lake, Soper River (downstream of Soper Lake), Lake Harbour, and Pleasant Inlet watersheds. The major trail system provides access north into the Soper Lake watershed and Katannilik Territorial Park.

The limited ability to travel on the land necessitates the use of water transporation. The majority of the boats are moored in Lake Harbour. Seasonal mooring of boats occurs on the Soper River because the break up of the river occurs well in advance of Lake Harbour.

Available sources of good granular material available in the Hamlet of Kimmirut are limited. Eight existing pits / quarries that had been utilized for aggregate sources at that time were inventoried. The quality and quantity of the aggregate has not been well documented, but the general descriptions available indicate that some of the existing sources were have been depleted and/or of questionable quality.

Other information on the application of the granular materials suggests that the material from the available sources have proven difficult to compact and/or have oversized materials. This information suggests that the materials may require processing such as screening prior to use.

4 LAND USE CONSTRAINTS

Definitive land use constraints for a wastewater facility in Kimmirut are associated with the the Fundo Lake Water shed, which provides drinking water to Kimmirut, and an environmental setback of 450 metres from the community for wastewater treatment facilities (See **Figure 3**). Other land use related constraints may be associated with community use along the shore of Soper Lake and along the shore of Soper River as well as the Airport Zoning Plan.

4.1 Community Land Use Plan

Kimmirut's Land Use Plan (See **Figure 4**) identifies several setback envelopes associated with the existing solid waste area and sewage diposal area immediately south of the community, as well as the "future sewage lagoon" to the east of the community.

Any additional areas considered for sewage treatment should consider the new and somewhat isolated development area northwest of the community, and the the planned public area to the northeast of the community.

Another signicant land use area is a possible location of a future fountain, or public art or inukshuk, to the north east, as presented on the land use plan. This locatoin is also the start of the access corridor into Katannilik Territorial Park, and the start of the access corridor for the 120 kilometre traditional trail to Iqaluit.

4.2 Airport Zoning Regulations

The Kimmirut airport has a zoning regulation that generally applies to the area "defined by a circle with a radius of 4000 metres centred on the airport reference point." The zoning regulation presents "prohibitions" associated with structures, as well as activities. The activities are associated with wildlife hazards which include "use any of the lands for activities or uses that attract wildlife, particularly birds, that may create a hazard for aviation safety."

With the potential limitations with the proximity of a wastewater treatment system to the community and the 4 kilometre setback, any wastewater treatment facility related activities must consider the bird hazard potential. This may require an explicit bird study, that would entail observations during during different seasons of the year to ascertain the variety of birds, their numbers, and their movements. This study in consideration of the aircraft types flying into Kimmirut would provide a risk assessment for bird strikes.

5 HAMLET COUNCIL MEETING NOTES

Currently, sewage disposal within the community is carried out by discharging the sewage to a ditch which drains directly to the ocean. Council advised, that due to regulatory pressures, Kimmirut needs to improve the effluent quality released into receiving waters. Options were reviewed that include the existing constructed pond/wetland system, construction of a new lagoon system and installation of a mechanical treatment plant. Council noted that they were advised that the use of the existing unused lagoon system would not be permitted due to fish habitat protection regulations.

The most effective configuration for passive lagoon treatment was discussed, which include two ponds connected in series with a constructed wetland. A design similar to this would take advantage of several different naturally occurring contaminant removal processes. The initial pond is designed to target solids removal through sedimentation. Once the water is clarified, additional contaminants are removed in the shallow ponded areas through reactions initiated by sunlight. Finally, in the wetland, remaining solids, and nutrients would be removed through biofiltration. Sites located using existing lake or ponds which could be converted into lagoons would reduce capital project costs.

Potential sewage treatment areas were discussed with Council to identify any concerns related to potential impacts on community interests such as fishing, hunting and trapping. Council agreed with most of the areas and suggested additional areas to consider (See **Figure 5).** Sites were selected outside of the park boundary to avoid development restrictions in the area. Additionally, Council identified lakes that have the potential to be used as a source for water supply and therefore should not be considered.

As a result of discussions with Council, several sites were eliminated from consideration. Since there is a concern with subsurface flow near the lakes just west of the hamlet, several sites were avoided to limit potential migration to Fundo Lake. Council advised that the area to the northeast and east may be too rough for access and so these areas may not be practical. Soper Lake and Lake Harbour were may be appropriate receiving waters for the treated effluent. Soper Lake is salty and therefore cannot be used as a secondary water source. However, char and rock cod fishing are popular activities in Soper Lake and so it is important to ensure that lake-use does not impact the water quality. Lake Harbour does not support fishing and therefore any concerns with use of this area would be mainly influenced by regulatory requirements.

A mechanical wastewater system would provide higher treated effluent quality compared to a lagoon system, however, this system has experienced relatively low success rates in Northern regions due to high capital and operational costs and increased operational and maintenance complexity.

6 EFFLUENT QUALITY STANDARDS

The effluent quality standards that have been historically used by the communities of Nunavut and the Northwest Territories have been based upon the “Guidelines for the Discharge of Treated Municipal Wastewater in the Northwest Territories” (GDTMWNT), which were issued in 1992. These guidelines were adopted by Nunavut in 2000. The effluent quality guidelines from this document have been implemented through the community water licencing process in Nunavut.

The guidelines provide for a variety of discharge scenarios depending upon the receiving environment and the wastewater flow. The receiving environments include streams, rivers, or estuaries, lakes and marine. The wastewater flows vary from less than 150 litres per capita per day to over 500 litres per capita per day.

The effluent quality criteria are generally expressed by limits on Biological Oxygen Demand (BOD_5), Total Suspended Solid (TSS) and Fecal Coliforms. The effluent quality criteria range from 30 mg/L for BOD_5 and 35 mg/L for TSS for a discharge into a steam, river or estuary with a low dilution rate to 360 mg/L for BOD_5 and 300 mg/L for TSS for a discharge into the ocean on an open coastline.

The Canadian Council of Ministers of the Environment (CCME) initiated a process to harmonize effluent quality standards across Canada and this process has produced the Wastewater Systems Effluent Regulations (WSER). However, the Government of Nunavut has deferred adoption of the regulation in favour of conducting Nunavut based research through Dalhousie University on the performance of lagoon systems in the north and the receiving water conditions.

The effluent quality standards appropriate to Kimmirut are the standards in the community water licence. Although the licence expired in January 2011, these effluent quality limits are still valid for the purposes of a feasibility study. These effluent quality standards are BOD_5 120 mg/L and Total Suspended Solids of 180 mg/L, and Fecal Coliforms of 1 x 10 exp6 (1 million), non-visible oil and grease, and pH between 6 and 9.

The effluent quality standards in the Kimmirut water licence reflect the effluent quality guidelines for either a river/estuary discharge with a dilution of a 10,000 to 1, or a marine discharge with a mixing condition of an open coastline or a bay/fjord (See **Appendix H** for Wastewater Effluent Quality Guidelines for Nunavut Territory 2000). Based upon the estimated per capita wastewater generation presented in **Section 7** of approximately 100 litres/person/day, the applicable effluent quality guidelines could be as high as 360 mg/L for BOD_5 and 300 mg/L for TSS for a summer discharge into a river/estuary, or as low as 100 mg/L for BOD_5 and 120 mg/L for TSS for a summer discharge into a bay or fjord (See tables in **Appendix H**).

7 WASTE WATER QUALITY AND QUANTITY

An estimate of the wastewater generation for Kimmirut for a 20 year horizon is presented in the following table.

Water Generation (l/c/day) = 90 x (1 + 0.00023 x population)
Solids Waste Generation (m3/c/d) = 0.01 x (1 + 0.00023 x population)

Year	Population	Water Generation		
		L/capita/day	Daily (L)	Annual (m3)
2014	473	99.8	47200	17200
2015	479	99.9	47900	17500
2016	485	100.0	48500	17700
2017	491	100.2	49200	18000
2018	497	100.3	49800	18200
2019	504	100.4	50600	18500
2020	511	100.6	51400	18800
2021	517	100.7	52100	19000
2022	524	100.8	52800	19300
2023	530	101.0	53500	19500
2024	536	101.1	54200	19800
2025	542	101.2	54900	20000
2026	548	101.3	55500	20300
2027	554	101.5	56200	20500
2028	559	101.6	56800	20700
2029	565	101.7	57500	21000
2030	570	101.8	58000	21200
2031	575	101.9	58600	21400
2032	580	102.0	59200	21600
2033	585	102.1	59700	21800
2034	591	102.2	60400	22000

*Population based on Government of Nunavut Bureau of Statistics population data (http://www.stats.gov.nu.ca/en/Population.aspx)

Based upon this estimates, the wastewater treatment system must have a capacity to treat 22,000 cubic metres per year. This number defines the storage capacity for an impermeable lagoon system, and may be used to define the average daily capacity of a continuous discharge system.

The anticipated strength of the wastewater in Kimmirut is 460 mg/L for BOD_5 and 490 mg/L for TSS. For the purposes of the discussion in this planning study, the wastewater strength in Kimmirut will be rounded up to 500 mg/L for BOD_5 and 500 mg/L for TSS.

8 WASTEWATER TREATMENT PROCESSES

A full range of wastewater treatment processes have been considered for the Kimmirut planning study. These processes include preliminary treatment, primary treatment, secondary treatment and tertiary treatment.

8.1 Preliminary Treatment

The objective of preliminary treatment is the removal of coarse solids and other large materials found in raw wastewater. Removal of these materials is necessary to enhance the operation and maintenance of subsequent treatment units or to meet the effluent compliance limits if the process requirement is limited to preliminary treatment. Preliminary treatment operations typically include coarse screening, grit removal and, in some cases, comminution (grinding) of large objects. Generally effluent quality standards do not limit the process performance to preliminary treatment.

In the far north, preliminary treatment has been associated with mechanical systems that are the first stage of an advanced treatment system. However, the communities of Dawson City and Rankin Inlet apply preliminary treatment as a stand along process, applying a rotating drum screen.

An equivalent passive system is the use of permeable (leaky) berms which will retain coarse material. Permeable of wastewater is a relatively short duration and would provide preliminary or primary treatment; the permeable berm structure is generally constructed from cobbles underlain with a geomembrane. The cobbles provide a flow constriction which reduces the flow velocity and reduces the channelization of the flow. The geomembrane base provides erosion protection from the flow.

8.2 Primary Treatment

The objective of primary treatment is the removal of settleable organic and inorganic solids by sedimentation (permeables ponds). Approximately 25 to 50% of the incoming BOD_5, 50 to 70% of the TSS, and 65% of the oil and grease may be removed during primary treatment. Some organic nitrogen, organic phosphorus, and heavy metals associated with solids are also removed during primary sedimentation but colloidal and dissolved constituents are not affected.

In the far north primary treatment is achieved with a sedimentation (permeable) pond as part of a multi cell treatment system (primary cell and secondary cell). However, many communities employ only a single cell for primary treatment and potentially some secondary treatment. It has been recognized that multi cell systems may achieve a higher effluent quality.

An alternative primary treatment configuration is used in Cambridge Bay, with the berm separating the primary cell and the secondary cell constructed of cobbles to provide a the flow restriction characteristic of a primary cell, with the free flow opportunity of a cobble structure. This configuration is used for sediment removal in storm water ponds.

A very unique primary treatment system in the City of Iqaluit utilizes a “Salsnes” filter, which is a belt filtration system that removes solids.

8.3 Secondary Treatment

The objective of secondary treatment is the further treatment of the effluent from primary treatment to remove the residual organics and suspended solids. In most cases, secondary treatment follows primary treatment and involves the removal of biodegradable dissolved and colloidal organic matter using aerobic biological treatment processes (including lagoons). Aerobic biological treatment is performed in the presence of oxygen by aerobic microorganisms (principally bacteria) that metabolize the organic matter in the wastewater, thereby producing more microorganisms and inorganic end-products

In the far north, lagoon systems are almost exclusively used for secondary treatment, with a single cell system the most common configuration. The lagoon systems provide retention of the sewage and a seasonal discharge at the end of the summer. A handful of communities utilize mechanical secondary treatment systems. Those communities are Pangnirtung, Fort Simpson, Carmacks and Dawson City; mechanical secondary treatment systems are planned for Resolute, Iqaluit, and Rankin Inlet.

The retention lagoon (impermeable berm) employs a berm structure that is generally constructed from granular material with a low permeability core material to provide a low permeability structure. The low permeability core may be constructed from silt and clay, or may be constructed using a low permeability geomembrane. A pond with an impermeable berm for wastewater provides up to one year of storage and may provide secondary treatment. The availability of wetlands or overland flow for the discharge from any lagoon systems will enhance the effluent quality.

8.4 Tertiary Treatment

Tertiary and/or advanced wastewater treatment is applied when specific wastewater constituents which cannot be removed by secondary treatment must be removed. Individual unit processes are necessary to remove nitrogen, phosphorus, additional suspended solids, and other constituents.

Advanced treatment in the far north consists of the application of wetland systems through which the discharge from a lagoon system is directed. Engineered and non-engineered wetland systems, such as the one in Kimmirut, have been applied in an increasing number of sewage treatment systems in the far north. The discharge through a wetland is seasonal, usually at the end of the summer or early in the fall.

The general effluent quality standards applied to the various process descriptions for a northern context are as follows:

- Preliminary treatment anticipated effluent quality of 500 mg/L BOD and 400 mg/L SS
- Primary treatment anticipated effluent quality of 350 mg/L BOD and 200 mg/L SS
- Secondary treatment anticipated effluent quality of 20 mg/L BOD and 20 mg/L SS
- Tertiary treatment anticipated effluent quality of 5 mg/L BOD and 5 mg/L SS

These are the “industry” standards for the process descriptions.

9 AREA ANALYSIS

An area analysis was completed as an initial step in determining sites that may be suitable for wastewater treatment around Kimmirut

A coarse terrain analysis (See **Figure 6**) identified areas with potential slopes generally less than 10 percent, which is an anticipated maximum slope for the construction of any sewage permeable structure. A maximum slope of 3 percent is the desirable slope for a proper functioning wetland.

An initial compilation of areas excluded from the consideration of a sewage lagoon site (See **Figure 7**) are the Lake Fundo catchment area, which is the water supply source; the 450 metre environmental setback from the community, and the area beyond a 3 kilometre radius from the community. A three (3) kilometre radius was selected based upon a maximum reasonable cost of construction of $1.5 million dollars for an engineered road from the community to a facility ($500,000 per kilometre).

A total of eighteen (18) potential areas (See **Figure 8**) for the development of a wastewater facility are identified based upon areas with an anticipated slope of less than 10 percent and areas outside the excluded areas. The areas identified are generally between 50 and 100 hectares in size; the anticipated size of a lagoon impermeable facility would be less than 3 hectares (30,000 square metres).

A total of 6 areas were selected for potentially advancing to a more detailed analysis (See **Figure 9**) to identify potential 3 hectare lagoon sites within these areas. Information concerning these areas was sent to the Hamlet administration in advance of the community visit as a tool to initiating the community consultation. It was anticipated that the direct discussion with the Hamlet Council would change some of the 6 areas that were identified to the Hamlet.

10 SITE SELECTION AND ANALYSIS

Based upon the area analysis, which identified six potential areas (See **Figure 9**), and the council discussion (See **Figure 5**), twelve sites were identified for consideration as wastewater treatment facility locations (See **Figure 10**).

Descriptions of the sites, the potential processes, and potential applied to the sites are as follows:

- **Site 1** is located 1.9 kilometres west from the airport terminal, and would be accessible with an existing road, and a length of new road. The general process technology would be primary treatment based upon a continuous discharge from the existing lake, however the effluent quality could be enhanced with dilution of the influent in the lake. The system would discharge into Soper River through a pond adjacent to the river. Active Arctic charr, cod, and mussel fisheries occur. As well, community members use the area adjacent to, and to west of the lake as a camp location. Site 1 is outside the environmental setback area for the community.
- **Site 2** is located 2.0 kilometres northwest from the airport terminal, and would be accessible with an existing road, and a length of new road. The general process technology would be primary treatment based upon a continuous discharge from the existing lake, however the effluent quality could be enhanced with a limited downstream wetland. The system would discharge into Soper Lake. Both cod and Arctic char fisheries occur at Soper Lake. As well, community members use the area adjacent to, and the west of, of the site as camp locations. Site 2 is outside the environmental setback area for the community.
- **Site 3** is located 1.9 kilometres northwest from the airport terminal, and would be accessible with an existing road, and a length of new road. The general process technical would be secondary treatment based upon retention (impermeable berm) of the wastewater in a lagoon (created from an existing pond) for up to a year. The effluent quality could be enhanced to some degree with the limited downstream wetland. The system would discharge into Soper Lake. Both cod and Arctic charr fisheries occur at Soper Lake. As well, community members use the area adjacent to, and the west of, of the site as camp locations. Site 3 is outside the environmental setback area for the community.
- **Site 4** is located 1.6 kilometres northwest from the airport terminal, and would be accessible with an existing road, and a length of new road. The proposed treatment system consists of a series of permeable berms constructed within an abandoned borrow excavation. The contaminant removal achieved through this system is limited to preliminary treatment based upon a continuous discharge through the permeable berms to Soper Lake. Both cod and Arctic charr fisheries occur at Soper Lake. As well, community members use the area adjacent to, and the west of, of the site as camp locations. Site 4 is outside the environmental setback area for the community.

- **Site 5** is located1.1 kilometres northwest from the airport terminal, and would be accessible with an existing road, and a length of new road. The general process technology would be primary treatment based upon a continuous discharge from an existing lake, however the effluent quality could be enhanced with dilution of the influent in the lake. The effluent would be discharged to Soper Lake. Both cod and Arctic charr fisheries occur at Soper Lake. As well, community members use the area adjacent to, and the west of, of the site as camp locations. Site 5 is within the environmental setback area for the community, and within close proximity to the future development area (See **Figure 4**).
- **Site 6** is located 1.0 kilometres west from the airport terminal, and would be accessible with an existing road, and a length of new road. The treatment process applied improves upon the primary treatment outlined for Site 5, which is an existing lake, through the addition of a second upstream existing lake. The two lakes in series provide an increased permeable time resulting in enhanced effluent quality. The system would discharge into Soper Lake. Both cod and Arctic charr fisheries occur at Soper Lake. As well, community members use the area adjacent to, and the west of, of the site as camp locations. Site 6 is within the environmental setback area for the community and within close proximity to the future development area (See **Figure 4**).
- **Site 7** is located 1.4 kilometres west from the airport terminal, and would be accessible with an existing road. The treatment processes applied includes two retention ponds (impermeable berms) constructed within the existing terrain, and wetland treatment, with an anticipated effluent quality close to, but above secondary treatment. Concerns were expressed by the regulators, the Government of Nunavut and the community about the location of the discharge from this location. The discharge area is now known Arctic char habitat.
- **Site 8** is located 2.5 kilometres south-south east from the airport terminal, and would be accessible with an existing road, and a length of new road through very steep and rugged terrain. The general process technology would be primary treatment based upon a continuous discharge from an existing lake, however the effluent quality could be enhanced with dilution of the influent in the lake. The system would discharge into Lake Harbour. There is no substantial fishery in Lake Harbour.
- **Site 9** is located 1.3 kilometres south from the airport terminal, and would be accessible with an existing road, and a length of new road. Two processes have been presented for this site. The first process would be secondary treatment based upon retention (impermeable berm) of the wastewater in a lagoon (created from an existing pond) for up to a year (Site 9 Impermeable). The effluent quality could be enhanced to some degree with the limited downstream overland flow. There is no substantial fishery in Lake Harbour.

  The second process would be enhanced preliminary treatment based upon a continuous discharge from an existing pond at the site by the construction of a permeable berm (Site 9 Permeable). The discharge would be further enhanced by the limited overland flow downstream. The system would discharge into Lake Harbour.

The second process would be

- **Site 10** is located 1.0 kilometres south-south east from the airport terminal, and would be accessible with an existing road. Two processes have been presented for this site. The first process (Site 10 MBR) would be a modular membrane bioreactor which would provide secondary treatment based upon the standard MBR process technology with a continuous discharge from facility. The effluent quality could be enhanced by the limited overland flow downstream. The system would discharge into Lake Harbour.

  The second process (Site 10 Septage) is a modular preliminary treatment system based upon septage receiving station. The effluent quality could be enhanced to some degree with the limited downstream overland flow.

- **Site 11** is located 600 metres north east from the airport terminal, and would be accessible with an existing road, which would require considerable upgrading. The general process technology would be primary treatment based upon a continuous discharge from an existing lake, however the effluent quality could be enhanced with dilution of the influent in the lake. The system would discharge into Lake Harbour. There is no substantial fishery in Lake Harbour. Site 11 is within the environmental setback area for the community, and within close proximity to a future community site (See **Figure 4**).

- **Site 12** is located 1.2 kilometres north east from the airport terminal, and would be accessible with an existing road, which would require considerable upgrading, and a length of new road through very steep and rugged terrain. The general process technology would be primary treatment based upon a continuous discharge from an existing lake, however the effluent quality could be enhanced with dilution of the influent in the lake. The system would discharge into Lake Harbour. There is no substantial fishery in Lake Harbour. Although Site 12 is not the environmental setback area for the community, the discharge from this site would be within close proximity to a future community site (See **Figure 4**).

Figures 11 through **21** show various improvements to each site applying several types of granular structures to provide either permeable or impermeable of wastewater. The development of the potential improvements was based upon the existing hydrology, surrounding terrain and slopes, and adjacent features, such as wetlands or other vegetated areas.

Any existing lakes would be anticipated for have flow year round and a major flow during the spring melt, therefore the appropriate control feature would be permeable (leaky) berm. Small ponds may be developed, depending on the area, as an impermeable pond which may retain the sewage for a whole year and require a seasonal discharge. Downstream of the discharges, permeable berms may be used to minimize channeling and maximize potential supplementary treatment through wetlands or vegetated areas.

Site 10 (See **Figure 19**) was selected as a site for a modular wastewater treatment system consisting of either a membrane bioreactor, or a septage receiving process.

Table 10.1 Process Summary

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7
Description Detail	Lake	Lake	Lagoon	Pond	Lake	Lake	Lagoons
Wastewater Processes	Preliminary/ Primary	Preliminary/ + Primary	Preliminary/ ++ Primary	Preliminary	Preliminary/ Primary	Preliminary/ Primary	Preliminary/ ++ Primary
Anticipated Effluent Quality - Summer	< 500/400 BOD/TSS	< 500/400 BOD/TSS	200/200 BOD/TSS	500/400 BOD/TSS	< 500/400 BOD/TSS	< 500/400 BOD/TSS	40/40 BOD/TSS
Anticipated Effluent Quality - Winter	< 500/400 BOD/TSS	< 500/400 BOD/TSS	Summer discharge	500/400 BOD/TSS	< 500/400 BOD/TSS	< 500/400 BOD/TSS	Summer discharge
Receiving Water Body	Estuary	Estuary	Estuary	Estuary	Estuary	Estuary	Freshwater

	Site 8	Site 9A	Site 9B	Site 10A	Site 10B	Site 11	Site 12
Description Detail	Lake	Lagoon	Pond	MBR	Septage	Lake	Lake
Wastewater Processes	Preliminary/ Primary	Preliminary/ ++ Primary	Preliminary/ Primary	Secondary (Mech System)	Preliminary/ Primary (Mech)	Preliminary/ Primary	Preliminary/ Primary
Anticipated Effluent Quality - Summer	< 500/400 BOD/TSS	100/100 BOD/TSS	< 500/400 BOD/TSS	20/20 BOD/TSS	< 500/400 BOD/TSS	< 500/400 BOD/TSS	< 500/400 BOD/TSS
Anticipated Effluent Quality - Winter	< 500/400 BOD/TSS	Summer discharge	< 500/400 BOD/TSS	20/20 BOD/TSS	< 500/400 BOD/TSS	< 500/400 BOD/TSS	< 500/400 BOD/TSS
Receiving Water Body	Marine	Marine	Marine	Marine	Marine	Marine	Marine

Notes:

1. Sites 1 to 7 would have effluent quality standards in the range of 80 to 360 mg/L for BOD and 100 to 300 mg/L for TSS (based upon receiving water body dilution)
2. Sites 8 to 12 would have effluenct quality standard of 100 mg/L for BOD and 120 mg/L for TSS based upon a marine environment with a bay or fjord.
3. + (plus sign) indicates enhanced performance from the baseline performance for the given process.
4. "Estuary" is Soper River / Soper Lake system which receives saltwater from tidal action
5. Site 7 performance based upon 2008 wetland study by Kadlec
6. BOD/TSS refers to BOD5 measurements, and Total Suspended Solids measurements

Table 10.2 Lagoon Design Characteristics

Lagoon Design Decisions	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9A	Site 9B	Site 10A	Site 10B	Site 11	Site 12
Exfiltrating	Yes	Yes	No	Yes	Yes	Yes	No	Yes	No	Yes	No	No	Yes	Yes
Impervious	No	No	Yes	No	No	No	Yes	No	Yes	No	No	No	No	No
Singular Storage Facultative	No	No	Yes	No	No	No	Yes	No	Yes	No	No	No	No	No
Series of Lagoons	No	No	No	No	No	No	Yes	No	No	No	No	No	No	No
Wetland Polishing	No	Limited Wetland	Limited Wetland	No	No	No	Major Wetland	No	No	No	No	No	No	No
Discharge Location	Estuary	Estuary	Estuary	Estuary	Estuary	Estuary	Fresh Water	Marine	Marine	Marine	Marine	Marine	Marine	Marine
Alternative Treatment Options	None	None	None	None	None	None	None	None	None	None	None	None	None	None

11 SITE ACCESSIBILITY

Site accessibility is a significant factor to the ongoing use of a sewage treatment facility. The large sewage trucks must travel the access road year round and under a vary of weather conditions, some of which may be extreme. The selected sites have a variety of access road lengths, some of which are existing roadways and some of which are new roadways. Existing roadways will generally require some degree of upgrading to accommodate the sewage truck with anticipated improvements to the road width, the driving surface and possibly the road geometry. Improvements are essential to the driving safety of the road.

The topography of a region is generally an important factor when considering the snowdrift potential of a site. In general, wind will scour snow from the windward side of hills and deposit it on the leeward side. As a result of this it is generally favourable to have a site and access routes located on the windward side of hills. However, given the bi-modal distribution of the winds in Kimmirut, there is not likely to be a significant benefit of locating the site on one side of the topographic features as opposed to the other. As a result, the impact of snow drifting conditions of a particular site is more a function of the access roads leading to the site.

Proposed locations farther from the community will have proportionally more required snow clearing to maintain a clear access road. Also, sections of the access roadways that are not aligned with the prevailing winds will be prone to heavier drift accumulations, particularly when the access road is located in a depression. As such, the total length of access road running in a northeast – southwest orientation should be minimized.

The following table presents road accessibility for selected sites with lengths of new road, lengths of existing road, and substantial drift zones. Sites 5, 6, 11, and 12 have been excluded because these sites or the discharges are within future development areas for the community (See **Figure 4**); site 8 was excluded because of extreme terrain required to construct a road. A snowdrift study was prepared and used to determine the length of a "drift zone" that will influence the operation and maintenance of the access, with the regular need for snow drift management through clearing or other snow drift mitigation tools.

Table 11.1: Road Accessibility to Selected Sites

Location	Existing Road (km)	New Road (km)	Total Distance (km)	Drift Zone (km)
Site 1	3.41	0.93	4.34	2.4
Site 2	3.29	0.06	3.35	1.7
Site 3	2.39	0.46	2.85	1.0
Site 7	1.99	0.00	1.99	1.2
Site 9	0.65	0.37	1.02	0.5
Site 10	0.65	0.29	0.95	0.4

12 DECISION ANALYSIS AND STRATEGIC REQUIREMENTS

12.1 Decision Analysis Framework

A decision analysis (Kepner Tregoe model) was undertaking to provide a structured methodology prioritizing and evaluating the information collected. The intent is not to find a perfect solution but rather the best possible choice, based on actually achieving the outcome with minimal negative consequences.

The basic steps are situation appraisal to clarify the situation, outline concerns and choose a direction; problem analysis to define the problem; and decision analysis to identify alternatives and complete a risk analysis for each.

The key element of the decision analysis are the strategic requirements or “must haves”, and the operational objectives or “want to haves”. The “must haves” are objectives that will screen out alternatives from further consideration. The “want to haves” are used in a mathematical ranking employing assignment of relative weights.

The maximum utility from a decision analysis is to generate as many potential feasible courses of action as possible. These courses of action are then analysed in comparison to the must haves which may reduce the number of actions.

The remaining actions are then subjected to the scoring and weighting. Each alternative is reviewed one by one rating it against each other for the particular “want to have” and then subjected to a mathematical evaluation.

12.2 Strategic Requirements or “Must” Evaluation

The strategic requirements or “must have” criteria for the sites were developed in consultation with the Government of Nunavut representatives. The must criteria for the sites are land use conflicts; accessibility; discharge location; and effluent quality.

For the purposes of the decision analysis, it is mandatory that a site does not conflict with land uses as identified in the communities land use plan (See **Figure 4**), which includes potential conflicts with future residential developments or other community related development. Related with land use conflicts is the public health related setback that requires any waste management activity be setback a minimum 450 metres from residential development (See **Figure 3**).

For the purposes of the decision analysis, it is mandatory that a site is reasonably easy and safe to access by a sewage pumpout truck. Reasonable access means an alignment that does not demand a huge capital cost, as well as a huge operation and maintenance cost. Safe access means an alignment that does not create a tortuous path for the sewage pumpout trucks that creates safety issues for these large vehicles.

For the purposes of the decision analysis it is mandatory that the effluent discharge does not enter waters that are used as a community fishery. Sewage effluent entering a community fishery may have an objective and subjective impact. The objective impact is the potential for directly impacting the fish, a subjective impact is a perceived impact on the fish. It should be noted that those options involving discharge to waters used as a community fishery were screened out. Through additional site specific studies, monitoring and possibly compensation, these options could still be a viable option. If acceptable evidence and justification that the receiving environment provides good dilution, is poor fish habitat, is used infrequently and / or is not used by commercial, recreational and Aboriginal species then the options could be included back in.

This evidence and justification would require fisheries impact assessments that would include a quantification of effects, and identification of mitigative and/or offset options. Additional studies may include hydrologic work to understand surface-water flow regimes, chemical analyses to understand seasonal water quality, and flow modeling to understand the hydraulics that may affect fish and fish habitat.

Two discharge scenarios are feasible for Site 7, which include the existing freshwater discharge, and an alternative estuary discharge (See **Section 2.3**). For the purposes of the decision analysis and strategic requirements, both of these scenarios would be considered to enter waters that are used as a community fishery, and therefore may be analyzed as equivalent options.

For the purposes of the decision analysis, it is mandatory that the effluent discharge meets or exceed the effluent quality criteria stated in the expired community water licence. These criteria are BOD_5 of 120 mg/L and TSS of 180 mg/L.

On the basis of the mandatory criteria, 10 of the 12 sites were screened from further consideration, which left sites only site 9 (Impermeable Berm option) and 10 (MBR option) remaining for the evaluation using the desirable criteria. At sites 9 and 10, options for a permeable berm lagoon, and a septage system sites were screened because the anticipated effluent quality would be above the water licence criteria.

Table 12.1 Evaluation of Strategic Requirements (MUSTS)

Strategic Requirement	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9A	Site 9B	Site 10A	Site 10B	Site 11	Site 12
No Land Use Conflicts	Yes	Yes	Yes	Yes	No	No	Yes	Yes	**Yes**	Yes	**Yes**	Yes	No	Yes
Easy and Safe Access	No	Yes	Yes	Yes	Yes	Yes	Yes	No	**Yes**	Yes	**Yes**	Yes	Yes	No
Discharge Does Not Enter Waters Used as Fishery	No	No	No	No	No	No	No	No	**Yes**	Yes	**Yes**	Yes	No	No
Meets Water Licence Effluent Criteria	No	No	No	No	No	No	Yes	No	**Yes**	No	**Yes**	No	No	No

Notes:
1 Site 9A is retention lagoon (impermeable berm) option associated with Site 9, and Site 9B is detention lagoon (permeable berm) option associated with Site 9
2. Site 10A is Membrane Bioreactor (MBR) option associated with Site 10, and Site 10B is septage receiving option associated with Site 10

13 OPINION OF PROBABLE COSTS FOR OPTIONS

Opinions of probable cost estimates (Class D) were developed by identifying the major cost components required for each site and multiplying these costs by rates which were used in a similar project. The component prices which are based on unit prices were estimated by taking measurements from scaled preliminary drawings and multiplying these by the unit rate. Some of the costs were based on lump sum pricing. A contingency was included to help account for differences in costs due to location, as well as account for any unknown costs which cannot be predicted at this early project phase. The tables below show the opinions of probably costs associated with the two sites remaining from the evaluation of strategic requirements for the development of an impermeable lagoon system and a mechanical systems.

13.1 Lagoon System

Lagoon systems are a passive process that may provide primary and secondary treatment through the simple activity of impermeable of the influent sewage. The general impermeable period applied to these systems is a complete year with an annual decant at the end of the summer. Although summers are short in the north, the biological activity is enhanced with the long days and relatively warm temperatures. Multiple cells systems (primary cell / secondary cell) may provide superior treatment.

Lagoon systems in the north may be created from existing ponds or the constructed in stand-alone earth structures. The construction of a stand-alone lagoon system will require considerable granular material, therefore the use of an existing pond offers an economy in the capital costs.

The earth structures associated with a lagoon are constructed to be low permeability to accommodate the impermeable process. The low permeability may be achieved with silt and clay, if it is availability, and geomembrane products may be used to reduce the permeability of the local materials.

The decant of a lagoon has previously utilized a permanent drain pipe embedded in the earth structures, however the performance of these drains has been inconsistent due to issues such as freezing. The decant of lagoons is evolving toward the use of portable pumping systems.

The lagoon system for Kimmirut would require a volume of 22,000 cubic metres for the estimated annual sewage generation in 2034. The operating depth of the lagoon would be 2 to 3 metres, with a surface area of 7,000 to 11,000 square metres. Provisions for sludge storage and surface runoff would be included in the pond volume.

The discharge path from a lagoon system may provide supplementary treatment through a wetland or overland flow. The discharge path for the Kimmirut concept cannot be configured as a wetland because of the 8 percent average overall slope, however the path may be configured for overland flow treatment with permeable berms spreading out the flow along the path, and optimizing contact with soil and the vegetation (grasses and willows).

The anticipated operation and maintenance cost for the lagoon system would be $100,000 for the maintenance of the earth structures, and the operation of the decant system.

Table 13.1: Opinion of Probable Costs for Site 9A (Impermeable Berm)

Description	Site 9A
New Access Road	$185,000
Existing Access Improvement	$130,000
Truck Turnaround	$45,000
Truck Discharge	$27,000
Permeable Berm	$154,000
Impermeable Berm	$116,000
Pond Spillway	$38,000
Decant System	$135,000
Overland Flow Development	$50,000
Contingency (40%)	$352,000
Total	**$1,232,000**

13.2 Mechanical System (MBR)

Membrane Bioreactors (MBR) are a secondary treatment process which combine a suspended growth biological reactor with solids removal by filtration. The filtration elements utilize a membrane system to provide microfiltration, or ultrafiltration as opposed to the conventional sedimentation systems and therefore offer a much smaller building footprint. The building footprint for the Kimmirut system is approximately 10 metres by 20 metres, with a modular configuration.

MBRs are able to achieve a higher level of treatment compared to other secondary treatment options. However, MBRs have higher operation and maintenance costs associated with energy for aeration, chemical costs for membrane cleaning and membrane replacement costs.

Skid mounted MBR systems complete with all required pretreatment components are available for shipment within pre-engineered buildings/sea cans. Inside the building the trucked sewage flows through a trash trap to capture floatables and heavy objects (preliminary treatment) followed by an equalization tank. The influent is then pumped from the equalization tank to bioreactors for biological treatment and then to the MBR module for further treatment and solids separation. The membrane modules require periodic chemical cleaning to mitigate fouling. Electrical power connection as well as an odour control and solids handling system are required.

The anticipated operation and maintenance of the MBR system is estimated to be $500,000 per year for the human resources to operate the facility, the potential chemicals associated with the process, and the energy costs. This is based upon an allowance of 10 % of the capital cost.

Table 13.2: Opinion of Probable Costs for Site 10A (MBR)

Item	Description	Subtotal	Total
1	**Site Preparation**		**$ 100,000**
2	**Process Equipment**		**$ 2,892,000**
	a) Equipment Cost from GE	$ 1,000,000	
	b) 50% install	$ 500,000	
	c) Wash Water System	$ 40,000	
	d) 30% Electrical	$ 462,000	
	d) 20% Piping and Valving	$ 308,000	
	e) Shipping	$ 100,000	
	f) 20% General Requirements	$ 482,000	
3	**Building**		**$ 1,128,000**
	a) Concrete $1,100/m3 concrete x 180m2	$ 198,000	
	b) Superstructure $1,750/m2 superstructure x 300m2	$ 525,000	
	c) 30% HVAC	$ 216,900	
	c) 20% General Requirements	$ 187,980	
4	**Onsite-Utilities (electrical service)**		**$ 120,000**
	a) 600 m total. $10,000 per pole @ 50 m each.	$ 120,000	
5	**Engineering & Contingency (40%)**		**$ 696,000**
	Total		**$ 5,936,000**

Training of operators would be an important part of the long term success of the membrane treatment option for Kimmirut. The nature and cost of the training will ultimately be a function of the individual operators employed by the community. Distance learning, combined with remote operational monitoring and assistance, and programs such as Circuit Rider will provide opportunities for effective and efficient operator training.

14 DECISION ANALYSIS AND OPERATIONAL OBJECTIVES

14.1 Operational Objectives or "Want" Analysis

The decision analysis for the "want to have" criteria applies a relative ranking of the option for each objection; the ranking used is 1 through 5, with 5 being the highest score for a given objective.

The decision analysis also applies a weighting to each objective. The weighting used is also 1 through 5, with 5 being the strongest weighting for a given objective. The relative weights of the objectives are based upon an objective perspective on this project. It is anticipated that the relative weights will vary depending upon the perspective or bias of the reader.

An explanation of the evaluation criteria and the relative rating is as follows:

1. Low Capital Cost (Weight 4) – Capital cost is the estimate of the opinion of the probable cost of each option based upon a planning level estimate. This is a preliminary estimate which, because of limited site information, and indicates the approximate magnitude of the cost of the proposed option. A low capital cost is the desired objective
2. Low Operation and Maintenance Cost (Weight 5) – Operation and maintenance cost is an estimate of operation and maintenance costs of each option; for the purposes of this evaluation, 10 percent of the capital cost has been used to estimate the operation and maintenance cost. A low operation and maintenance cost is the desired objective
3. Long Service Life (Weight 5) – Service life is the overall anticipated operating lifespan of a facility from the time of its original construction. A long service life is the desired objective
4. Low Environmental Risk (Weight 3) – Environmental risk refers to the potential for an event of catastrophic proportions, such as the breach of the lagoon system. A low environmental risk is the desired objective
5. Low Performance Risk (Weight 4) – Performance risk refers to the ability for an option to maintain compliance with a given effluent criteria. Factors such as weather may influence the performance of system exposed to the natural environment. A low performance risk is the desired objective
6. High Effluent Quality (Weight 3) – Effluent quality refers to the quality of the discharge of each option. A high effluent quality is the desired objective
7. Low Effluent Toxicity (Weight 3) – Effluent toxicity is an issue with the discharge from a wastewater treatment system because of the toxicity requirements under the Federal Fisheries act. A low effluent toxicity is the desired objective
8. Space for Future Expansion (Weight 2) – Future expansion refers to the ease of expansion that each option will accommodate at some point in the future. An option that has space for future expansion is the desired objective
9. Simple Operation (Weight 4) - Simple operation refers to the level of training required for the system operator, and the level of attention required for successful system operation. Simple operation is the desired objective

10. Low Aesthetic Impact (Weight1) - Aesthetic impact refers to the sensory impact each option may have on community residents. Low aesthetic impact is the desired objective
11. Ease of Constructability (Weight 3) – Constructability refers to the anticipated ease with which the construction may advance with an option. An easily constructed facility is the desired objective
12. Ease of Site Accessibility (Weight 4) – Site accessibility refers to the ease with which a option may be accessed year round given the length of the roadway and the potential for snow drifting on the access road. An easily accessed facility is the desired objective

14.2 Outcome of Decision Analysis

The decision analysis of the operational requires conveys a significantly higher rating for the lagoon system over the mechanical system. The lagoon system excels in the objectives associated with Low Capital Cost, Low Operation and Maintenance Cost, Long Service Life, and Simple Operation.

The objectives of low operation and maintenance cost and simple operation are particularly important factors for a small community where the funding and human resources for a facility operation are always a challenge.

Table 14.1 Evaluation of Operational Objectives (Wants)

Objective	Weight	Site 9A Lagoon Rating	Site 9A Lagoon Score	Site 10A Mechanical Rating	Site 10A Mechanical Score
1. Low Capital Cost	4	4	16	1	4
2. Low Operation and Maintenance Cost	5	5	25	1	5
3. Long Service Life	5	5	25	2	10
4. Low Environmental Risk	3	2	6	5	15
5. Low Performance Risk	4	3	12	4	16
6. High Effluent Quality	3	2	6	5	15
7. Low Effluent Toxicity	3	3	9	5	15
8. Space for Future Expansion	2	2	4	4	8
9. Simple Operation	4	5	20	2	8
10. Low Aesthetic Impact	1	4	4	2	2
11. Ease of Constructability	3	2	6	4	12
12. Ease of Site Accessibility	4	5	20	5	20
Total			**153**		**130**

15 CONCLUSIONS AND RECOMMENDATIONS

15.1 Existing Systems

The existing wastewater treatment system used by the community of Kimmirut is a trench discharge that drains to the ocean over a steep embankment, followed by a gradual drop to the ocean at Lake Harbour. Some treatment is achieved through this discharge, although it may be limited to preliminary treatment; the treatment would be enhanced during the limited summer months with overland flow treatment through the grasses and willow in area immediately before the ocean discharge.

The existing un-commissioned wastewater system has been evaluated to provide a potential effluent quality of less than 40 mg/L for BOD5 and TSS with the permeable, impermeable and wetland process elements. However, this system discharges into the freshwater catchment area of Pleasant Inlet, which is a local fishery. The discharge from this system could be pumped into the catchment area of the Soper River, however, the system would lose the supplementary treatment from the wetland, and the Soper River catchment area is also a local fishery.

15.2 Site Selection and Analyses

A broad base of wastewater treatment processes has been considered and these processes were applied to sites selected from an initial area analyses. This culminated in 12 sites that were selected and analyzed to develop conceptual treatment configurations. Independent fisheries, wetland, geotechnical and snow drift reviews were completed (see appendices) to provide necessary information for the analysis and advancement of options that may be develop from any of the 12 selected sites.

The fisheries review noted that over half of the selected sites would require effluent discharges into freshwater, or an estuary associated with the Soper River, and these water bodies have community fishery related activities. The remainder of the site would ultimately discharge into a marine environment, where the fishery related impacts would not be as significant.

The wetland review noted that only 1 of the selected site would have a large enough wetland to provide significant supplemental treatment to the effluent discharge. The remainder of the potential wetland areas would provide only very limited treatment Other land areas where effluent discharges would be directed are too steep for wetlands, and may provide only limited supplemental treatment associated with overland flow.

The geotechnical review noted that Kimmirut is deficient of any good source of granular material and relies on periodic blasting and crushing operation to provide the building requirements.

The existing terrain around Kimmirut does not afford the use of the generally configured northern lagoon system because there is no suitable level ground. The adapted configurations to meet this challenge include existing ponds and lakes for impermeable systems, and existing small valleys for permeable systems.

A decision analysis was completed on the 12 sites, first applying the strategic requirements (musts) and then applying the operational requirements (wants). On the basis of the strategic requirements criteria, 10 of the 12 sites were screened from further consideration, which left sites only site 9 and 10 remaining for the evaluation using the desirable criteria. At sites 9 and 10, additional options for these sites were screened because the anticipated effluent quality would be above the water licence criteria.

The decision analysis applying operational requirements identified the lagoon system at site 9 as the better option to pursue. This lagoon option would apply an impermeable lagoon with seasonal overland discharge to the ocean through a series of permeable berms.

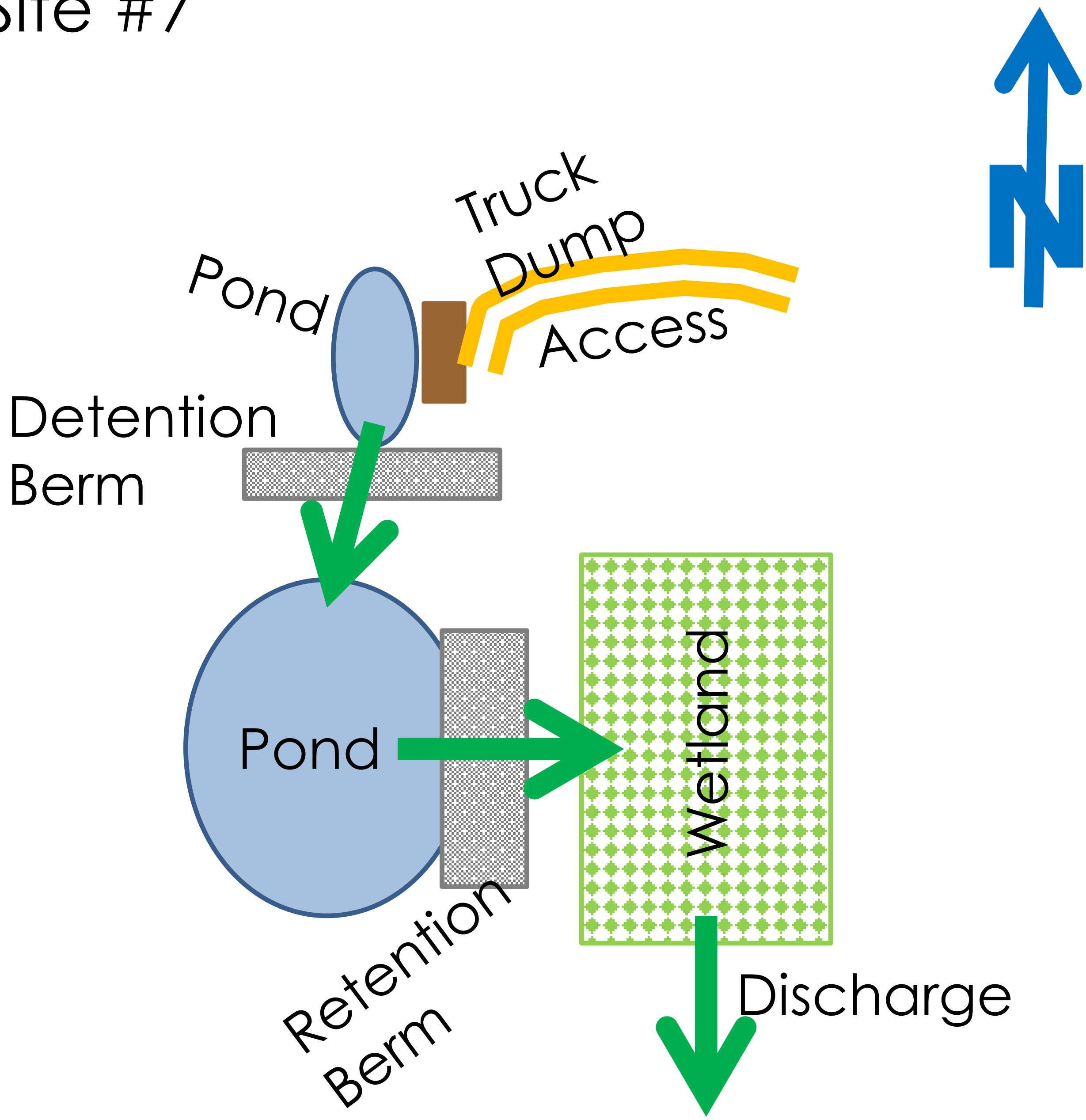
15.3 Conclusions and Recommendations

A lagoon system emerged from the decision analysis as the better option to pursue for the community of Kimmirut. This option should be incrementally advanced to implementation.

The incremental steps should include consultation with the community and the regulatory community, reconfiguration of the concept (as required), final acceptance of the concept, engineering with consultation during the engineering process, and finally construction.,

There will be a need for additional information collection in support of all of the steps to implementation. In particular the information will include site specific information on the local hydrology, geology, topography, fish habitat, the fishing and recreational use, vegetation, and snow accumulation. An important offsite piece of information will be the geotechnical information associated with the construction material, the updating of the community's granular needs and management plans, and the execution of the work, in advance of construction to provide the granular materials.

Site #7



NOT TO SCALE

Kimmirut

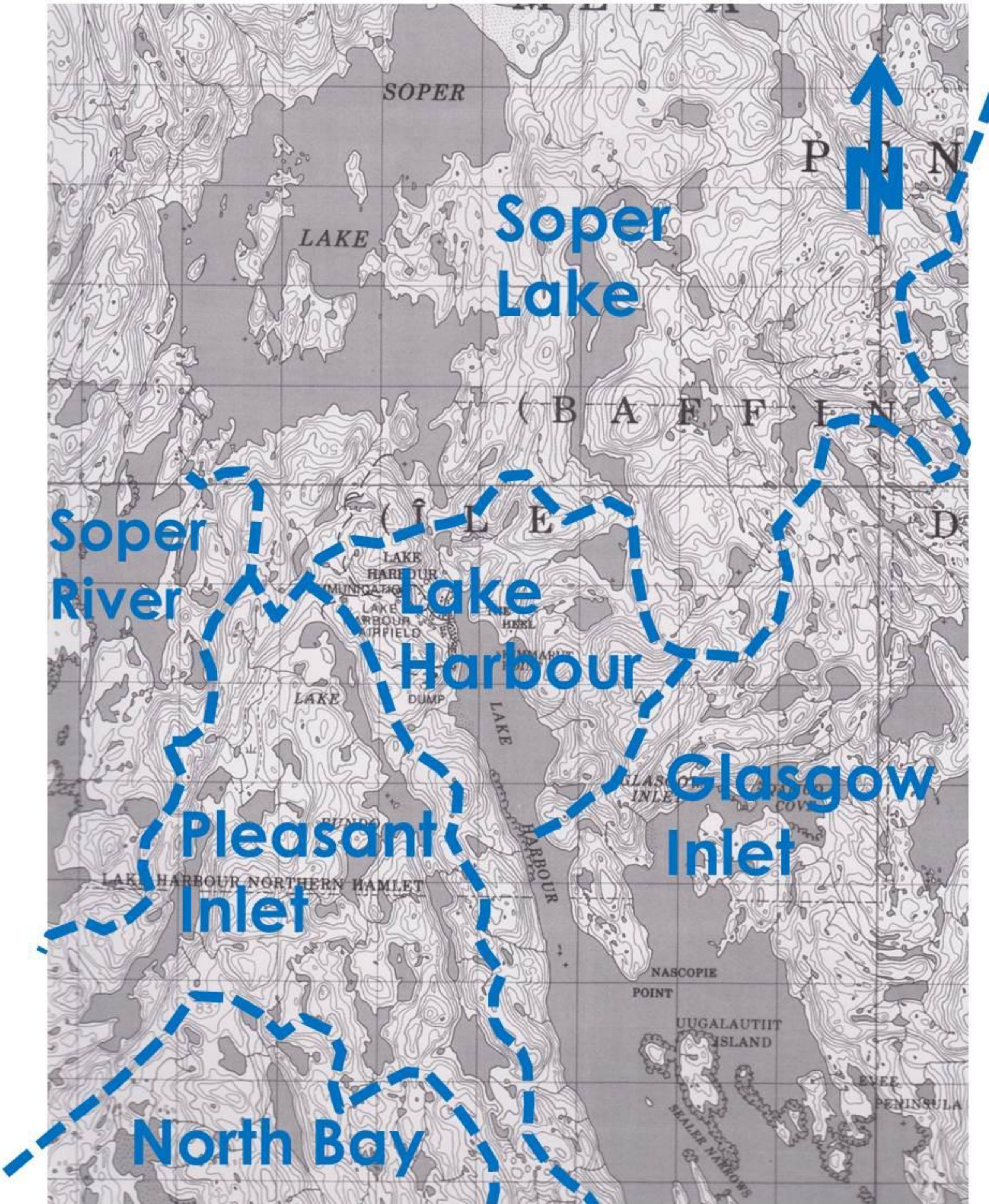
Sewage Treatment Study

Wastewater Treatment Processes

Prepared by Ken Johnson, RPP, P.Eng. 2014 11 24

Figure 1

Stantec



Kimmirut

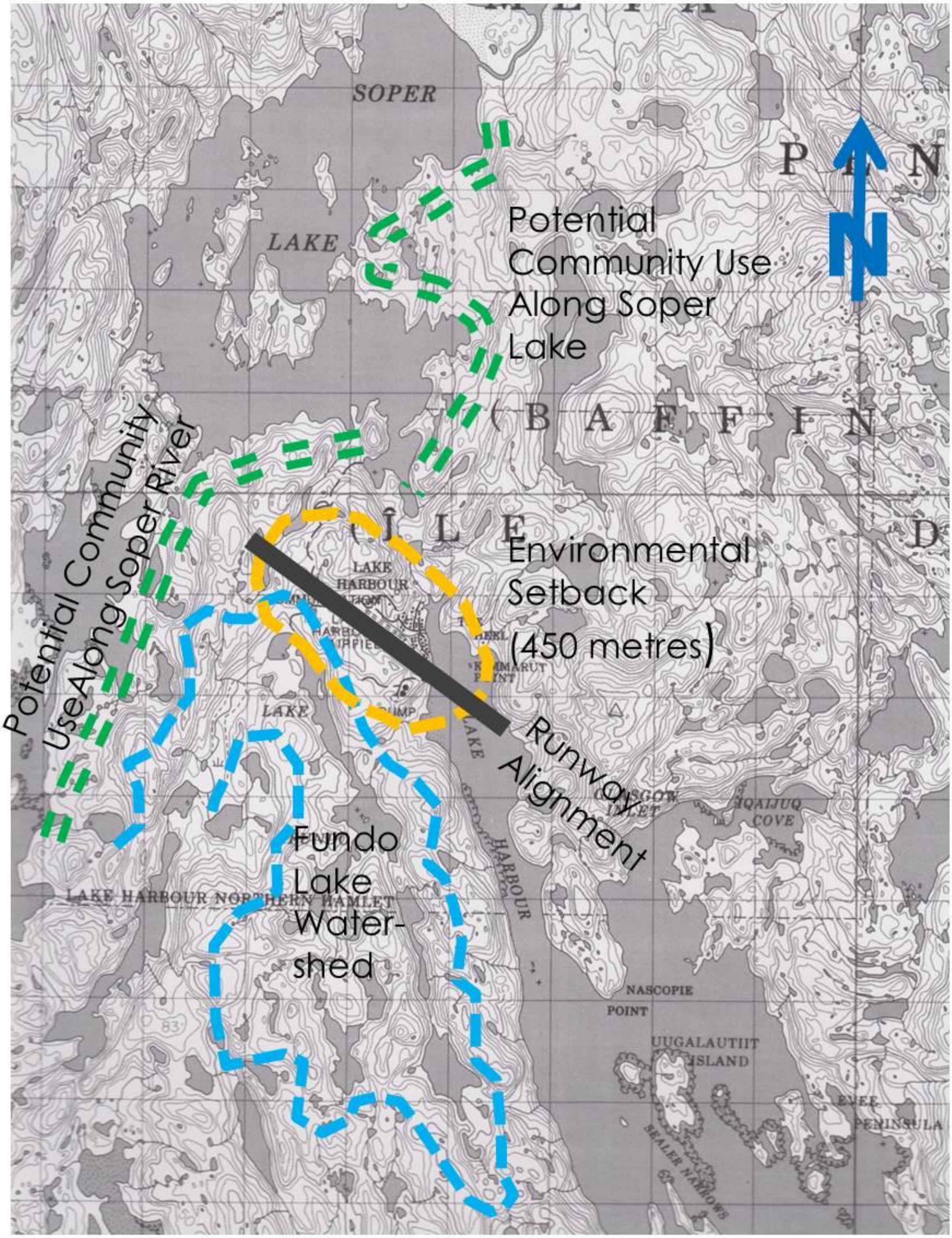
Figure 2

Sewage Treatment Study

Watersheds

Prepared by Ken Johnson, RPP, P.Eng. 2014 12 15

Stantec



Kimmirut

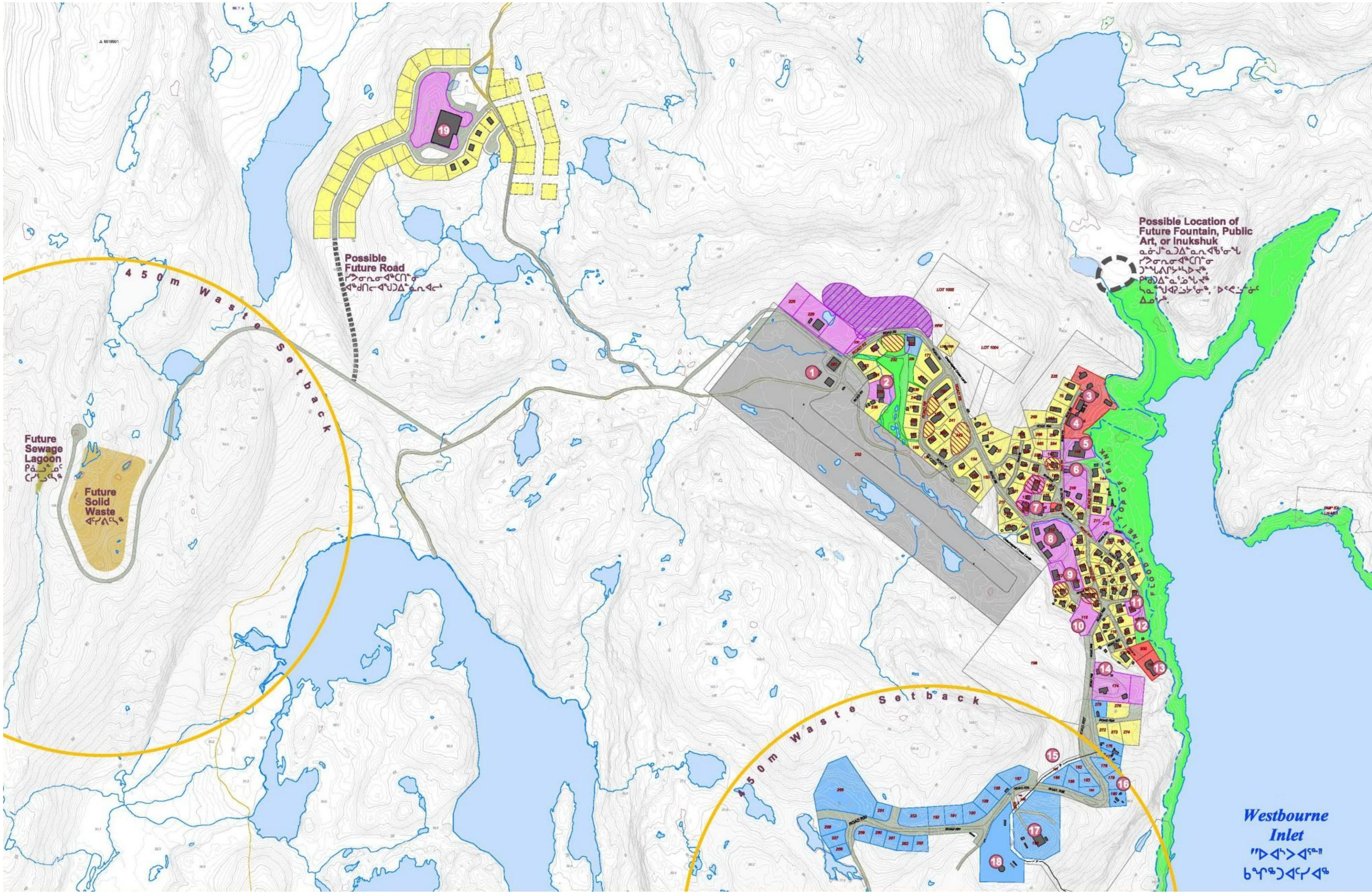
Figure 3

Sewage Treatment Study

Land Use Constraints

Prepared by Ken Johnson, RPP, P.Eng. 2014 11 24

Stantec

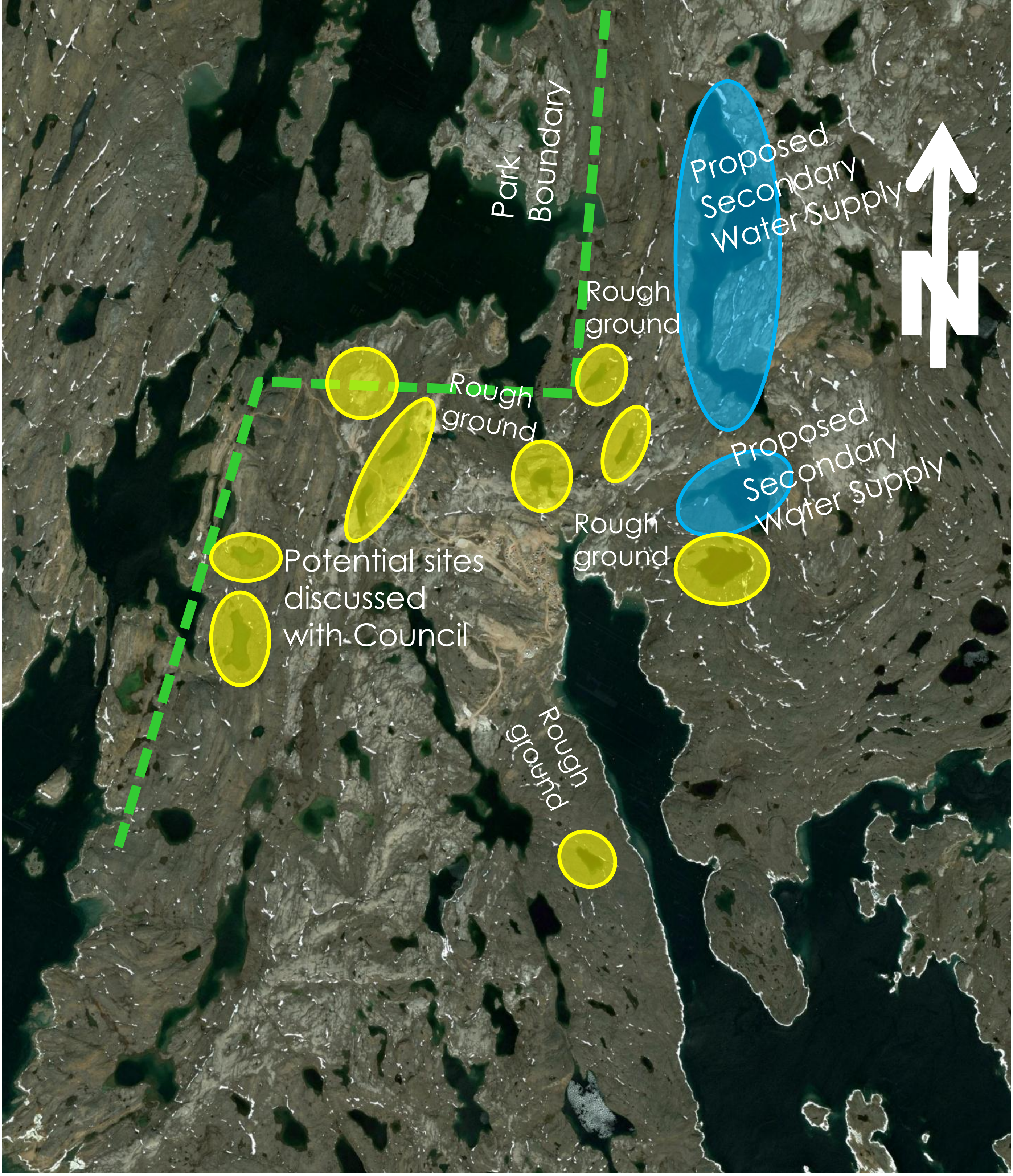


Kimmirut

Sewage Treatment Study
Land Use Plan

Figure 4

Prepared by Ken Johnson, RPP, P.Eng.
2014 12 16



Kimmirut

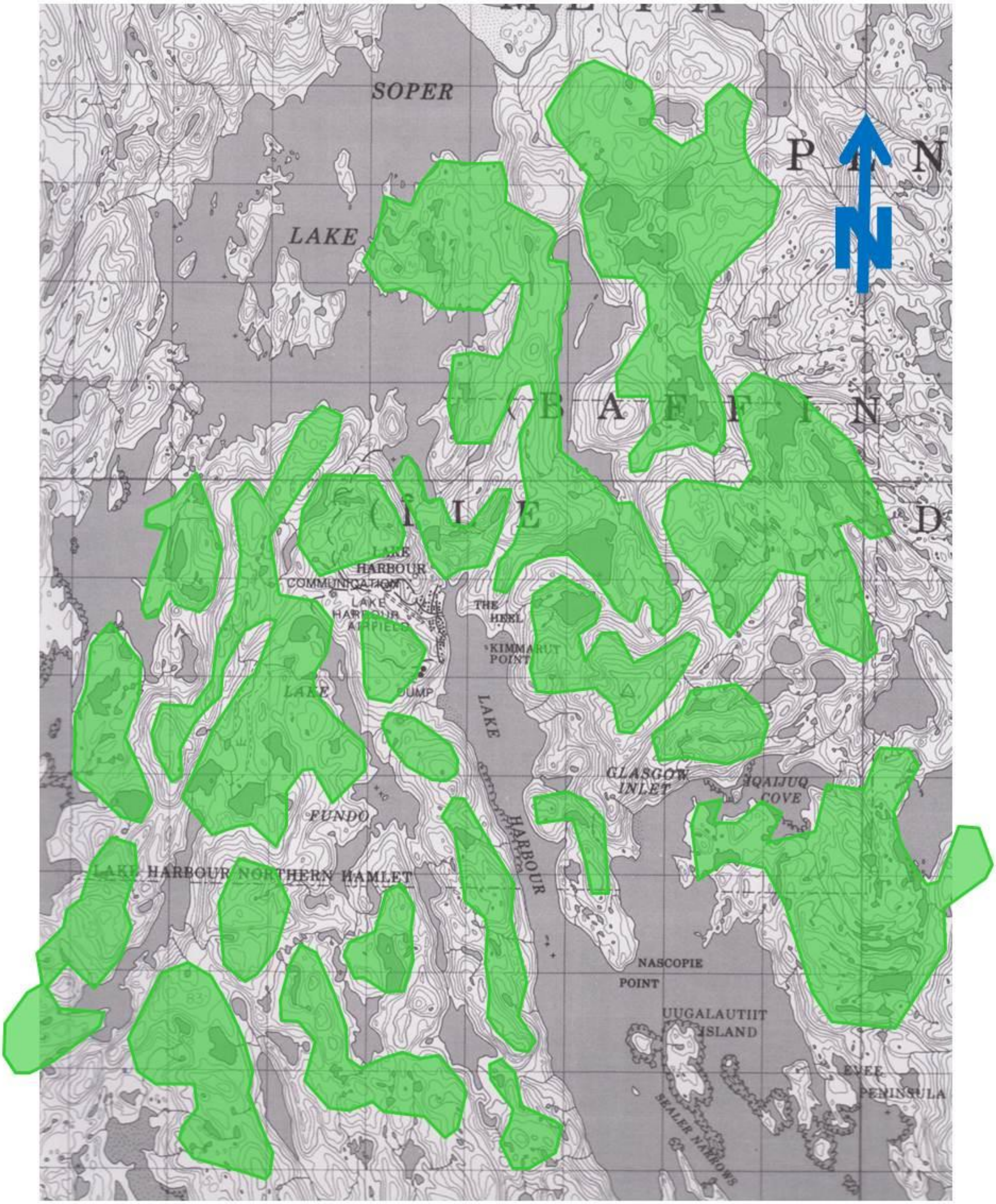
Sewage Treatment Study

Council Meeting Notes

Prepared by Ken Johnson, RPP, P.Eng. 2014 11 24

Figure 5

Stantec



Kimmirut

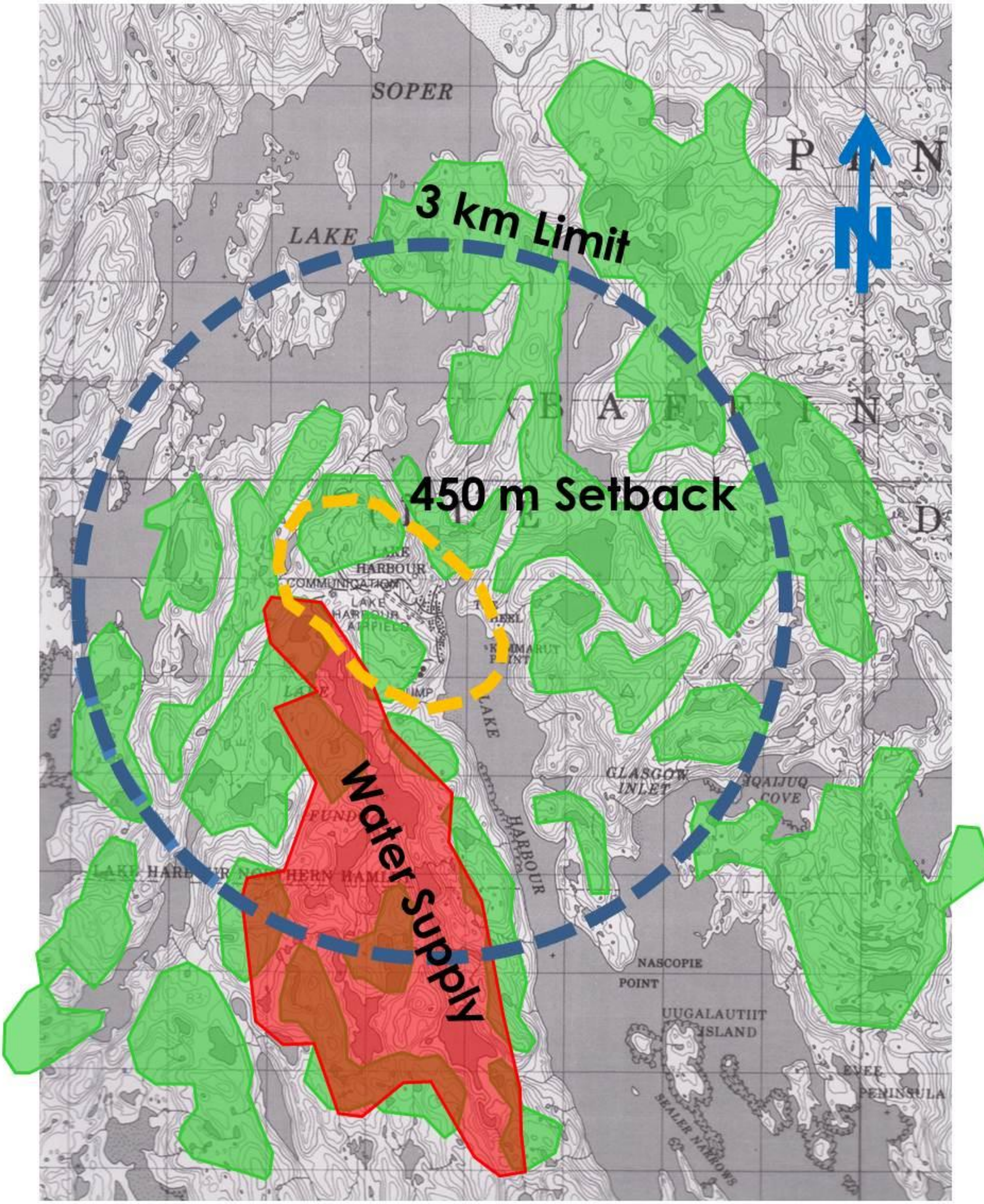
Sewage Treatment Study

Coarse Terrain Analysis

Prepared by Ken Johnson, RPP, P.Eng. 2014 11 24

Figure 6

Stantec



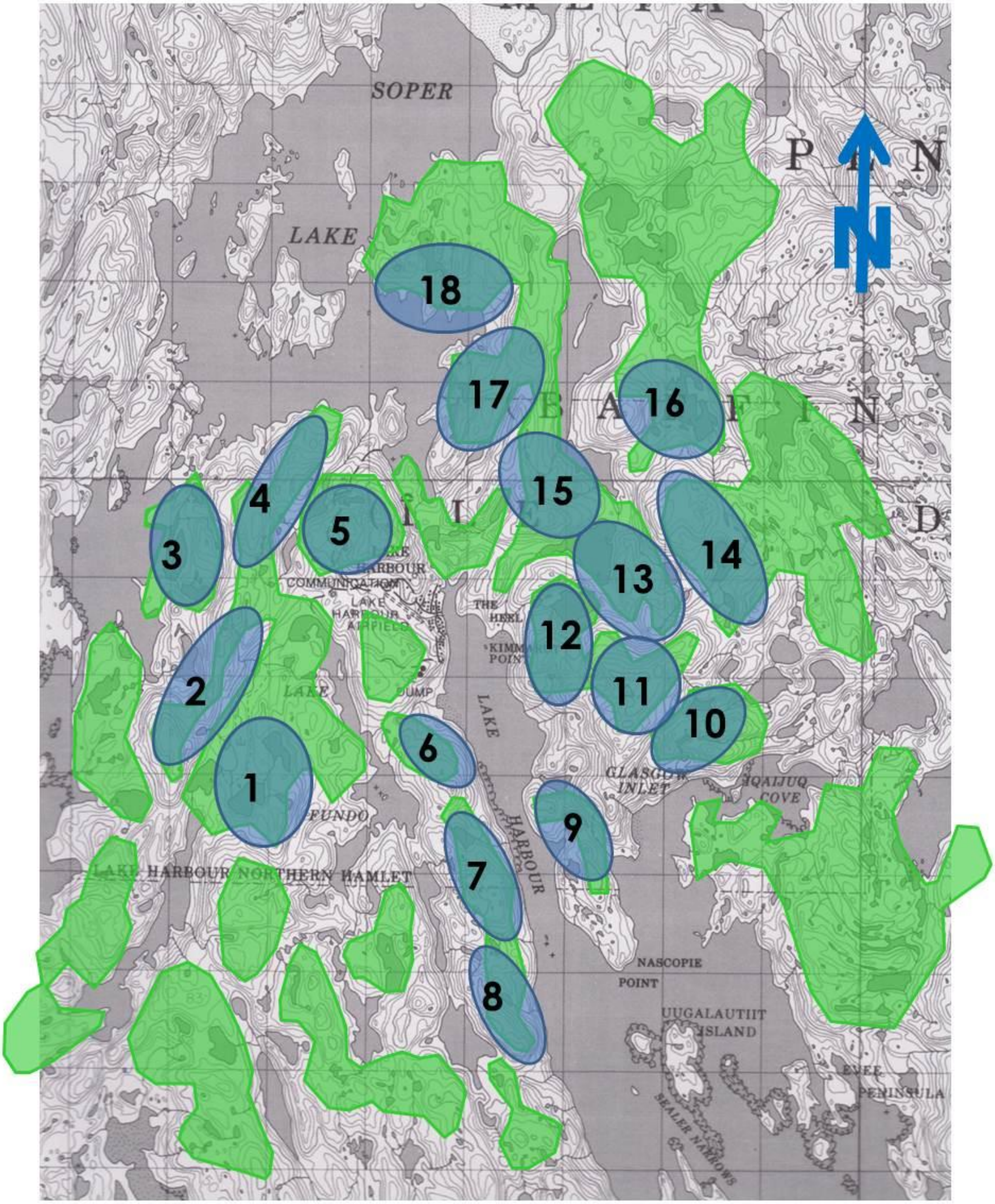
Kimmirut

Figure 7

Sewage Treatment Study

Excluded Areas

Prepared by Ken Johnson, RPP, P.Eng. 2014 11 24



Kimmirut

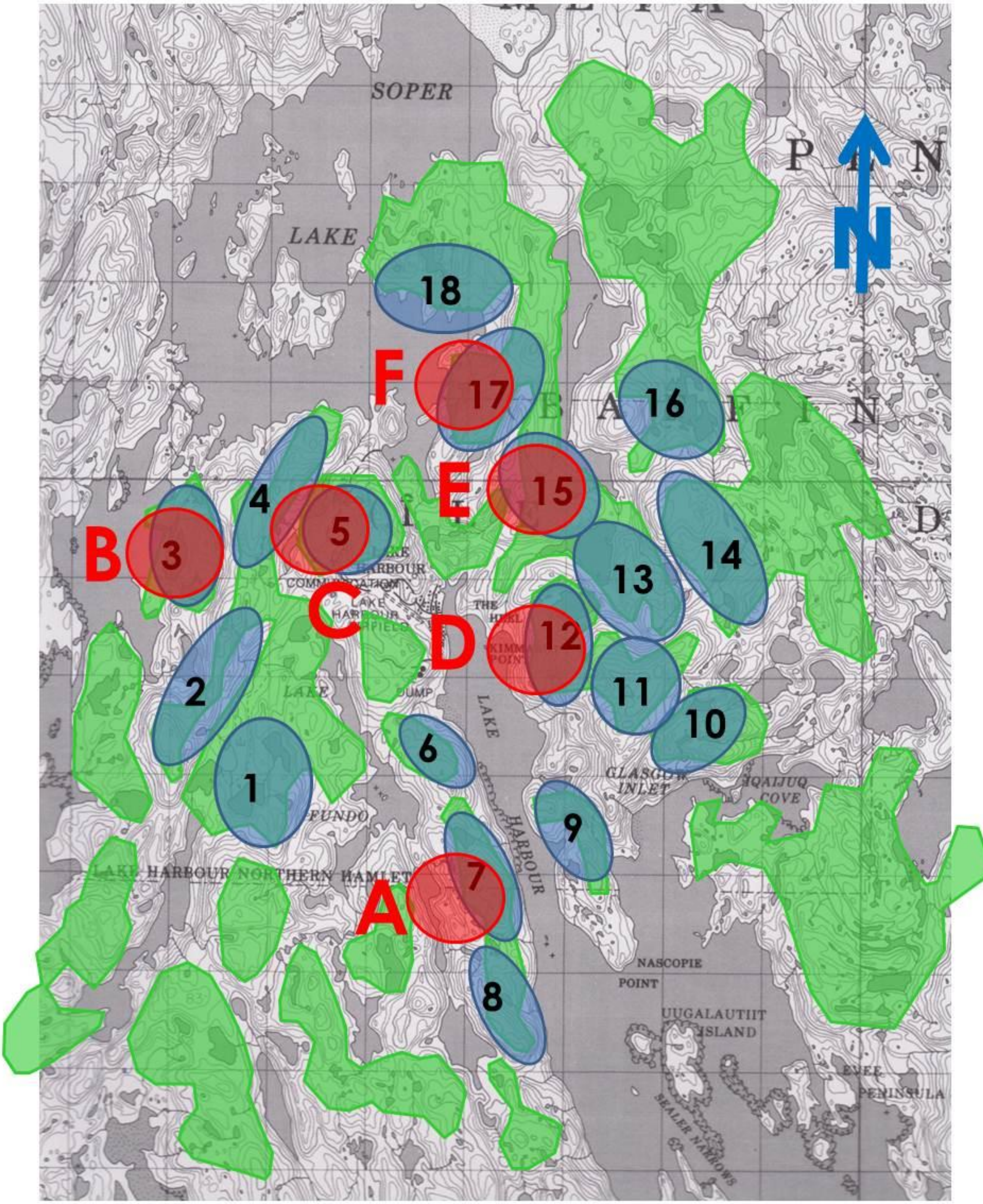
Sewage Treatment Study

Potential Areas

Prepared by Ken Johnson, RPP, P.Eng. 2014 11 24

Figure 8

Stantec



Kimmirut

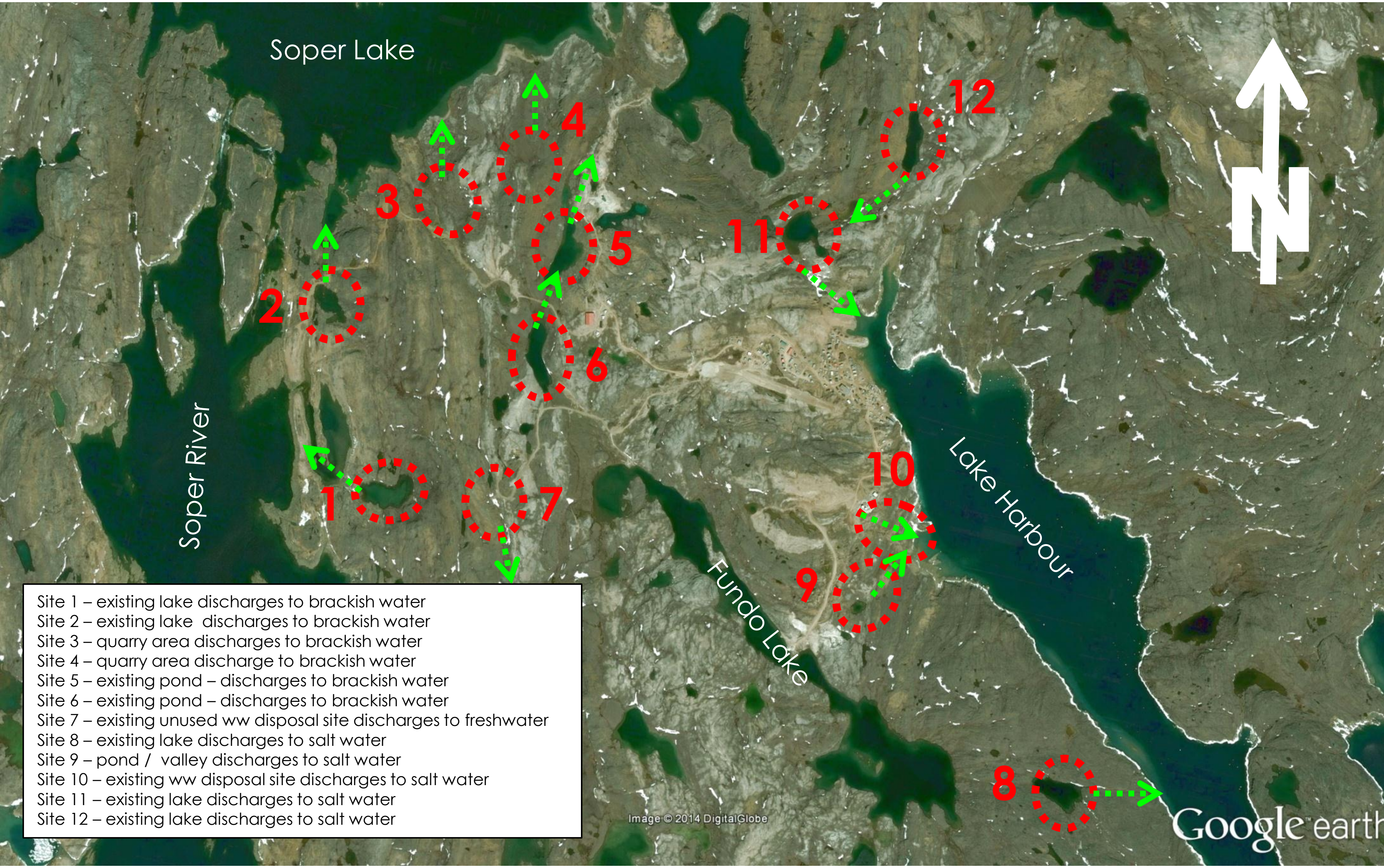
Figure 9

Sewage Treatment Study

Selected Areas

Prepared by Ken Johnson, RPP, P.Eng. 2014 11 24

Stantec



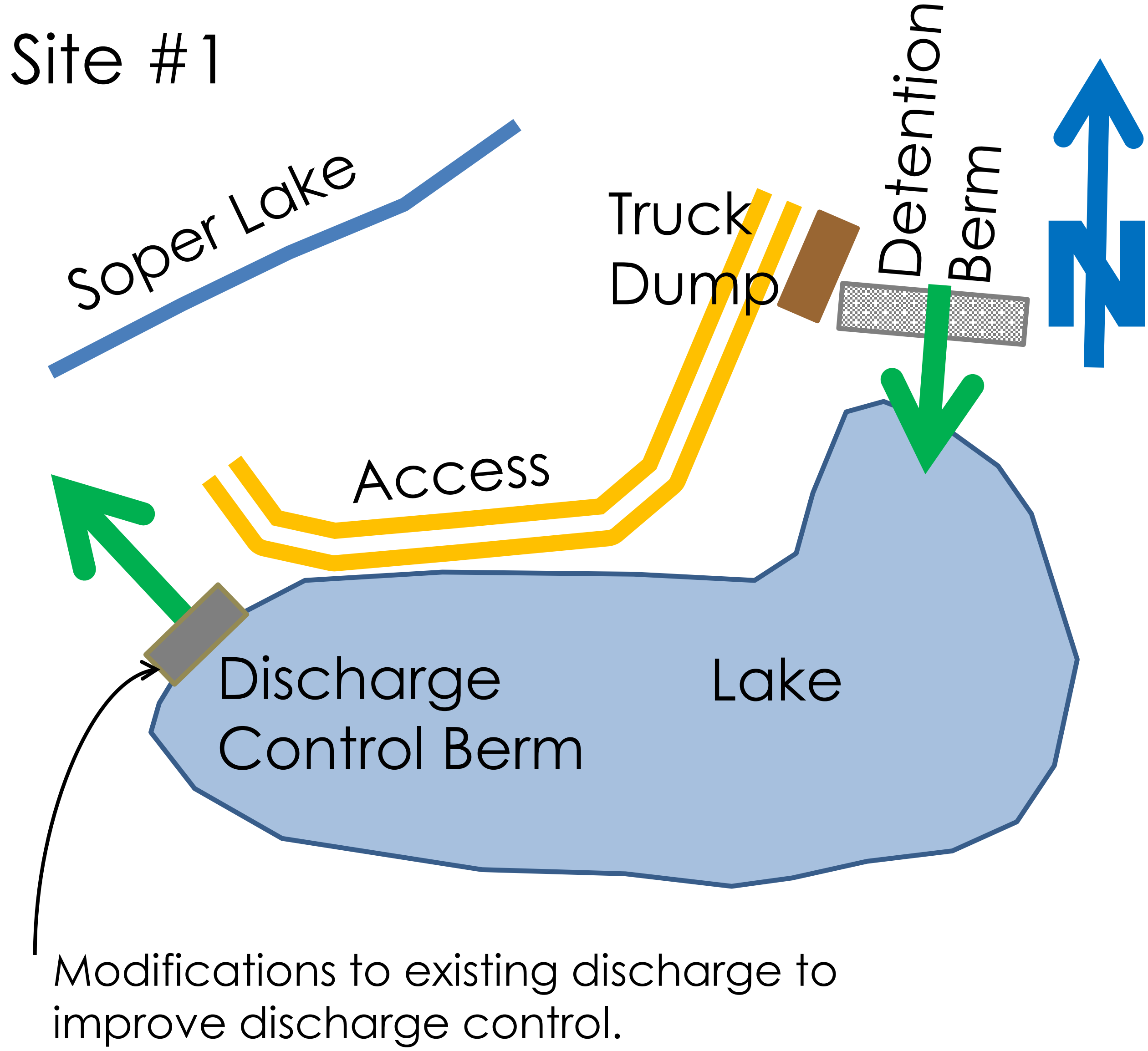
Kimmirut

Sewage Treatment Study
Sites for Consideration

Stantec

Figure 10

Prepared by Ken Johnson, RPP, P.Eng.
2014 11 23



NOT TO SCALE

Kimmirut

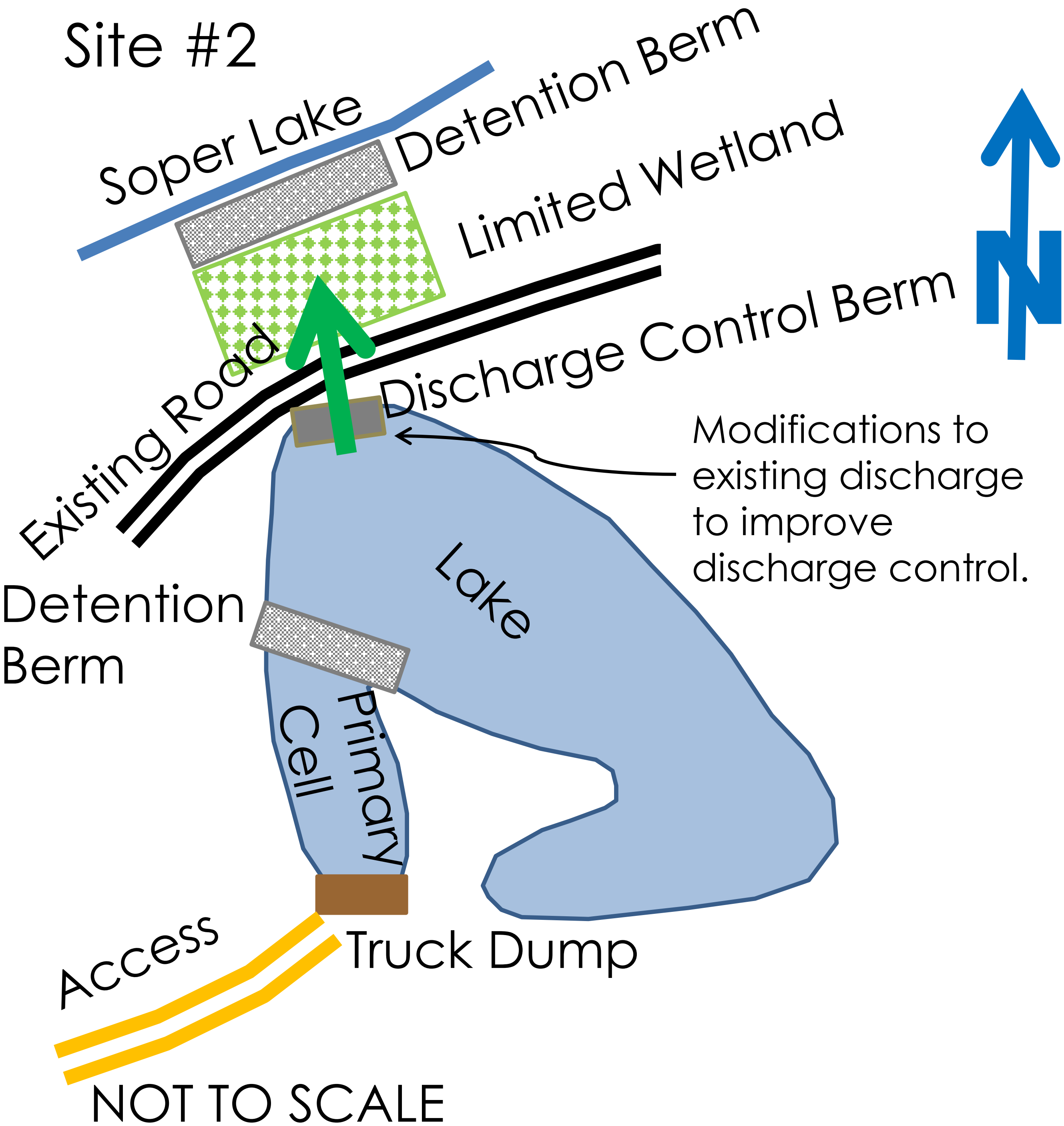
Sewage Treatment Study

Wastewater Treatment Processes

Prepared by Ken Johnson, RPP, P.Eng. 2014 11 24

Figure 11

Stantec



Kimmirut

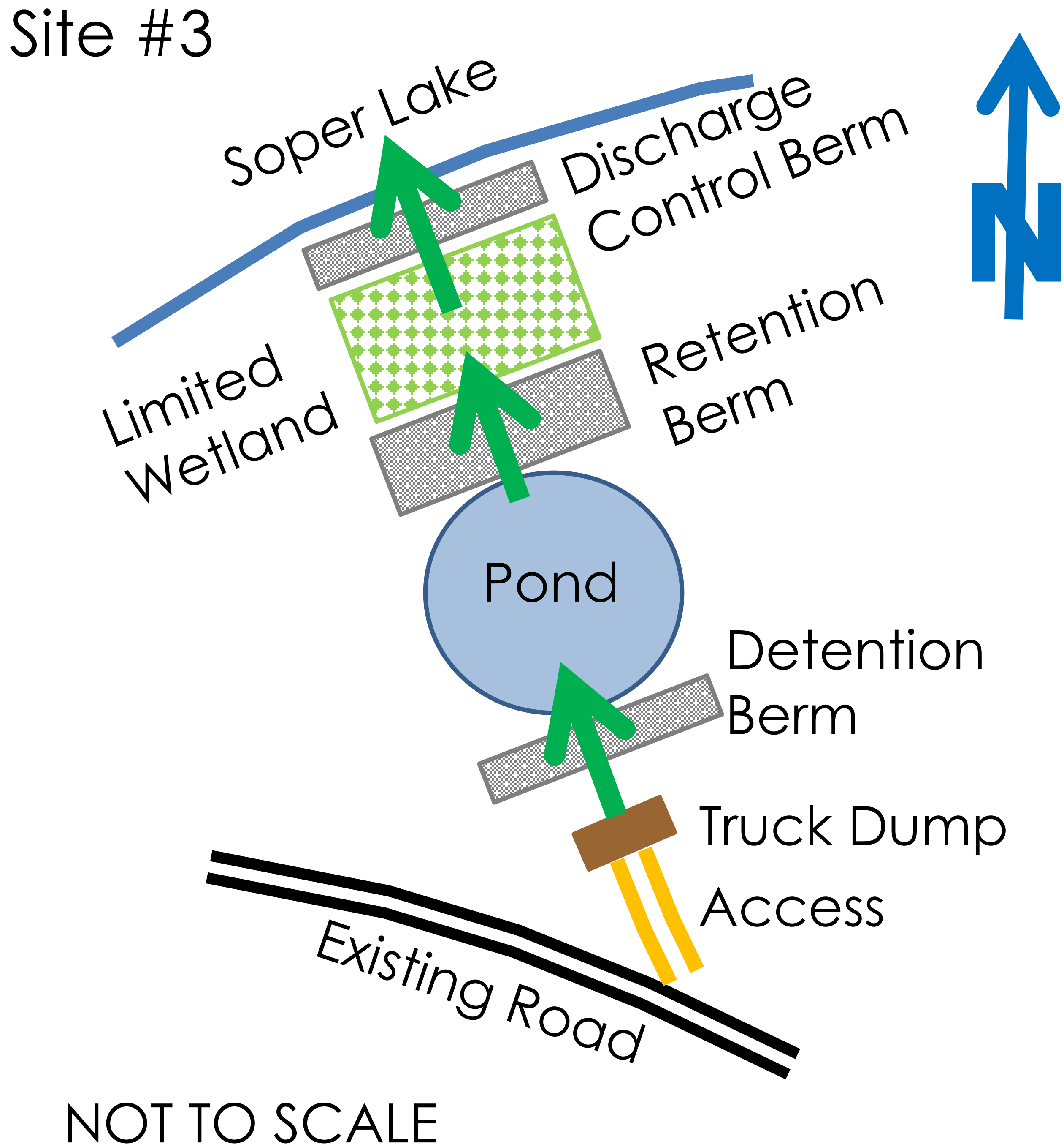
Figure 12

Sewage Treatment Study

Wastewater Treatment Processes

Prepared by Ken Johnson, RPP, P.Eng. 2014 11 24

Stantec



Kimmirut

Sewage Treatment Study

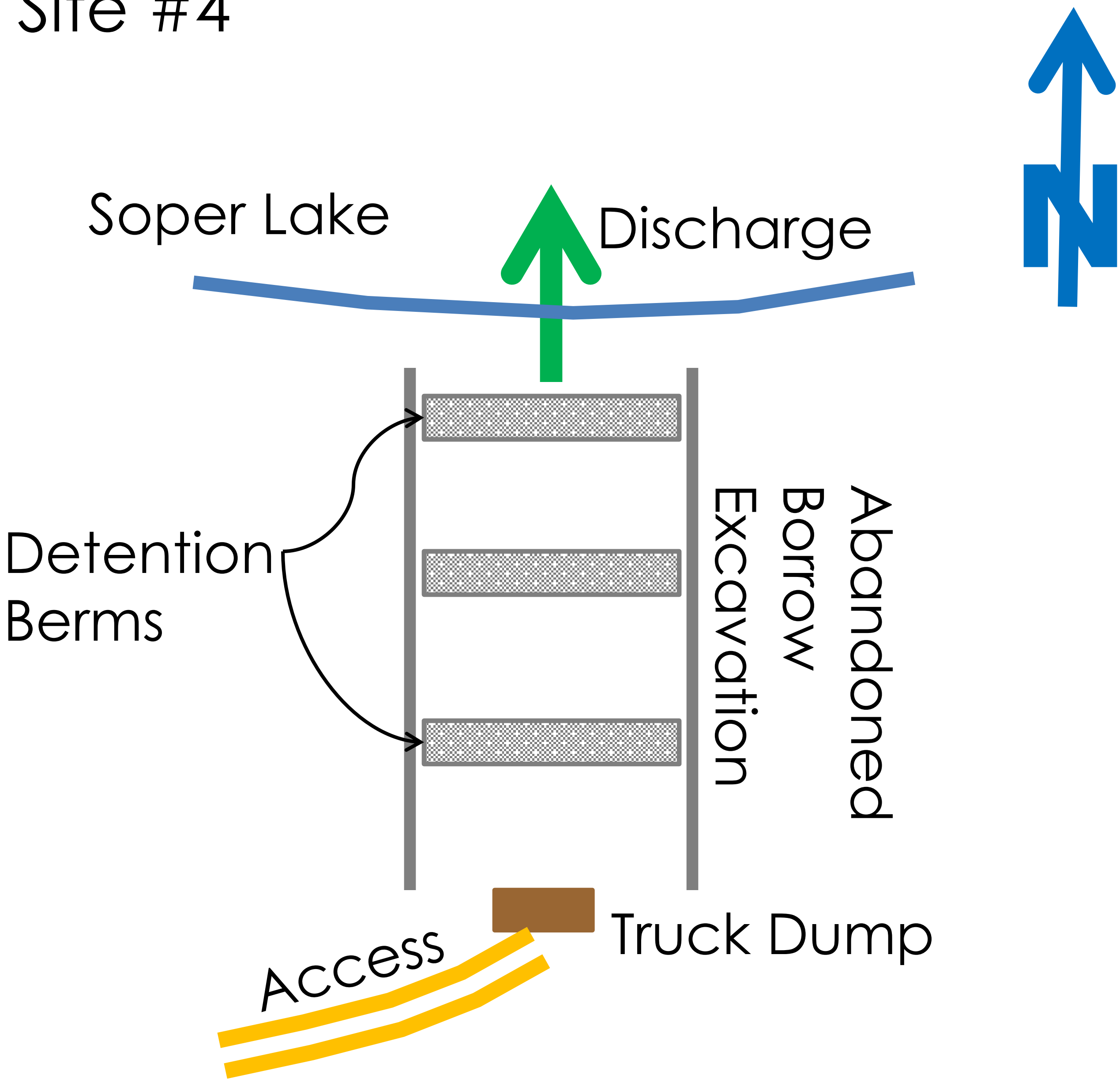
Wastewater Treatment Processes

Prepared by Ken Johnson, RPP, P.Eng. 2014 11 24

Figure 13

Stantec

Site #4



NOT TO SCALE

Kimmirut

Sewage Treatment Study

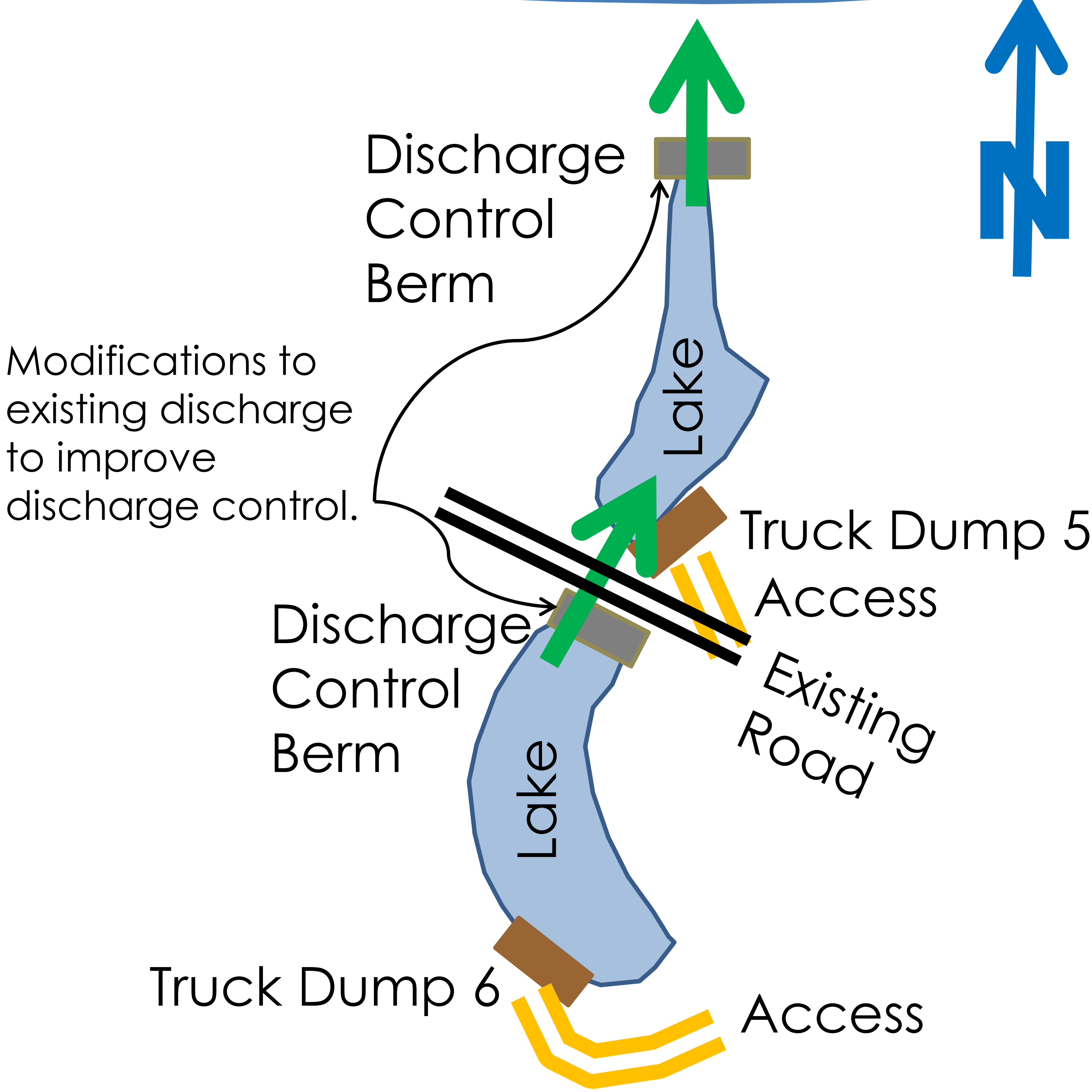
Wastewater Treatment Processes

Prepared by Ken Johnson, RPP, P.Eng. 2014 11 24

Figure 14

Stantec

Site #5/6



NOT TO SCALE

Kimmirut

Sewage Treatment Study

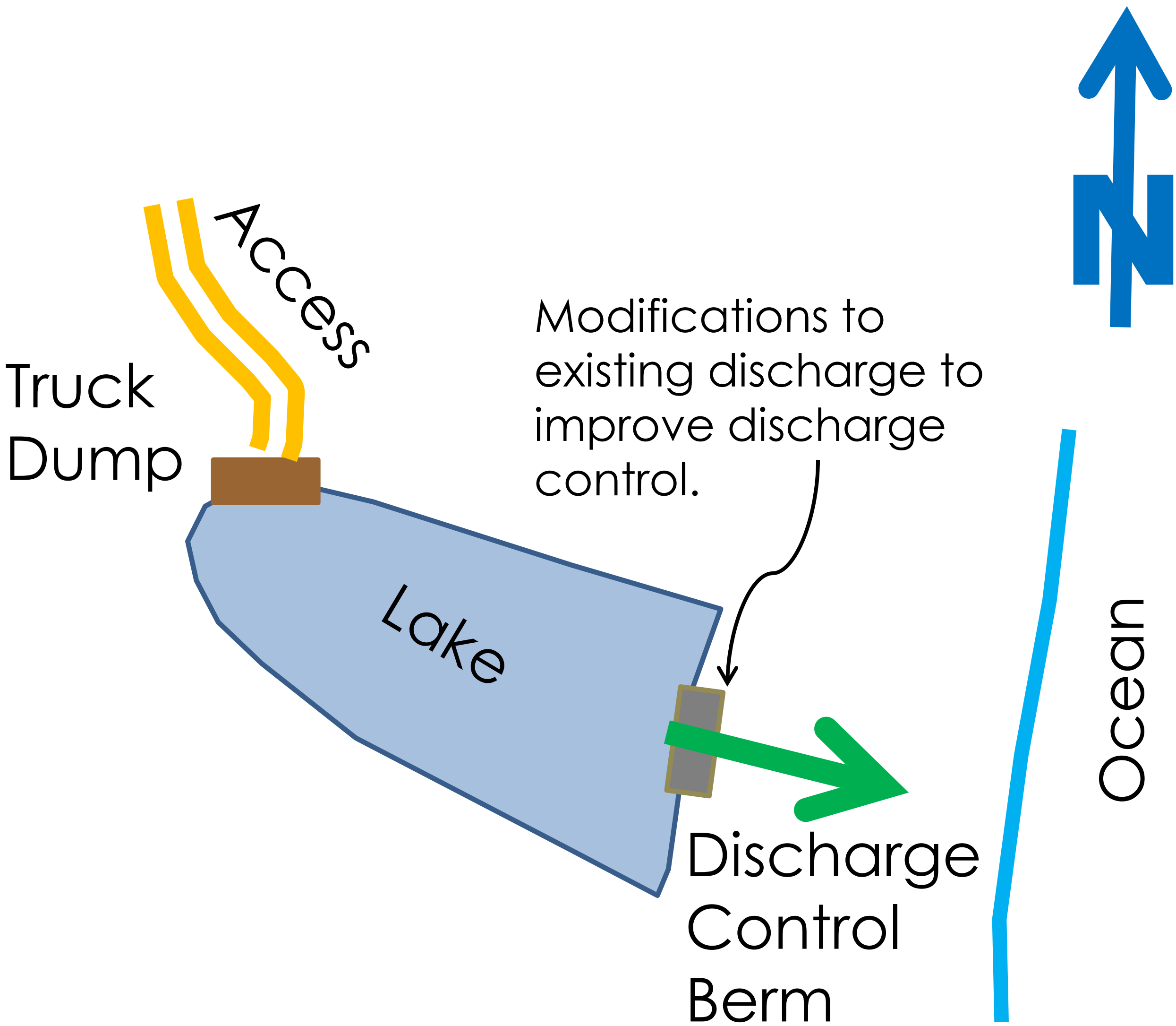
Wastewater Treatment Processes

Prepared by Ken Johnson, RPP, P.Eng. 2014 11 24

Figure 15

Stantec

Site #8



NOT TO SCALE

Kimmirut

Sewage Treatment Study

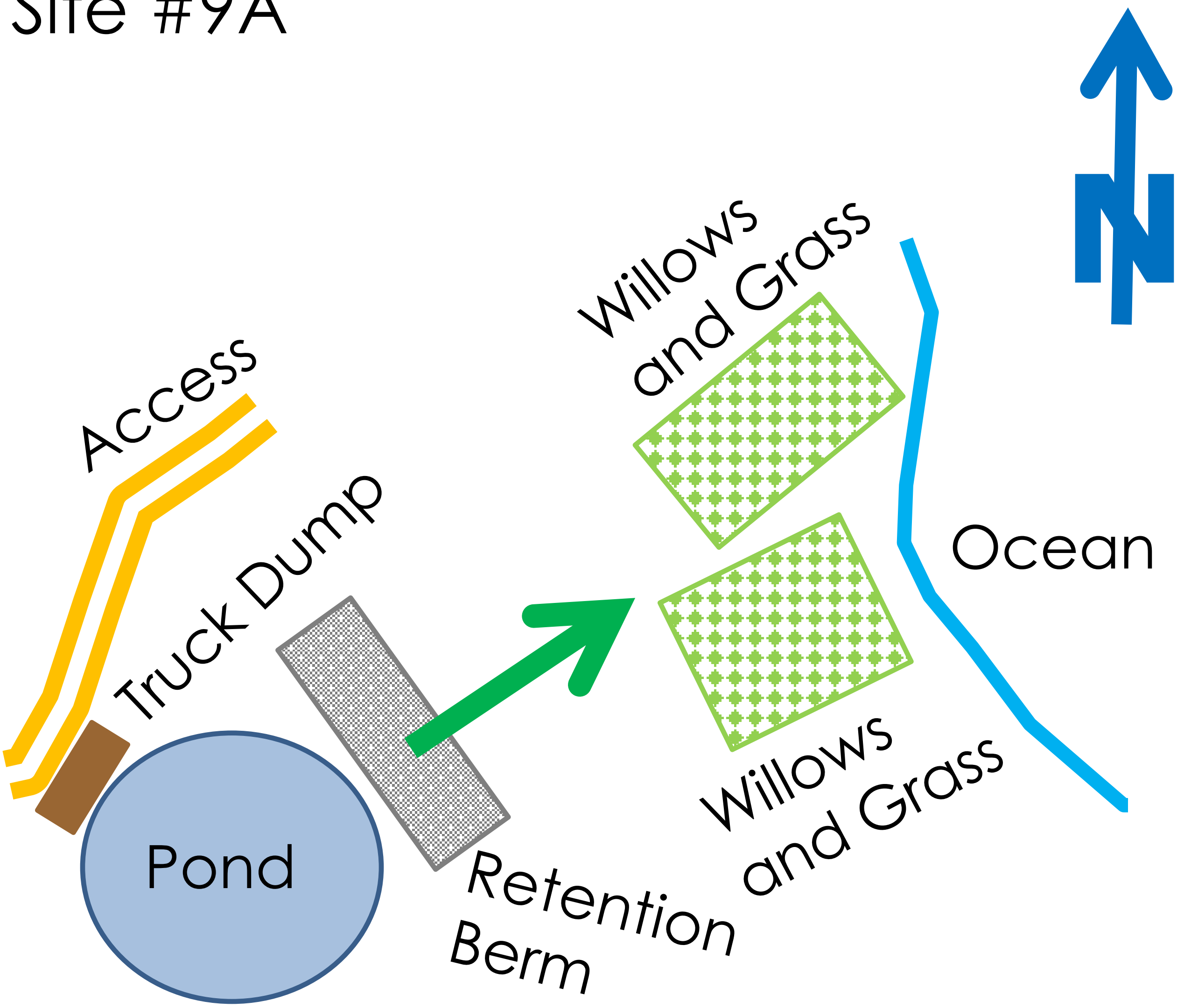
Wastewater Treatment Processes

Prepared by Ken Johnson, RPP, P.Eng. 2014 11 24

Figure 16

Stantec

Site #9A



NOT TO SCALE

Kimmirut

Sewage Treatment Study

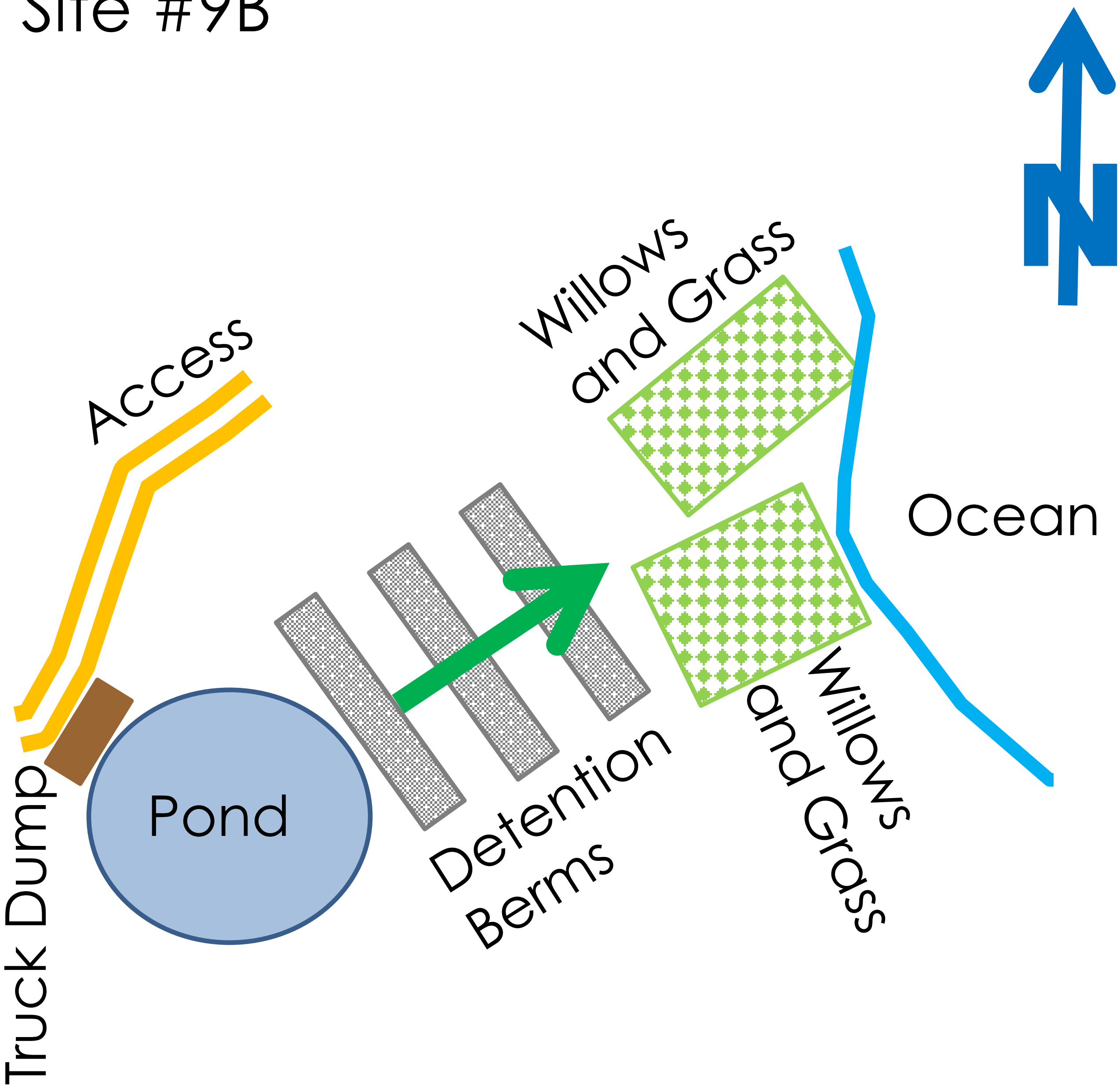
Wastewater Treatment Processes

Prepared by Ken Johnson, RPP, P.Eng. 2014 11 24

Figure 17

Stantec

Site #9B



NOT TO SCALE

Kimmirut

Sewage Treatment Study

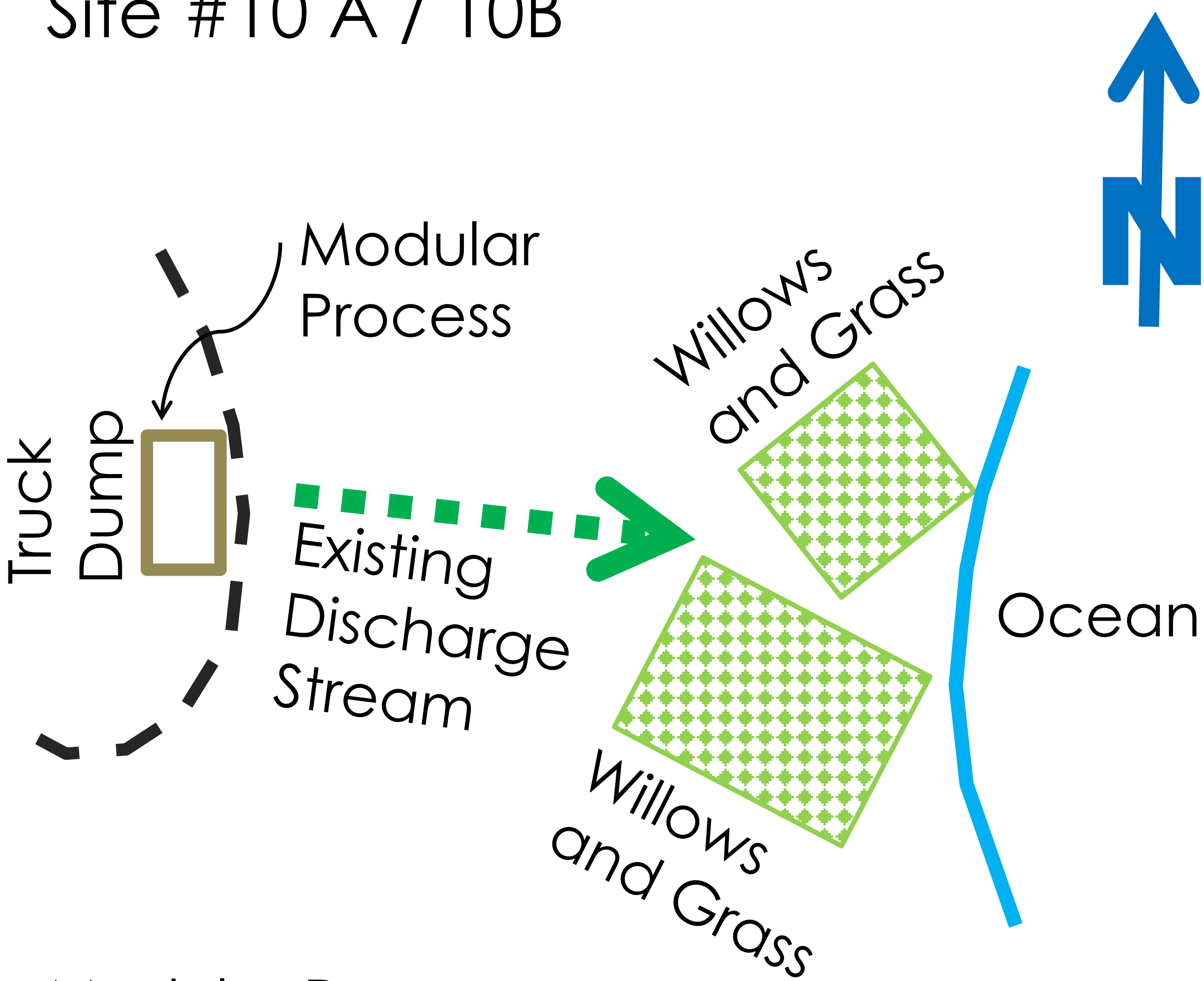
Wastewater Treatment Processes

Prepared by Ken Johnson, RPP, P.Eng. 2014 11 24

Figure 18

Stantec

Site #10 A / 10B



Modular Processes

1. Membrane Bioreactor
2. Septage Receiving

NOT TO SCALE

Kimmirut

Sewage Treatment Study

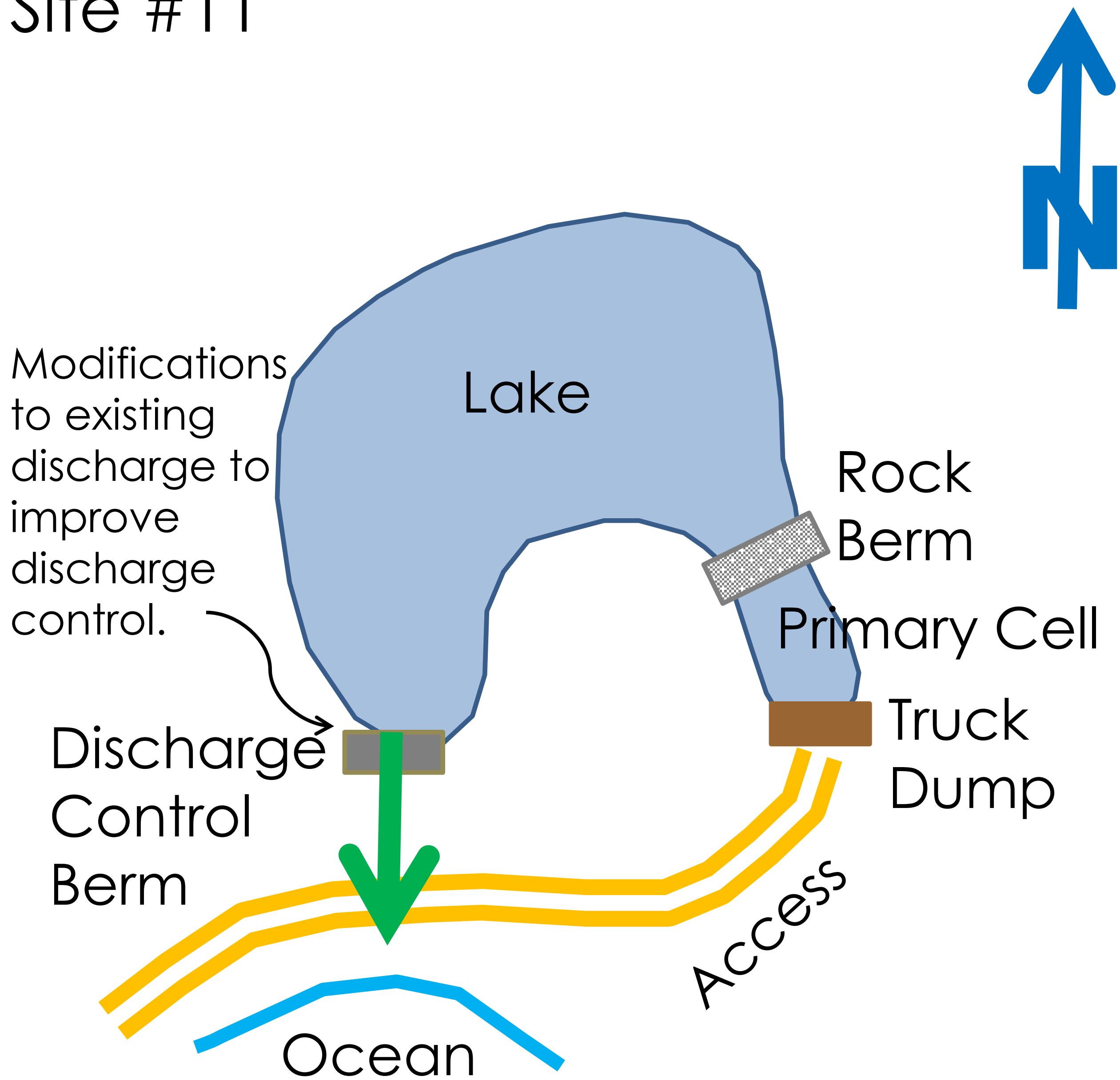
Wastewater Treatment Processes

Prepared by Ken Johnson, RPP, P.Eng. 2014 11 24

Figure 19

Stantec

Site #11



NOT TO SCALE

Kimmirut

Sewage Treatment Study

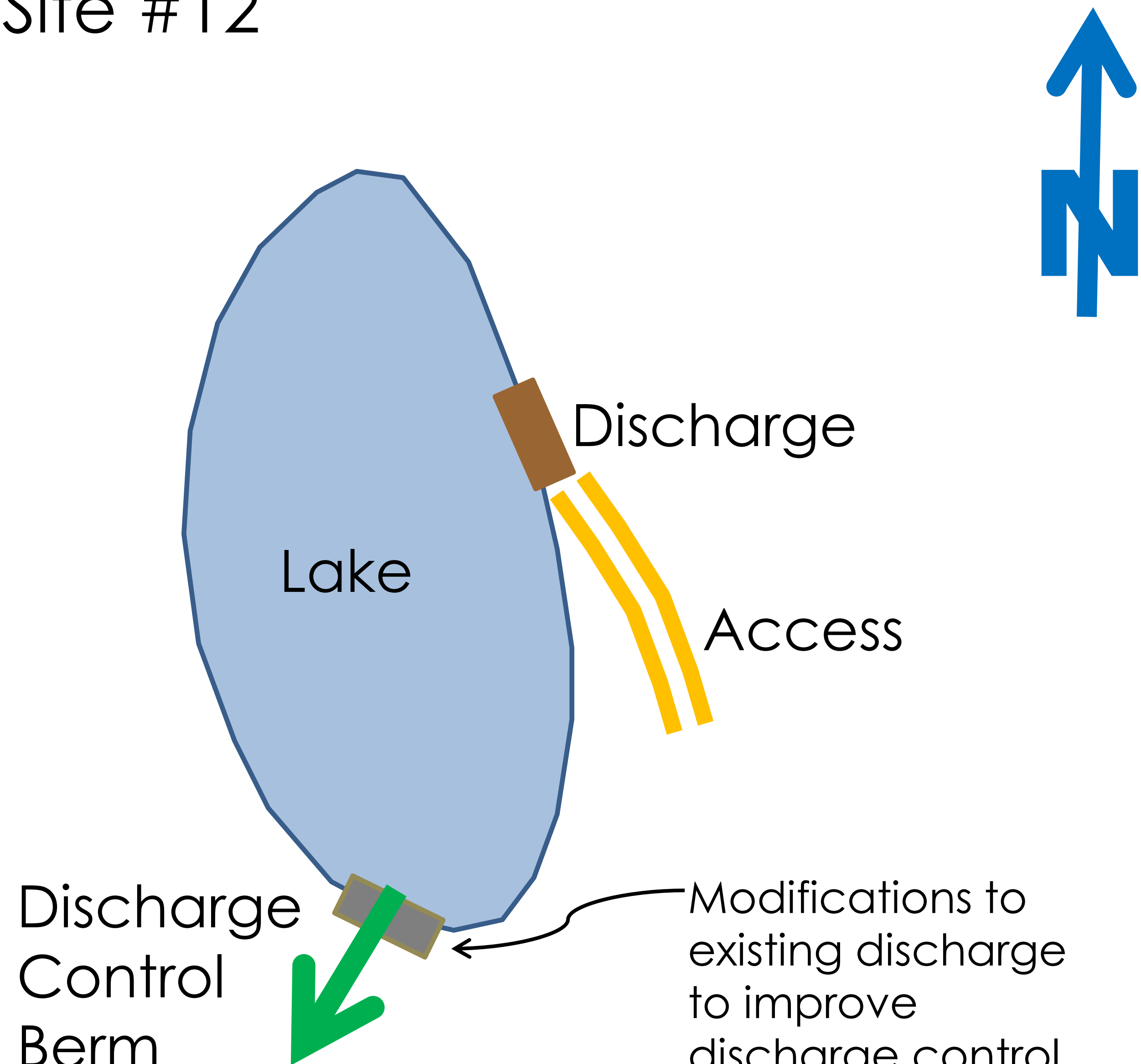
Wastewater Treatment Processes

Prepared by Ken Johnson, RPP, P.Eng. 2014 11 24

Figure 20

Stantec

Site #12



NOT TO SCALE

Kimmirut

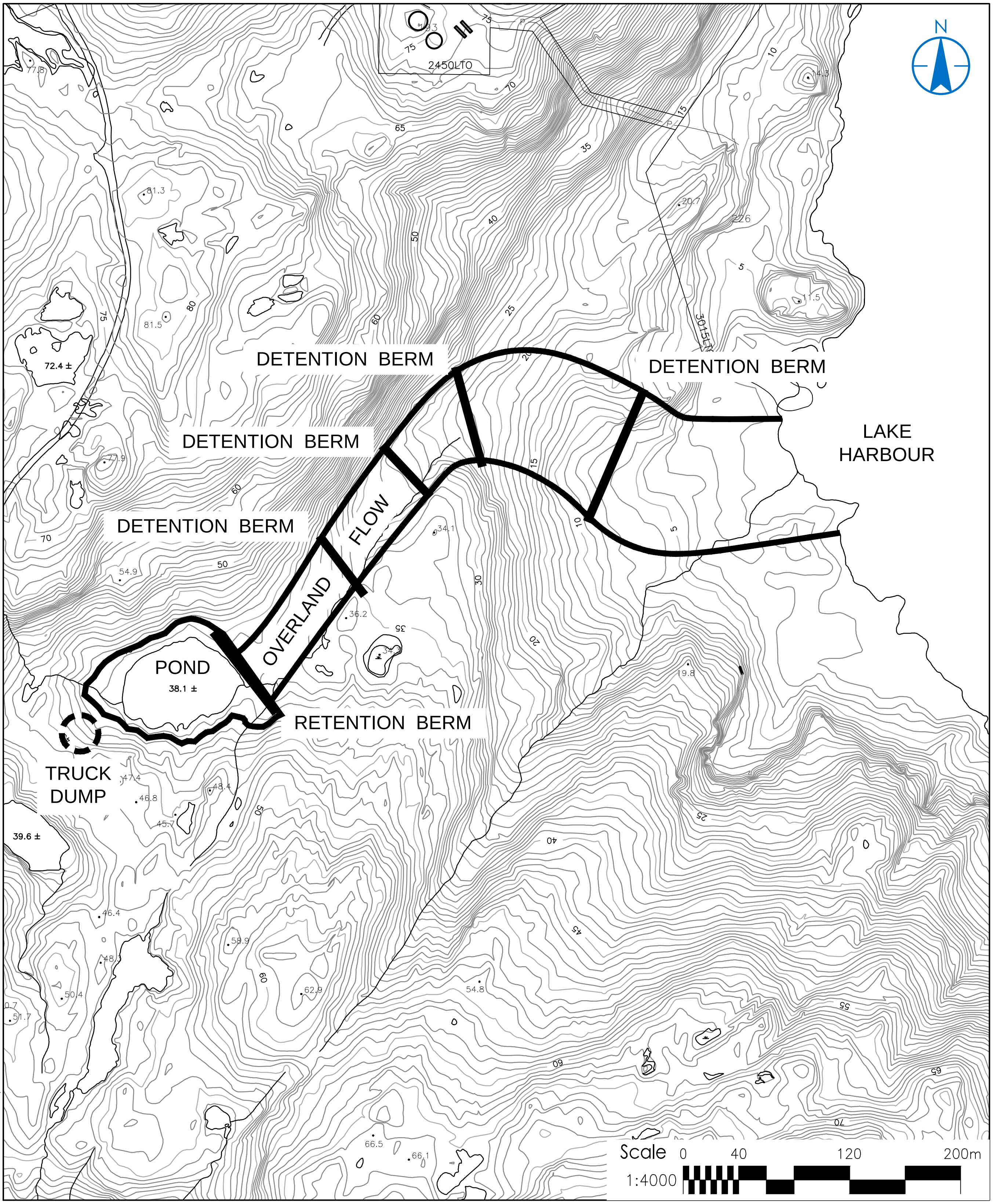
Sewage Treatment Study

Wastewater Treatment Processes

Prepared by Ken Johnson, RPP, P.Eng. 2014 11 24

Figure 21

Stantec



V:\1101\active\144902060\figures\current\figure_site-9A.DWG
2015/01/13 1:12 PM By: Buchsdruecker, Bernie

Stantec

10160 - 112 Street
Edmonton AB
www.stantec.com

Client/Project

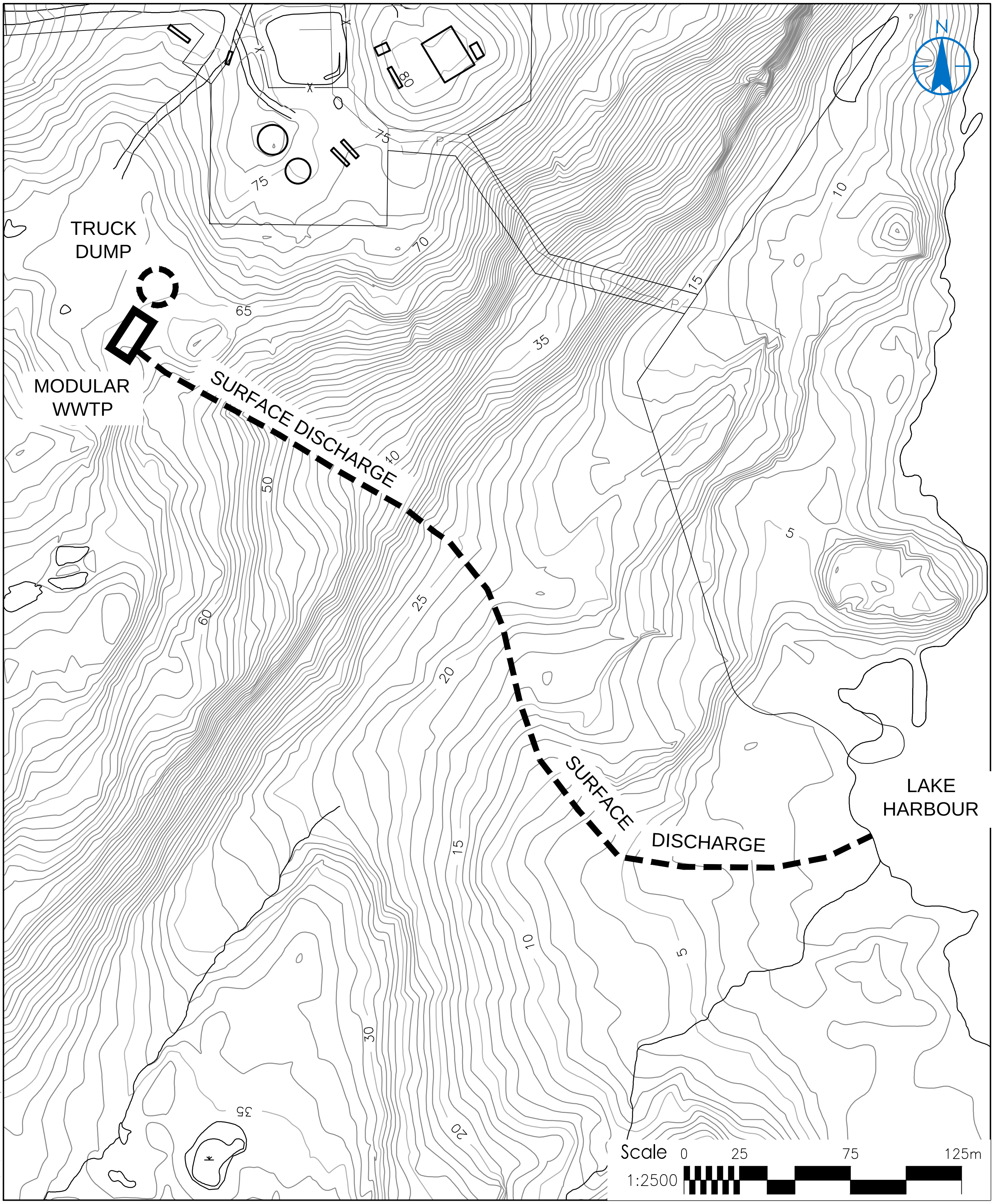
GOVERNMENT OF NUNAVUT
KIMMIRUT WASTEWATER FEASIBILITY STUDY

Figure No.

22

Title

Site 9A



V:\1101\active\144902060\figures\current\figure_site-10.DWG
2015/01/13 1:19 PM By: Buchsdruecker, Bernie

Stantec

10160 - 112 Street
Edmonton AB
www.stantec.com

Client/Project
GOVERNMENT OF NUNAVUT
KIMMIRUT WASTEWATER
FEASIBILITY STUDY

Figure No.
23

Title
Site 10

APPENDIX A

Initial Area Analyses and Selection

To:	Government of Nunavut Pond Inlet	From:	Ken Johnson, RPP, P.Eng. Edmonton
File:	1444902060	Date:	October 3, 2014

RE: INITIAL FACILITY SITING ANALYSIS

A. Watersheds (See Figure 1) – the area around Kimmirut has been segmented into 6 distinct watersheds representing surface runoff draining into Soper Lake, Soper River (downstream of Soper Lake), Lake Harbour, Glasgow Inlet, Pleasant Inlet (includes Kimmirut water supply lake (Lake Fundo), and North Bay. Sewage from Kimmirut currently discharges in the Lake Harbour catchment area, and the new sewage area would discharge into the Pleasant Inlet catchment area (downstream of the water supply lake.

B. Land Use Constraints (See Figure 2) – Definitive land use constraints for a lagoon facility are associated with the the Fundo Lake Water shed which provides drinking water to Kimmiruat, and an environemntal setback of 450 metres from the community for wastewater treatment facilities. Other land use related constraints may be associated with community use along the shore of Soper Lake and along the shore of Soper River.

C. Terrain Analysis (See Figure 3) – A very coarse terrain analysis identifies areas with slopes generally less than 10 percent, which is an anticipated maximum slope for the construction of any sewage detention structure. A maximum slope of 1 % is the desireable slope for a proper functioning wetland.

D. Excluded Areas (See Figure 4) – An initial compilation of areas excluded from the consieration of a sewage lagoon site are the Lake Fundo catchment area, which is the water supply source; the 450 metre environmental setback from the community (rounded to 500 metres), and; an the area beyond a 3 kilometre radius from the community. A three (3) kilometre radius was selected based upon an maximum reasonable cost of construction of $3 million dollars for a engineered road from the community to a facility ($1 million per kilometre).

E. Potential Areas (See Figure 5) – A total of eighteen (18) potentia areas for the development of a lagoon facility are identified based upon areas with an anticipated slope of less than 10 percent and areas outside the excluded areas (Figure 4). The areas identified are generally

Reference: Kimmirut Wastewater Facility Feasibility Study

between 50 and 100 hectares in size; the anticipated size of a lagoon retention facility would be less than 3 hectares (30,000 square metres).

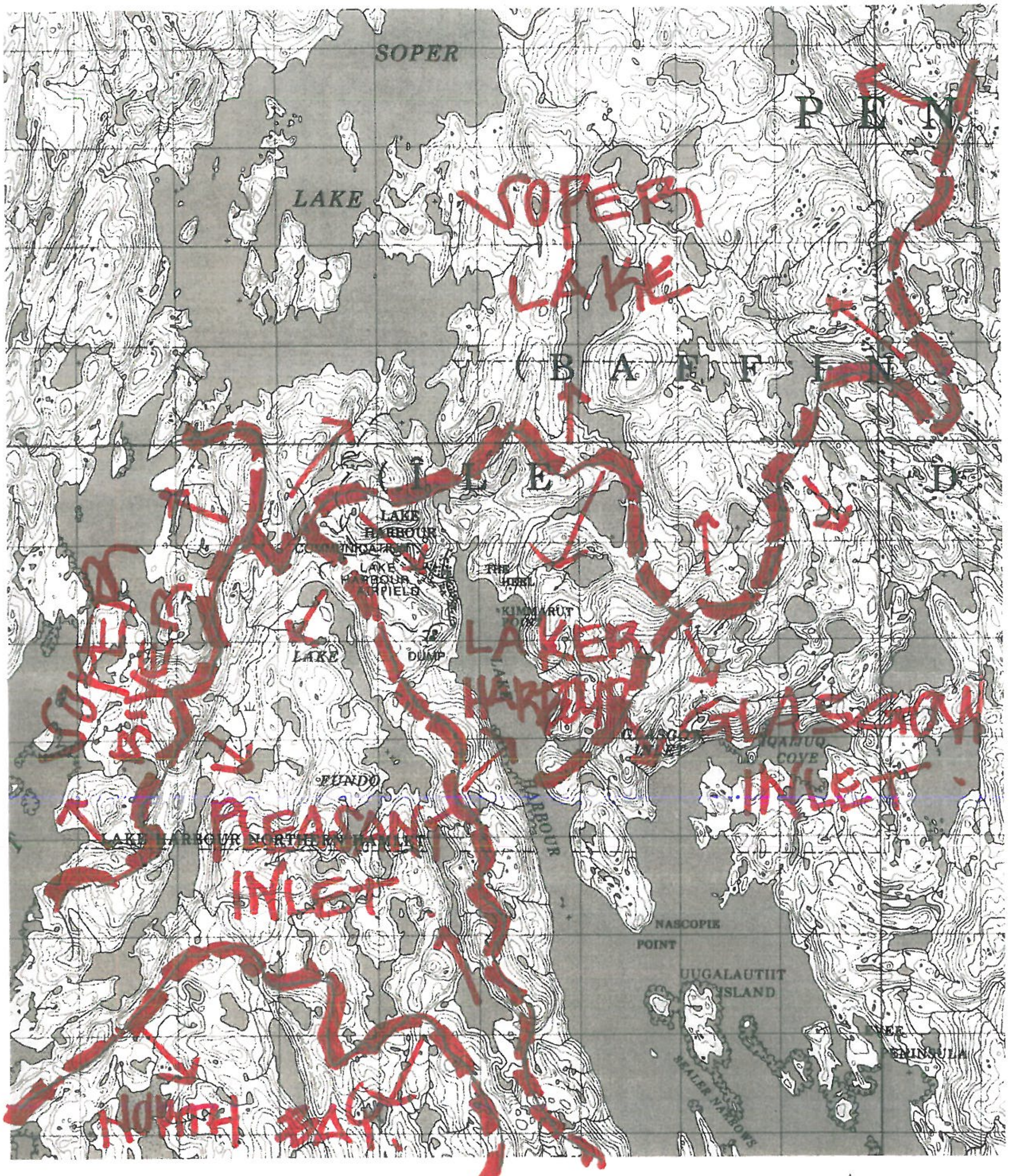
F. Areas Selected for Further Analysis (See Figure 6) – A total of 6 areas have been selected for potentially advancing to a more detailed analyis to identify potential 3 hectare lagoon sites within these areas; 2 additional areas may be considered in the analysis, names area 2 (existing new site) and area 6, which was identified in previous report (Dilllon 1999). The community visit and discussion with Council may change some of the 6 areas.

STANTEC CONSULTING LTD.

Ken Johnson, RPP, P.Eng.
Environmental Planner and Engineer
Phone: 780 984 9085
Ken.Johnson2@stantec.com

Attachments

Figures 1 through 6, as referenced in memo, dated October 3, 2014



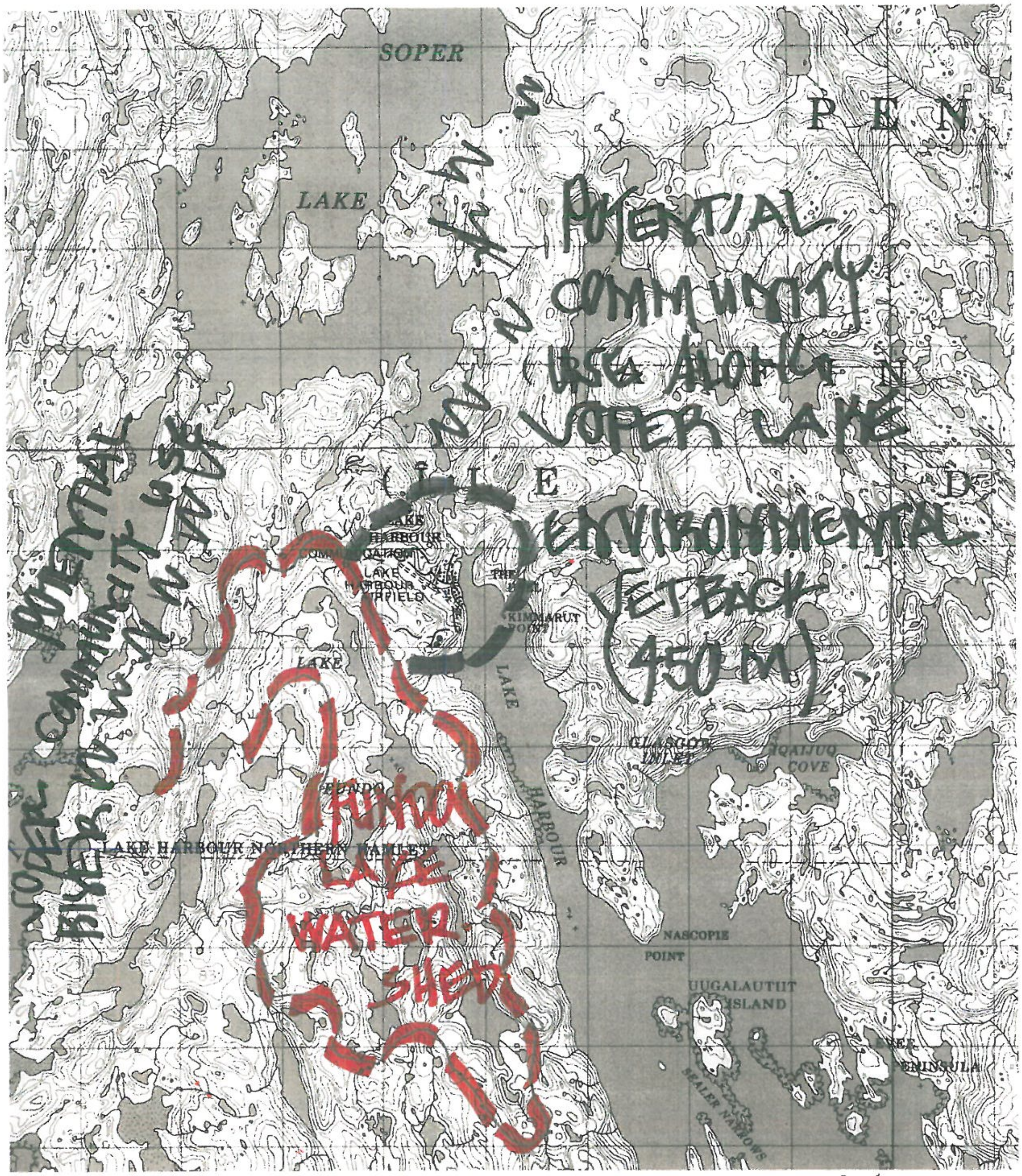
WATERSHEDS.

Kimmirut
Sewage Treatment Study

Stantec

Prepared by Ken Johnson, RPP, P.Eng.
October 3, 2014

FIGURE 1



LAND USE CONSTRAINTS

Kimmirut

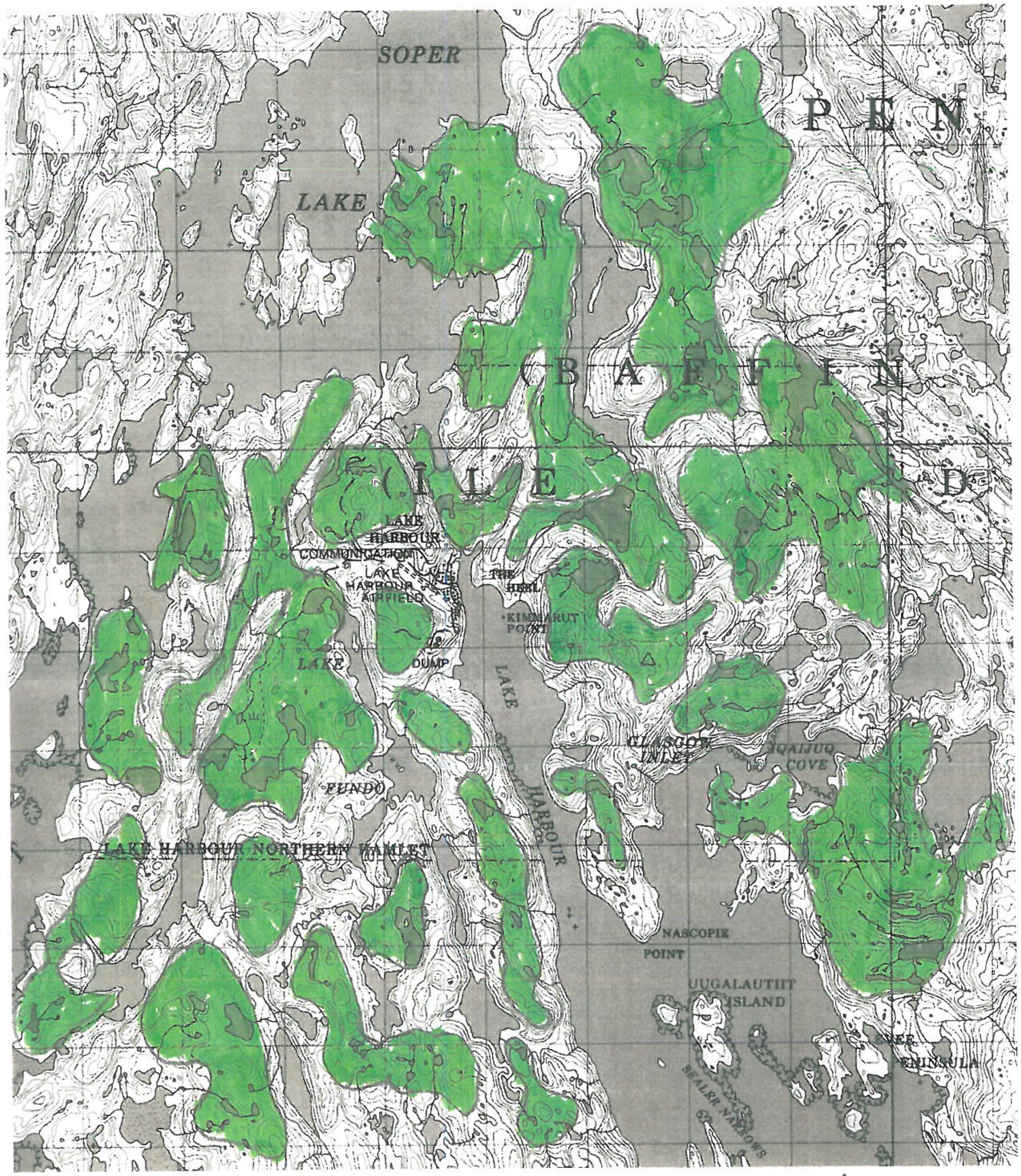
Sewage Treatment Study

FIGURE 2

Stantec

Prepared by Ken Johnson, RPP, P.Eng.
October 3, 2014

NOTES: 1 FUNDO LAKE IS KIMMIRUT'S WATER SUPPLY
2. 450 METRE SETBACK IS PUBLIC HEALTH REGULATION.



Kimmirut
Sewage Treatment Study

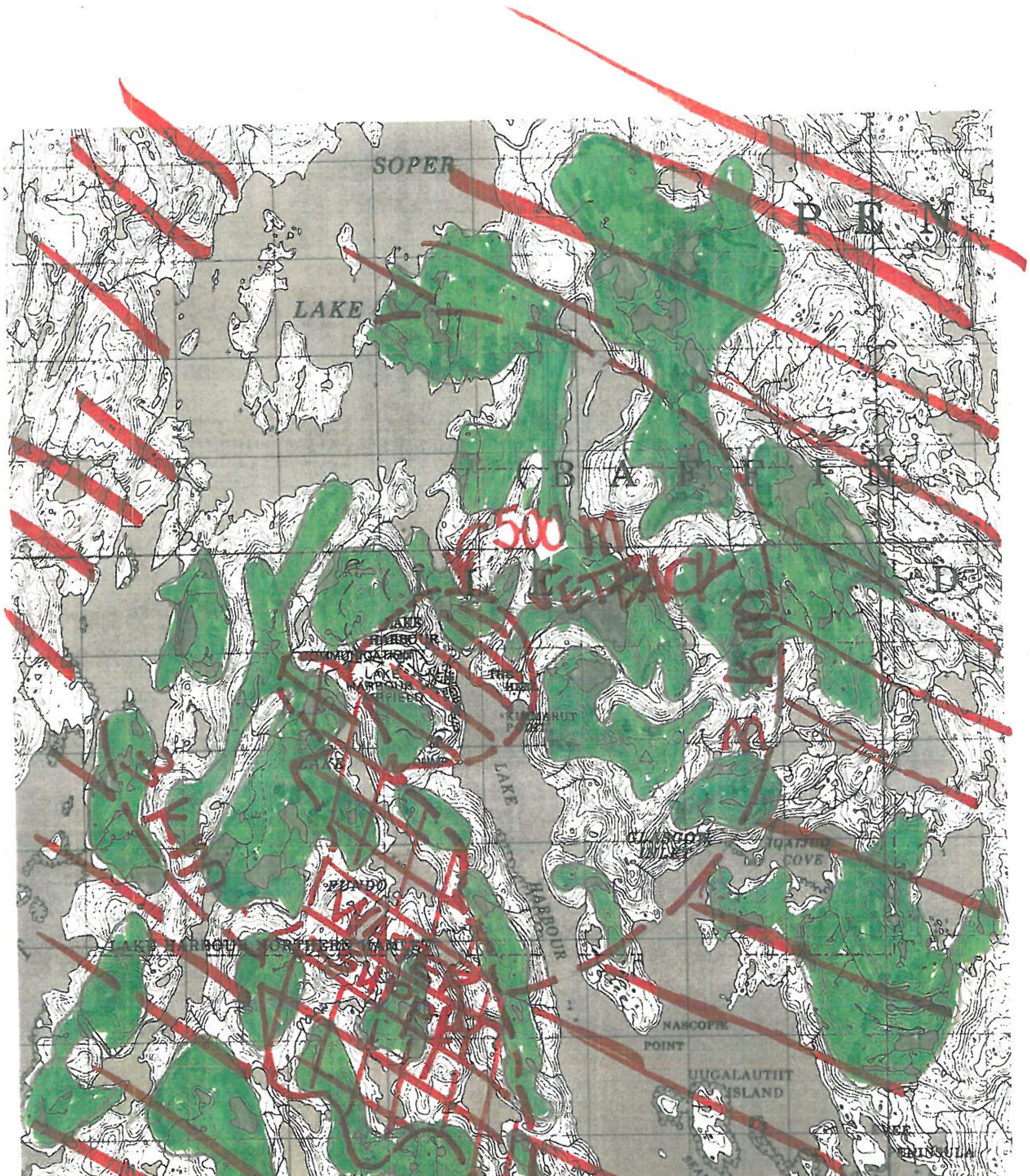
FIGURE 3

Stantec

TERRAIN ANALYSIS (<10%)

Prepared by Ken Johnson, RPP, P.Eng.
October 3, 2014

COARSE ANALSIS



EXCLUDED AREAS

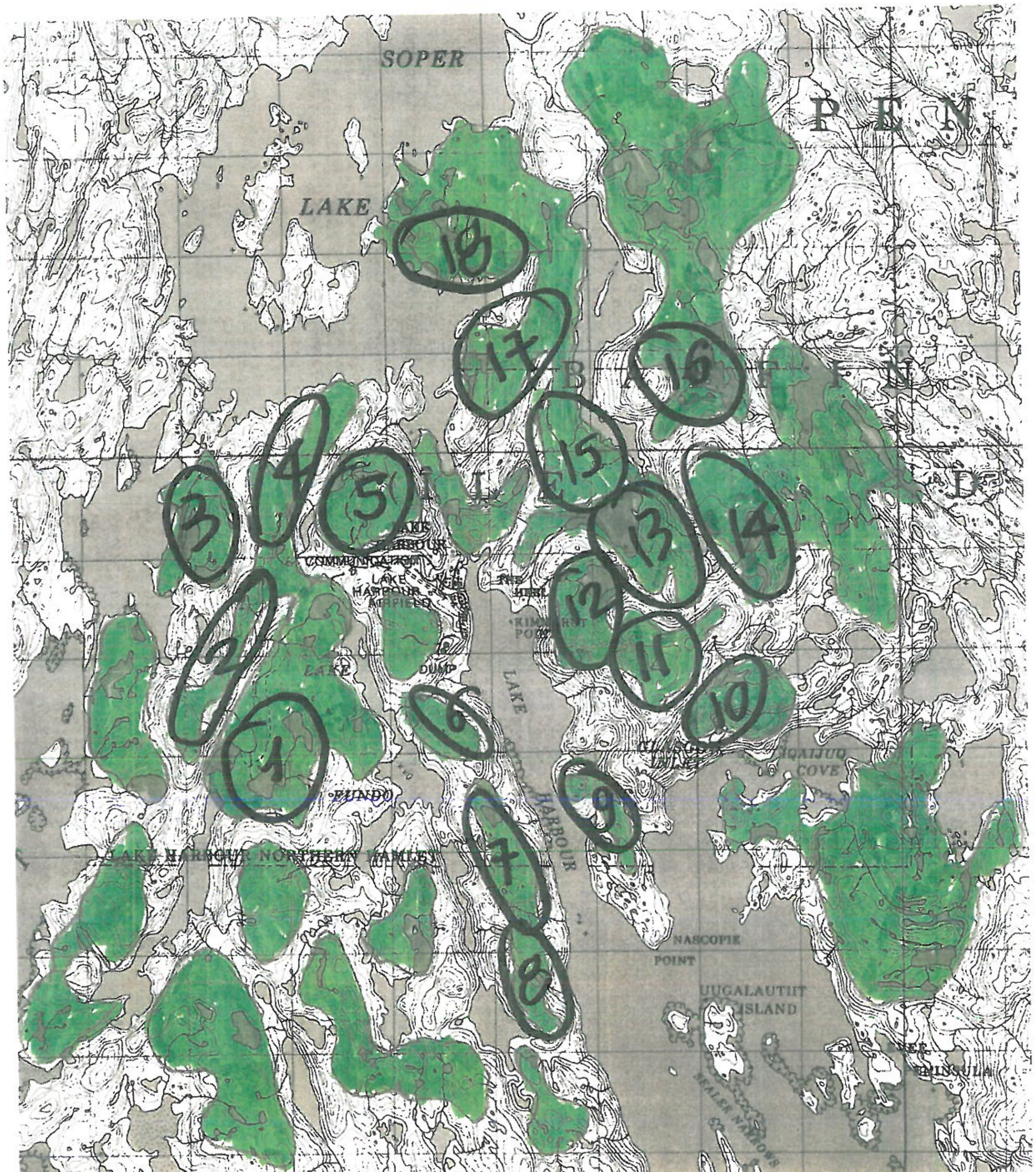
Kimmirut
Sewage Treatment Study

FIGURE 4

Stantec

Prepared by Ken Johnson, RPP, P.Eng.
October 3, 2014

NOTE: ROAD CONSTRUCTION BEYOND 3 km LIMIT ESTIMATED TO BE $2 TO $3 MILLION.



POTENTIAL AREAS

Kimmirut
Sewage Treatment Study

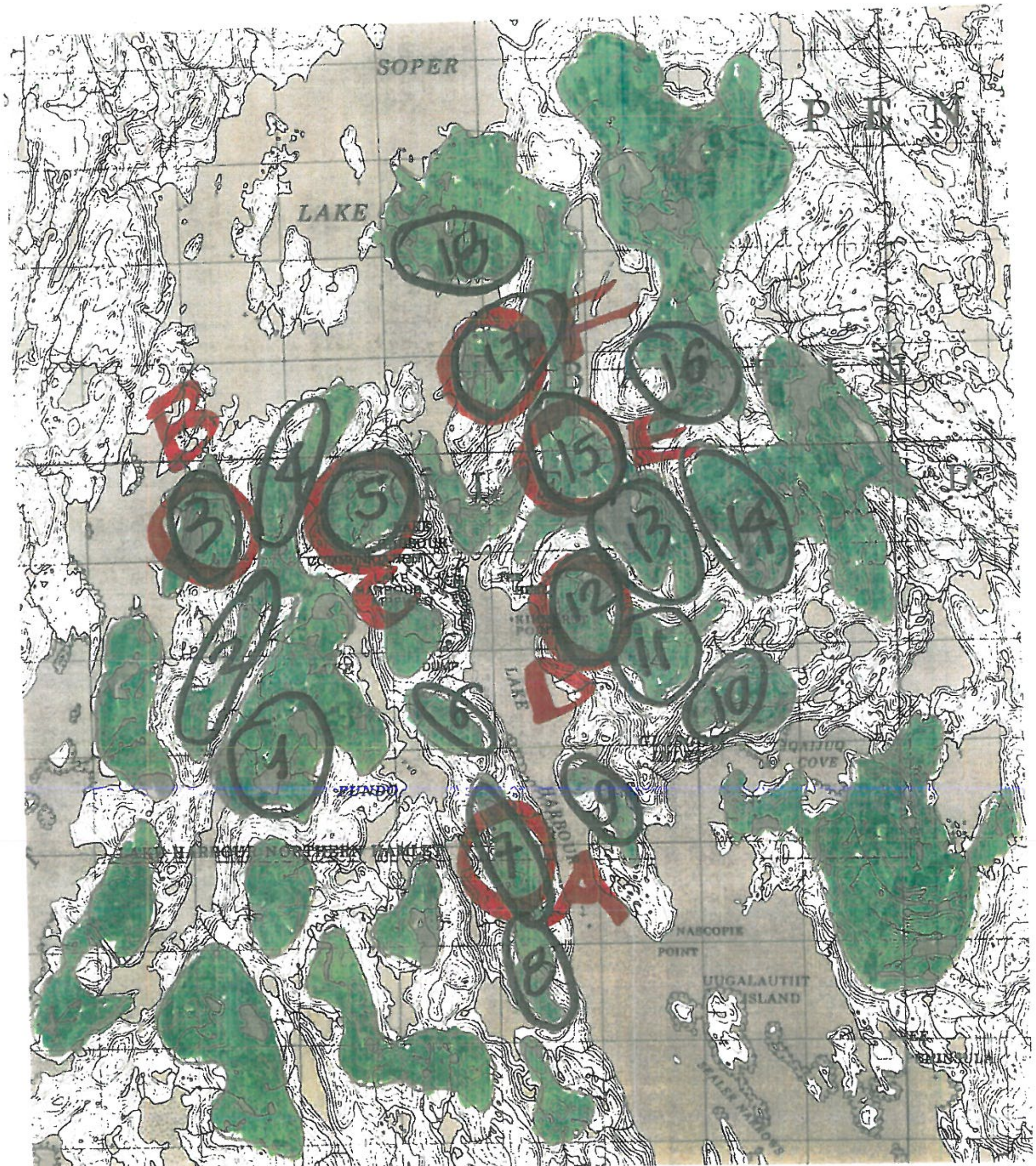
Stantec

Prepared by Ken Johnson, RPP, P.Eng.
October 3, 2014

FIGURE 5

LAGOON AREA ANTICIPATED TO BE UNDER 3 HECTARES (150 M x 150 M)

NOTE: AREAS ARE OUTSIDE EXCLUDED AREAS AND GENERALLY 50 TO 100 HECTARES.



Kimmirut
Sewage Treatment Study

Stantec

FIGURE 6

AREAS SELECTED FOR FURTHER ANALYSIS A THROUGH F

Prepared by Ken Johnson, RPP, P.Eng.
October 3, 2014

NOTE: AREA 2 IS EXISTING NEW AREA; AREA 6 ANALISED IN 1999 DILLON REPORT.

APPENDIX B

Council Meeting Notes

Stantec

Meeting Minutes

Hamlet Council Meeting

Kimmirut Wastewater Feasibility Study/ File 144902060

Date: October 23, 2014 , Council Chambers, Kimmirut, NT

Prepared by Ken Johnson, P.Eng., RPP

General Discussion

Currently, the community discharges sewage to a ditch which drains directly to the ocean. In response to regulatory pressures, Kimmirut will need to improve the effluent released into receiving waters. Stantec has been retained by the Government of Nunavut to complete a study outlining and evaluating various options for sewage treatment in Kimmirut.

Rankin Inlet currently uses relatively low-cost screens to separate out larger material prior to piping the screened effluent to the ocean. Since Kimmirut experiences high tides and ice build-up, piped discharge may not be feasible for the community. Significant reductions in capital costs could be achieved by using the constructed pond / wetland system; this system has never been used. If this option is not deemed feasible, a new pond system would be the most cost-effective method. The community could also consider installation of a mechanical plant. However, this option would result in significantly higher capital and operating costs. Council indicated that funding is not available for any new facility development.

Review and Discussion of Existing Facilities

It was determined that the existing lagoon site, which would discharge into a wetland downstream of Lake Fundo should be eliminated from consideration due to Government of Nunavut regulatory restrictions related to fish habit protection.

Review and Discussion of Lagoon Wastewater Systems

The preferred configuration for passive lagoon treatment is two ponds connected in series with a constructed wetland. This design will take advantage of several different naturally occurring contaminant removal processes. The first pond is designed to target solids removal through sedimentation. Once the water is clarified, additional contaminants are removed in the shallow second pond through reactions initiated by sunlight. Finally, in the wetland, remaining solids, heavy metals and nutrients which pollute receiving waters would be removed through biofiltration.

Approximate pond dimensions are anticipated to be between 150 metres by 150 metres by 2 m deep. Any pond excavation will need to be accomplished by rock blasting and is expected to be costly. The operational and maintenance costs of this system are expected to be within the order of tens of thousands annually. This is less than half of the cost that would be expected in a mechanical wastewater system.

Review and Discussion of Mechanical Wastewater System

A mechanical wastewater system would provide higher treated effluent quality. However, operation of this type of facility could prove to be a financial burden to the community overtime. Based on available information, initial capital cost will likely be within the order of four to six million, while operating and maintenance costs are anticipated to be hundreds of thousands of dollars per year. Historically, mechanical plants have experienced limited success in Northern regions due to these high costs as well as difficulty in maintaining these systems. Repairs often require technicians from outside of the community and delivery of parts can take significantly longer, potentially resulting in long periods of down time.

Community Use Issues

When selecting potential sites, community interests such as fishing, hunting and trapping need to be considered so that the proposed facility will not detrimentally impact these activities. Council expressed generally no concern over the use of existing lakes as a sewage receiving "pond."

There is a park boundary to the north along the south shore of Soper Lake resulting in building restrictions. It was noted that Soper Lake is salty and therefore cannot be used as a secondary water source. Char and rock cod fishing are, however, popular activities in Soper Lake and so it is important to ensure that lake-use does not impact the water quality. Lake Harbour does not support fishing and therefore any concerns with use of this area would be mainly influenced by regulatory requirements. Additionally, it was noted that there is a concern with subsurface flow near the lakes just west of the hamlet.

Review and Discussion of Potential Site on Satellite Image

Several locations were evaluated for use as new sewage treatment site. The area to the northeast was determined to be too rough for road construction and several areas were eliminated based on environmental sensitivity.

Potential locations of a secondary water supply were discussed.

Discussion of Water License Process

The water license, issued by the Nunavut Water Board, sets water use limits and defines the acceptable effluent discharge quality that can be returned to the environment. The water license is enforced by Aboriginal Affairs and Northern Development Canada (AANDC) as The Water Board does not have the necessary personnel to carry out site inspections. There are several other independent regulatory agencies that also have jurisdiction over water such as the Department of Fisheries and Oceans (DFO). Legislation set by DFO supersedes Water Board legislation, and this this can complicate the water license process.

APPENDIX C

Fisheries Notes

<u>Kimmirut</u>

<u>Wastewater Feasibility Study</u>

<u>Fishery Review</u>

<u>Physical Environment</u>

Nunami identified a number of potential sites for wastewater treatment facilities (WWTFs) in the hamlet of Kimmirut, NU, for further feasibility assessment. Construction and operation of a WWTF at any of these potential sites has the potential to interact with marine, brackish, or freshwater environments, and these environments may contain fish species with commercial, recreational, or Aboriginal (CRA) value. For each potential site, there are two areas where fish and fish habitat interactions need to be considered: at the site where the WWTF would be built, and the downstream receiving environment, where effluent will be discharged to.

As a requirement of the federal *Fisheries Act,* potential interactions of the WWTF sites with possible CRA fisheries were examined. Additionally, any fish species of territorial or federal conservation concern were included in this assessment, especially those species listed under Schedule 1 of the federal *Species at Risk Act* (SARA). A desktop assessment of fish and fish habitat was completed for the freshwater, brackish and marine environments associated with the WWTF sites.

<u>Freshwater Habitat</u>

The WWTF Sites 1, 2, 7, 9, 10 and 11 include the use of assumed freshwater water bodies for wastewater containment and primary treatment. These water bodies are considered freshwater based on their location and elevation above sea level (i.e. greater than the highest forecasted high tide for 2015 of 12.3 m above sea level), and a presumed lack of tidal influence (DFO, 2014a).

Harvest data for Kimmirut (Priest and Usher, 2004), and discussions with the Hunters and Trappers Association (HTA), indicate that the community's freshwater fishery mainly consists of Arctic charr (*Salvelinus alpinus*). The principal locations for this fishery are Lake Fundo, Lake Tuullitsut and Long Lake (K. Pitsiuliak, *pers. comm.*). Harvest data also reports that inconnu (*Stenodus leucichthys*) are captured (Priest and Usher, 2004), however Evans *et a.l* (2002) states inconnu are not known to occur in Nunavut. Catch locations for inconnu were not provided by Priest and Usher (2004) and is it possible that community members may refer to a different local fish species as "inconnu" or they are captured elsewhere. The discrepancy does warrant further investigation.

Arctic charr exhibit two life history strategies: anadromous and freshwater resident (Scott and Crossman, 1973). Anadramous Arctic charr may be found in freshwater (e.g., lakes, rivers and streams), brackish, and marine habitats at different times in their lifecycle (Evans *et al*, 2002. The potential WWTF sites identified as freshwater may contain resident or anadromous Arctic charr at some point throughout the year. A field investigation into the potential use of these freshwater sites by Arctic charr should be considered.

Various governmental, non-governmental, and academic resources were searched to find site-specific fish and fish habitat information at the potential freshwater WWTF sites. Little information was found except for Site 7. From August 3 to September 4, 2013, Nunami conducted a fish and fish habitat assessment of the wetland area between Lake Tuullitsut and Lake Fundo (Nunami Stantec, 2014). This wetland was proposed to receive effluent from the constructed WWTF at Site 7. Six locations within the assessment area were sampled and three fish species were caught: Arctic charr, threespine stickleback (*Gasterosteus aculeatus*), and ninespine stickleback (*Pungitius pungitius*). The assessment concluded that the wetland area was important habitat for rearing/foraging, migrating, and possibly spawning Arctic charr (Nunami Stantec, 2014). As mentioned, the HTA also identified Lake Tuullitsut and Lake Fundo as community fishing sites for Arctic charr (K. Pitsiuliak, *pers. comm.*).

The SARA registry was searched to identify any freshwater species of territorial or federal conservation concern that might interact with the potential freshwater WWTF site. No freshwater species were found.

<u>Marine and Brackish Habitats</u>

Marine and brackish habitats were identified as receiving water bodies for potential WWTF sites. Lake Harbour is the only marine environment that would receive effluent from a WWTF directly (Sites 9, 10 and 11). Pleasant Inlet is a marine environment as well but it would not receive effluent directly from a WWTF; it is situated downstream from two brackish receiving environments. These two brackish receiving environments include Soper Lake, which would receive effluent from a potential WWTF at Sites 2, 3 and 4, and a presumed brackish lake on the east shore of Pleasant Inlet that would receive effluent from a potential WWTF at Site 1. Although the term ‘lake’ is usually associated with freshwater, a study of Upper Soper Lake, north of the mouth of the Soper River, identified that lake as brackish and lying within the tidal influence (Anderson *et al*, 1999).

Consultation with the Kimmirut HTA, and review of Kimmirut harvest data from the Nunavut Wildlife Harvest Study (Priest and Usher, 2004), indicate that the community’s fishery in marine and brackish environments consists of, but is not limited to: Arctic charr, unspecified cod species (potentially *Gadus ogac* or *Gadus morhua*) and sculpin species (*Myoxocephalus spp*). The HTA also noted that there is a local mussel fishery near the reversing falls between Soper Lake and Pleasant Inlet (K. Pitsiuliak, *pers. comm.*).

Migratory Arctic charr reach maturity around six to nine years of age. In the fall, charr will move up rivers to spawn and overwinter in the river or connected lakes. Juvenile anadromous Arctic charr remain in freshwater for four to five years when they take their first-time migration to sea from freshwater (Evans *et al*, 2002). Juvenile and adult Arctic charr return to estuarine and marine waters at freshet in the spring, spending approximately 40 days along the coast prior to returning to freshwater in the fall (Evans *et al*, 2002). A local Arctic charr fishery at the brackish Soper Lake, and near the reversing falls between Soper Lake and Pleasant Inlet, was identified by the HTA (K. Pitsiuliak, *pers. comm.*).

Other marine species that could interact with effluent from potential WWTFs include the three cod species known to occur around Baffin Island: Greenland cod (*Gadus ogac*), Atlantic cod

(Gadus morhua), and Arctic cod (*Boreogadus saida*). Greenland cod, although found in marine waters up to 400 m deep, are more common in nearshore areas than offshore areas (Scott and Scott 1988). Greenland cod are demersal and considered non-schooling (Mikhail and Welch 1989). Spawning occurs in nearshore brackish waters during the winter months, often at the mouths of rivers (D. Chiperzak, *pers. comm.*).

Both marine and land-locked populations of Atlantic cod are known in the waters around Baffin Island. Little is known about the Arctic marine population of Atlantic cod; they are infrequently caught and may be an extension of cod stocks from western Greenland (COSEWIC 2010). Land-locked Atlantic cod are documented from several brackish lakes on Baffin Island and these populations are designated as Special Concern (COSEWIC 2010) and are under consideration for SARA. In these lake populations, Atlantic cod spend most of their time in the saline waters in the bottom half of the brackish, meromictic lakes, and only venture into the upper freshwater layer for short periods of time (DFO 2014b). Spawning occurs in water depths up to 30 m in these lakes (DFO 2014b). Whether the species of cod in Soper Lake is Greenland or Atlantic is unknown and needs to be confirmed.

Arctic cod are often associated with drifting pack ice, but large congregations of Arctic cod have been reported in the nearshore region of the Alaskan Beaufort Sea during the summer months (Craig et al. 1982), depending on the location of the shoreward edge of the cooler and more saline marine water mass (Moulton and Tarbox 1987). Large concentrations of Arctic cod have also been reported in deep water, ice-covered bays such as Franklin Bay (Benoit et a. 2008) and during the open water season along the Beaufort Sea and Chukchi continental shelf and slope between 250 to 350 m depth (Crawford et al. 2012).

Eight marine species of sculpin were identified during a wildlife inventory for Nunavut (Nunami Stantec 2012). Some of these species are likely to occur in the shallow, brackish and marine effluent receiving environments near Kimmirut. For example, fourhorn sculpin (*Myoxocephalus quadricornis*) are known to be taken as food fish throughout Nunavut (Priest and Usher 2004) and is typically associated with brackish waters (Scott and Scott 1988).

Three species of wolffish were identified as species of federal conservation concern in Nunavut: Atlantic wolffish (*Anarhichas lupus*; Special Concern), spotted wolffish (*Anarhichas minor*; Threatened) and northern wolffish (*Anarhichas denticulatus*; Threatened) (COSEWIC 2012a, b, c). However, Kimmirut lies on the extreme western edge of the three species distributions (COSEWIC 2012a, b, c) and they are not expected to occur.

Options Assessment

Site 1

At Site 1, the use of a small freshwater lake is proposed for wastewater containment and primary treatment with discharge into a brackish lake, and then into Pleasant Inlet. Through communication with the HTA, active Arctic charr, cod, and mussel fisheries were identified in Pleasant Inlet. As well, the HTA indicated that community members use the area adjacent to, and to west of the lake as a camp location. To identify baseline fish and fish habitat conditions of the lake and downstream receiving environments, and to support the assessment of potential effects of the WWTF, Nunami recommends the following field surveys:

- Fish and fish habitat field survey;
- Surface water chemistry sampling;
- Sediment chemistry sampling; and,
- Bathymetry field survey.

A field survey should include a reach-based assessment of fish habitat to examine habitat suitability for species of interest (e.g., Arctic charr, other CRA species) and connectivity to other potential fish-bearing waterbodies. At each reach, which includes freshwater ponds/lakes, streams, and brackish/marine receiving environments, fish habitat conditions, such as physical channel measurements, substrate composition, bank condition, water depth, and flow, should be characterized. At Site 1, fish sampling should be completed at the small freshwater lake and downstream brackish lake to determine fish presence and fish use, and support the assessment of potential effects, as required by the Nunavut Water Board (NWB). Typical non-lethal sampling methods could include the use of seine nets, hoop nets, dip nets, minnow traps, angling, and electrofishing. Any captured fish should be documented, photographed, enumerated, and identified to the lowest taxonomic level feasible. Depending on the depth of the lakes, gillnets could also be used to obtain an improved characterization of fish presence and use.

To characterize baseline water-chemistry conditions and allow for adequate monitoring of potential effects from WWTF discharge, seasonal sampling should be completed at both the small freshwater lake and the downstream brackish lake, near the outlet of the small freshwater lake. *In-situ* field measurements (e.g. temperature, conductivity and pH) should be taken, as well as water samples for chemical analysis (e.g., baseline nutrients, metals).

To characterize baseline sediment chemistry of the downstream receiving environments, a sediment-sampling program should be conducted in the downstream brackish lake, near the outlet of the small freshwater lake, and in Pleasant Inlet, near the outlet of the brackish lake. This will provide baseline data on sediment quality for use in future monitoring and assessment of potential effects from WWTF discharge.

Where adequate bathymetry information is not available for the small freshwater lake proposed for wastewater storage and treatment, a bathymetry survey should be completed to confirm water body volume and capacity for wastewater storage. This information will also assist with the assessment of habitat suitability. A boat could be used to collect bathymetric data.

The above recommendations for field surveys serve to collect baseline information on the existing condition of potential fish habitat associated with the potential WWTF site, fish presence, and use of habitat. Additional consultation with the community will likely be required for any of the proposed WWTF sites. Further, should a CRA fish species, or supporting fish species, be identified through these surveys, at Site 1 or any of the other potential WWTF sites described below, additional fisheries work may be required.

Site 2

At Site 2, the use of a small freshwater lake is proposed for wastewater treatment and storage with discharge into Soper Lake. It is noted that the HTA identified both cod and Arctic charr fisheries at Soper Lake, and also indicated that community members use the area adjacent to, and the west of, potential WWTF Site 2 as a camp location. Due to these reasons, there may be community opposition to the use of Soper Lake as a receiving water body.

Regardless, to identify baseline fish and fish habitat conditions of the lake and downstream receiving environment of Soper Lake, and to support the assessment of potential effects of the WWTF, Nunami recommends the following field surveys:

- Fish and fish habitat field survey;
- Surface water chemistry sampling;
- Sediment chemistry sampling; and,
- Bathymetry field survey.

As described for Site 1 above, a field survey for fish and fish habitat should include a reach-based assessment of fish habitat and fish sampling. At Site 2, fish sampling should be completed at the small freshwater lake and in Soper Lake, near the proposed WWTF discharge. Baseline water chemistry sampling could be completed in the small freshwater lake, while water and sediment chemistry sampling should be considered in the Soper Lake, near the proposed WWTF discharge. Bathymetry information could be collected for the small freshwater lake to confirm water body volume and capacity for wastewater storage, as well as assessment of fish habitat suitability.

Site 3

Site 3 is situated within an abandoned borrow source and wastewater treatment is proposed from the construction of detention berms with discharge to Soper Lake. As described above, there may be community opposition to the use of Soper Lake as a receiving water body due to the identified cod and Arctic charr fisheries, and community use of the area.

Regardless, to assess baseline fish and fish habitat conditions at Soper Lake, near the proposed WWTF discharge, and to support the assessment of potential effects of the WWTF, Nunami recommends the following field surveys:

- Fish and fish habitat field survey;
- Surface water chemistry sampling;
- Sediment chemistry sampling; and,
- Bathymetric field survey

As described for the previous sites above, a field survey for fish and fish habitat should include an assessment of fish habitat and fish sampling in Soper Lake, in the vicinity of the proposed WWTF discharge of Site 3. Baseline water and sediment chemistry sampling should be completed in Soper Lake, near the proposed WWTF discharge of Site 3, as well as a bathymetric survey to assess potential changes in fish habitat due to sediment transport from the WWTF. While the abandoned borrow source is not expected to provide fish habitat, the potential WWTF site should be visited to document site conditions and the presence of any nearby water bodies.

Site 4

Site 4 is situated within an abandoned borrow source and wastewater treatment is proposed from the construction of detention berms with discharge to Soper Lake. As described above, there may be community opposition to the use of Soper Lake as a receiving water body due to the identified cod and Arctic charr fisheries, and community use of the area.

Regardless, to assess baseline fish and fish habitat conditions at Soper Lake, near the proposed WWTF outlet, and to support the assessment of potential effects of the WWTF, Nunami recommends the following field surveys:

- Fish and fish habitat field survey;
- Surface water chemistry sampling;
- Sediment chemistry sampling; and,
- Bathymetric field survey.

As described for the previous sites above, a field survey for fish and fish habitat should include an assessment of fish habitat and fish sampling in Soper Lake, in the vicinity of the proposed WWTF discharge of Site 4. Baseline water and sediment chemistry sampling should be completed in Soper Lake, near the proposed WWTF discharge of Site 4, as well as a bathymetric survey to assess potential changes in fish habitat due to sediment transport from the WWTF. While the abandoned borrow source is not expected to provide fish habitat, the potential WWTF site should be visited to document site conditions and the presence of any nearby water bodies.

Site 7

The WWTF at Site 7 was constructed in 2011 but the facility has never been used since the NWB has not issued a water licence for the facility. The NWB expressed concern over potential fish habitat of the wetland, the downstream receiving environment of Site 7; this area is now known Arctic charr habitat, based on the study by Nunami Stantec (2014).

Because the downstream receiving environment of Site 7 is known habitat for a CRA fish species (i.e. Arctic charr), the use of Site 7 for the community's wastewater treatment has the potential to cause serious harm to fish (under Section 35 of the *Fisheries Act*) that utilize the wetland, and to their habitat in the wetland. Effects can arise from thermal loading (i.e. differences in water temperature between discharge and the receiving environment), nutrient loading, the input of contaminants, and the input of pathogens (DFO, 2010). If the GN proceeds with Site 7 and discharge to the wetland, further investigation into mitigative and/or offset options is necessary, as well as discussion with the NWB and the Department of Fisheries and Oceans (DFO) regarding regulatory requirements. As an example, the GN may need to consider guaranteed discharge quality from the WWTF to minimize (mitigate) effects of effluent on the wetland, and examine offset measures to balance the residual effects of the effluent discharge. Preferably, the impacts to the wetland would be avoided completely through selection of a new site, or engineering the effluent discharge to an alternate location.

If the GN proceeds with Site 7 and discharge to the fish-bearing wetland, further information will be necessary to complement the baseline information collected in 2013 to assist with quantification of effects, and identification of mitigative and/or offset options. Refining the exact study requirements should involve discussion with DFO. Additional studies may include a seasonal hydrologic program in the wetland to understand surface-water flow regimes throughout the year and their effect on fish habitat and use, further water chemistry sampling to characterize seasonal variability, and water quality and flow modeling to quantify potential effects to fish and fish habitat.

Site 9

At Site 9, the use of a small freshwater lake is proposed for wastewater storage and treatment with discharge into the marine environment of Lake Harbour. To identify baseline fish and fish habitat conditions of the lake and downstream receiving environment, and to support the assessment of potential effects of the WWTF, Nunami recommends the following field surveys:

- Fish and fish habitat field survey;
- Surface water chemistry sampling;
- Sediment chemistry sampling; and,
- Bathymetric field survey.

As described for the previous sites above, a field survey for fish and fish habitat should include a reach-based assessment of fish habitat and fish sampling. At Site 9, fish sampling should be completed at the small freshwater lake and in Lake Harbour, near the proposed WWTF discharge. Water chemistry sampling could be completed in the small freshwater lake, while water and sediment chemistry sampling should be considered in Lake Harbour, near the proposed WWTF discharge. Bathymetry information could be completed for the small freshwater lake to confirm water body volume and capacity for wastewater storage, as well as assessment of fish habitat suitability.

Site 10

Site 10 is located at the community's existing wastewater disposal site and wastewater is presently discharged directly to a stream, which eventually flows into the marine environment of Lake Harbour. There is an existing untreated wastewater at the site. Construction of wastewater treatment infrastructure here would improve effluent quality, and subsequently fish habitat conditions, near the WWTF discharge in Lake Harbour. A site visit is recommended to characterize the existing fish and fish habitat conditions at the stream and outlet site in Lake Harbour. By characterizing existing conditions, the hamlet and GN could to monitor any changes or improvements to these areas over time, following construction of treatment infrastructure. The following field surveys are recommended for the stream and outlet area on Lake Harbour:

- Fish and fish habitat field survey;
- Surface water chemistry sampling; and,
- Sediment chemistry sampling.

As described for the previous sites above, a field survey for fish and fish habitat should include a reach-based assessment of fish habitat and fish sampling. At Site 10, fish sampling should be completed along the stream and in Lake Harbour, near the proposed WWTF discharge. Water and sediment chemistry sampling should be considered in Lake Harbour, near the proposed WWTF discharge. Bathymetry information could be collected for Lake Harbour, in the c the small freshwater lake to confirm water body volume and capacity for wastewater storage, as well as assessment of fish habitat suitability.

REFERENCES CITED

Anderson, F.R., Hughen, A.R., and J.T. Overpeck. 1999. Recent warming in a 500-year palaeotemperature record from varved sediments, Upper Soper Lake, Baffin Island, Canada. The Holocene 10: 9-19.

Benoit, D., Y. Simard and L. Fortier. 2008. Hydroacoustic detection of large winter aggregations of Arctic cod (Boreogadus saida) at depth in ice-covered Franklin Bay (Beaufort Sea). Journal of Geophysical Research 113.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2010. COSEWIC Assessment and Status Report on the Atlantic Cod (*Gadus morhua)* in Canada. Available at: http://www.sararegistry.gc.ca/virtual_sara/files/cosewic/sr_Atlantic%20Cod_0810_e.pdf. Accessed: December 2014.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2012a. COSEWIC Assessment and Status Report on the Atlantic Wolffish (*Anarhichas lupus)* in Canada. Available at: http://www.registrelep-sararegistry.gc.ca/document/default_e.cfm?documentID=1133. Accessed: December 2014.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2012b. COSEWIC Assessment and Status Report on the Northern Wolffish (*Anarhichas denticulatus)* in Canada. Available at: http://www.registrelep-sararegistry.gc.ca/document/default_e.cfm?documentID=1156. Accessed: December 2014.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2012c. COSEWIC Assessment and Status Report on the Spotted Wolffish (*Anarhichas minor)* in Canada. Available at: http://www.registrelep-sararegistry.gc.ca/document/default_e.cfm?documentID=1162. Accessed: December 2014.

Craig, P.C., W.B. Griffiths, L. Haldorson and H. McElderry. 1982. Ecological studies of Arctic cod (*Boreogadus saida*) in Beaufort Sea coastal waters, Alaska. Canadian Journal of Fisheries and Aquatic Sciences 39: 395-406.

Crawford, R.E., S. Vagle and E.C.mack. 2012. Water mass and bathymetric characteristics of polar cod habitat along the continental shelf and slope of the Beaufort and Chukchi Seas. Polar Biology 35: 179-190

Evans, C.L., J.D. Reist and C.K. Minns. 2002. Life history characteristics of freshwater fishes occurring in the Northwest Territories and Nunavut, with major emphasis on riverine habitat requirements. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2614: xiii + 169 pp

Fisheries and Oceans Canada (DFO). 2010. Projects Near Water. Wastewater Management Schematic Diagram. Accessed December, 2014, from: http://www.dfo-mpo.gc.ca/pnw-ppe/pathways-sequences/wastewater-eaux-eng.html

Fisheries and Oceans Canada (DFO). 2014a. Tide Predictions for Kimmirut, NU. Accessed December, 2014, from: http://waterlevels.gc. ca/eng/data/ table/ 2015/ wlev_sec/4205

Fisheries and Oceans Canada (DFO). 2014b. Aquatic Species at Risk – Atlantic Cod (Arctic Lakes population). Accessed December 2014, from: http://www.dfo-mpo.gc.ca/species-especes/species-especes/cod-morue-eng.htm

Government of Canada. 2014. Species at Risk Act Public Registry. Accessed December 2014, from: http://www.sararegistry.gc.ca/

Morin, B., C. Hudon, and F. Whoriskey. 1991. Seasonal distribution, abundance, and life-history traits of Greenland cod, *Gadus ogac,* at Wemindji, eastern James Bay. Canadian Journal of Zoology 69: 3061-3070.

Nunami Stantec Limited (Nunami Stantec). 2012. Nunavut Wildlife Resource and Habitat Values. Amendment. Prepared for the Government of Nunavut Department of Community and Government Services .Vancouver, BC. 229 pp.

Nunami Stantec Limited (Nunami Stantec). 2014. Kimmirut Fish Habitat Assessment Project. Final Summary Report. Prepared for Government of Nunavut, Department of Community and Government Services. Edmonton, AB. 67 pp.

Pitsiulak, K. Hunters and Trappers Association of Kimmirut. Email correspondence. December, 2014.

Priest, H., Usher, P.J. 2004. The Nunavut Wildlife Harvest Study. Final Report. Nunavut Wildlife Management Board. Iqaluit, NU. 822 pp.

Scott, W.B. and E.J. Crossman. 1973. Freshwater Fishes of Canada. Bulletin of the Fisheries Research Board of Canada 184: xi + 966 pp.

Scott, W.B. and M.G. Scott. 1988. Atlantic fishes of Canada. Vol. 730. University of Toronto Press and Ministy of Fisheries and Oceans.

APPENDIX D

Wetland Notes

MEMORANDUM

Date: December 4, 2014

To: Ken Johnson, M.A.Sc., M.C.I.P., P.Eng.
Senior Environmental Engineer and Planner
Stantec, Edmonton, AB
Canada

From: Robert H. Kadlec, PhD, P.E.
Wetland Management Services
6995 Westbourne Drive
Chelsea, MI 48118

Subject: Potential for Treatment Wetlands for Kimmirut

I have reviewed the videos from your field inspection, and the one-meter contours you sent. As you know, I also have some knowledge gained from my own field trip a few years ago.

Per our phone discussions, here are some brief summary comments on the Kimmirut alternatives.

The terrain near Kimmirut is very rugged, consisting mostly of steep rocky slopes. There is only one site conducive to wetlands, and that is site 7. An extensive wetland exists at that site. It has been examined in some detail in precursor studies, and estimated to be capable of good wastewater treatment. A report on the site 7 alternative was prepared in January 2008. Subsequently, the waters of the existing recipient wetland were studied, and found to be fish habitat. Site 7 has therefore been deemed undesirable.

Sites 1 through 6 all involve discharge to Soper Lake, which is a local fishery. The terrain at these sites is too steep and rocky to allow development of a treatment wetland. As noted by KJ, sites 5 & 6 are earmarked for future community expansion.

The remaining sites (8 through 12) discharge to the ocean (Westbourne Inlet). Two of these (11 & 12) involve existing ponds and discharge to the north end of the inlet, in close proximity to the town proper. Sites 8 & 12 are virtually inaccessible according to the KJ reconnaissance.

Sites 9 & 10 are reachable. These are the existing discharge site (10) and a slightly moved discharge point (9). Both discharges are/would be to the ocean at the point where the present discharge enters the ocean. It is not known what degree of treatment is being achieved by the current system, which involves a lengthy traverse down a moderate but vegetated slope.

It would be difficult and expensive to attempt modifications of the existing discharge slope. However, the discharge point(s) are accessible, and pretreatment works could be established there – i.e., settling and screening.

The decision process could profit from a further understanding of the impacts of the current discharge on the ocean outfall region. What is the water quality reaching the ocean? What is the assimilative capacity and size of the mixing zone? Are there any complaints from the people in Kimmirut about the current system? Can it be established that the discharge point is/is not a local fishing spot, or supports other local useage?

In any case, there does not appear to be a role for treatment wetlands in potential improvements of the Kimmirut treatment process.

Please let me know if you wish further comments.

MEMORANDUM

Date: December 15, 2014

To: Ken Johnson, M.A.Sc., M.C.I.P., P.Eng.
Senior Environmental Engineer and Planner
Stantec, Edmonton, AB
Canada

From: Robert H. Kadlec, PhD, P.E.
Wetland Management Services
6995 Westbourne Drive
Chelsea, MI 48118

Subject: Potential for Treatment Wetlands for Kimmirut at Site 2

The site in question appears to offer the potential for a lagoon (natural pond), followed by wetland terraces leading to Soper Lake.

The potential wetland area at site 2 would be about 0.5 ha; but high-resolution topographical information is not available. As a reference, the (previous) candidate site 7 was 15 ha, of which 3 ha was presumed to be in the flow path from the lagoon(s); and candidate site 3 also has a potential area of 0.5 ha. The construction of terracing at site 2 might be necessary, depending on topographical details. For the sake of discussion, presume that the entire 0.5 ha would be available. A preliminary calculation estimate is that this size wetland (0.5 ha) would reduce BOD and TSS by about 40%. The potential discharge to Soper Lake would be of the order of 150 mg/L of BOD and TSS.

The discharge would be to fish-bearing waters.

MEMORANDUM

Date: December 14, 2014

To: Ken Johnson, M.A.Sc., M.C.I.P., P.Eng.
Senior Environmental Engineer and Planner
Stantec, Edmonton, AB
Canada

From: Robert H. Kadlec, PhD, P.E.
Wetland Management Services
6995 Westbourne Drive
Chelsea, MI 48118

Subject: Potential for Treatment Wetlands for Kimmirut at Site 3

The site in question appears to offer the potential for a lagoon (natural pond), followed by wetland terraces leading to Soper Lake.

The potential wetland area would be about 0.5 ha. As a reference, the (previous) candidate site 7 was 15 ha, of which 3 ha was presumed to be in the flow path from the lagoon(s). In the case of site 3, the construction of terracing would make better use of the overall footprint. For the sake of discussion, presume that the entire 0.5 ha would be available. A preliminary calculation estimate is that this size wetland (0.5 ha) would reduce BOD and TSS by about 40%. Additionally, passage through permeable berms (if used) would further reduce TSS. That would leave a discharge to Soper Lake of the order of 150 mg/L of BOD and TSS.

The 3% slope is also considerably greater than that previously estimated for proposed for site 7. The overall drop of over five meters would require construction of berms, as indicated in your earlier concept sketch. I would estimate the necessity is for three berms (as indicated on your concept sketch), which would have a total length of well over 100 meters and a height of perhaps 1.5 meters.

The discharge would be to fish-bearing waters.

APPENDIX E

Snowdrift Notes

Tel: 519.823.1311
Fax: 519.823.1316

Rowan Williams Davies & Irwin Inc.
650 Woodlawn Road West
Guelph, Ontario, Canada
N1K 1B8

CONSULTING ENGINEERS & SCIENTISTS

December 12, 2014

Mr. Ken Johnson, M.A.Sc., MCIP, P.Eng.
Senior Environmental Engineer and Planner
Stantec
10160 - 112 Street, Suite 500
Edmonton, AB
T5K 2L6

Re: Snowdrift Assessment
Sewage Lagoon Site Selection Study
Kimmirut, NU
RWDI Reference No. 1402518

Email: kenneth.johnson@stantec.com

Dear Ken,

The following provides our initial overview of the snowdrift conditions for the proposed sewage lagoon sites in Kimmirut, Nunavut.

Introduction

The primary purpose of this snowdrift assessment was to qualitatively review the potential for undue snow drifting at each of the proposed sites and to provide guidance for the site selection. This assessment focused on the local topography and site orientation with respect to prevailing winter winds associated as these design aspects will have the greatest impact on snowdrifting conditions at each site.

Our assessment is based on the potential site information provided by Stantec including:

- an outline of the 12 potential sewage lagoon sites;
- site photographs and site visit information;
- information regarding the surroundings (i.e., topographic plans);
- a meteorological assessment of the prevailing winter winds in Kimmirut; and
- our past experience and professional judgment.

Wind Data

Meteorological data from the Kimmirut Airport for the period 1987 to 2013 were used as reference for wind and snow drift potential in the region. The historical wind data were analyzed to determine the wind directions that would most often be associated with drifting snow. The data are summarized in Figure 1. The following meteorological conditions were assessed for the winter months (September through May):

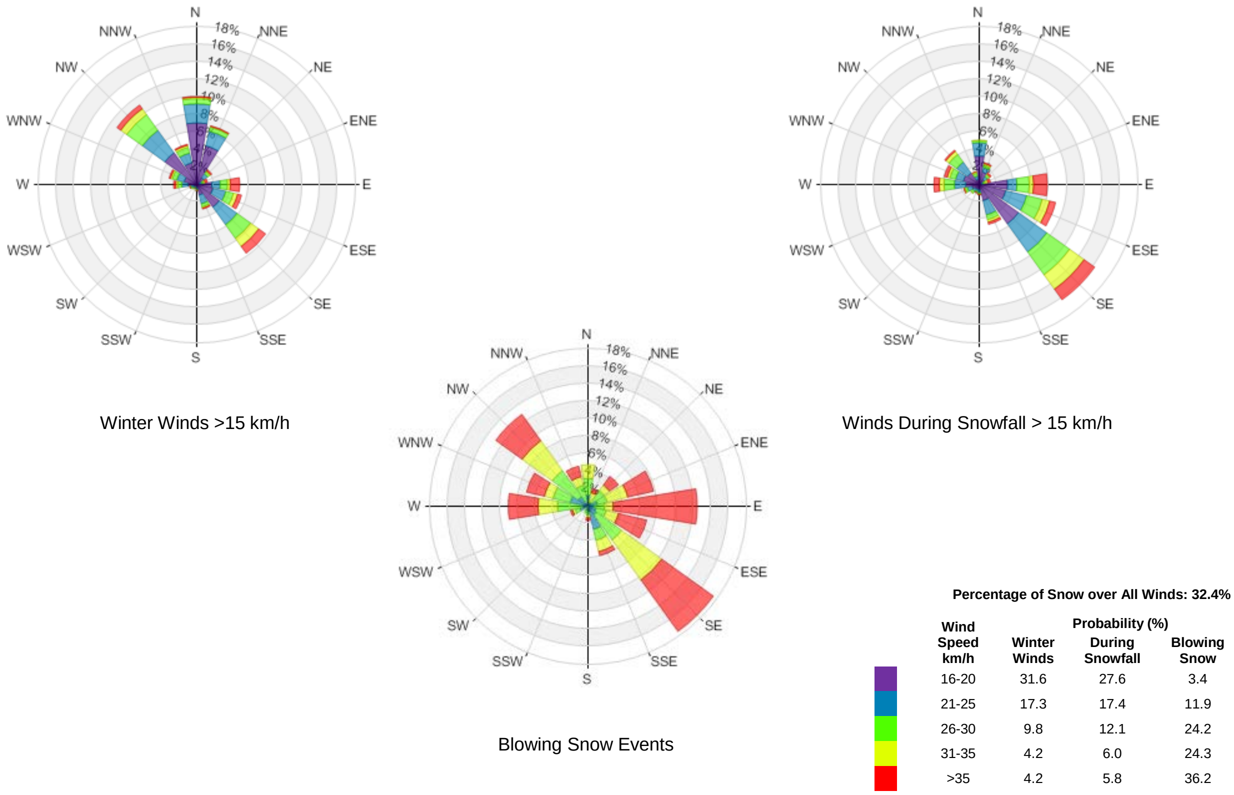
- Winds greater than 15 km/h;
- Winds greater than 15 km/h with snowfall; and
- Blowing snow events.

The movement of drifting snow at low wind speeds is negligible. A threshold wind speed of 15 km/h was therefore used to determine the predominant winds that could be associated with snow movement on and around each study site. The 15 km/h wind speed is measured at the weather station anemometer, which is typically located on a mast approximately 10 m above the ground. Winter winds with blowing snow represent higher wind speeds often associated with storm events and significant drifting.

The analysis of winter winds greater than 15 km/h (refer to the upper left wind rose in Figure 1) indicates that the northwest and southeast winds are the most prevalent, with secondary winds from the north and easterly directions. When considering winds greater than 15 km/h with snowfall (refer to the upper right wind rose in Figure 1), the southeasterly through east winds are the most prevalent.

When considering the snow drift potential for an arctic site, the analysis considering blowing snow events provides the best indication of the key directions as snow transported during blowing snow events is the primary source for accumulations in these climate regions. The lower wind rose in Figure 1 indicates that the northwest and southeast are prevalent, with a secondary component from the easterly directions.

For our assessment, we consider winds from the northwest and southeast to be the most important.



Percentage of Snow over All Winds: 32.4%

Wind Speed km/h	Probability (%) Winter Winds	During Snowfall	Blowing Snow
16-20	31.6	27.6	3.4
21-25	17.3	17.4	11.9
26-30	9.8	12.1	24.2
31-35	4.2	6.0	24.3
>35	4.2	5.8	36.2

Figure 1 – Directional Distribution (%) of Winds (Blowing From) – Kimmirut Airport (1987-2013)

Potential Snowdrift Issues

The topography of a region is generally an important factor when considering the snowdrift potential of a site. In general, wind will scour snow from the windward side of hills and deposit it on the leeward side. As a result of this it is generally favourable to have a site and access routes located on the windward side of hills. However, given the bi-modal distribution of the winds in Kimmirut, there is not likely to be a significant benefit of locating the site on one side of the topographic features as opposed to the other. As a result, the impact of snow drifting conditions of a particular site is more a function of the access roads leading to the site.

Proposed locations farther from the community will have proportionally more required snow clearing to maintain a clear access road. Also, sections of the access roadways that are not aligned with the prevailing winds will be prone to heavier drift accumulations, particularly when the access road is located in a depression. As such, the total length of access road running in a northeast – southwest orientation should be minimized.

CONSULTING ENGINEERS & SCIENTISTS

Closing

We trust this satisfies the current requirements for the project. RWDI can provide further guidance on the potential snow drift accumulations as specific site details are developed. Should you have any questions or require additional information, please do not hesitate to call.

Yours very truly,

ROWAN WILLIAMS DAVIES & IRWIN Inc.

Jan Dale, M.E.Sc., P.Eng.
Senior Engineer / Associate

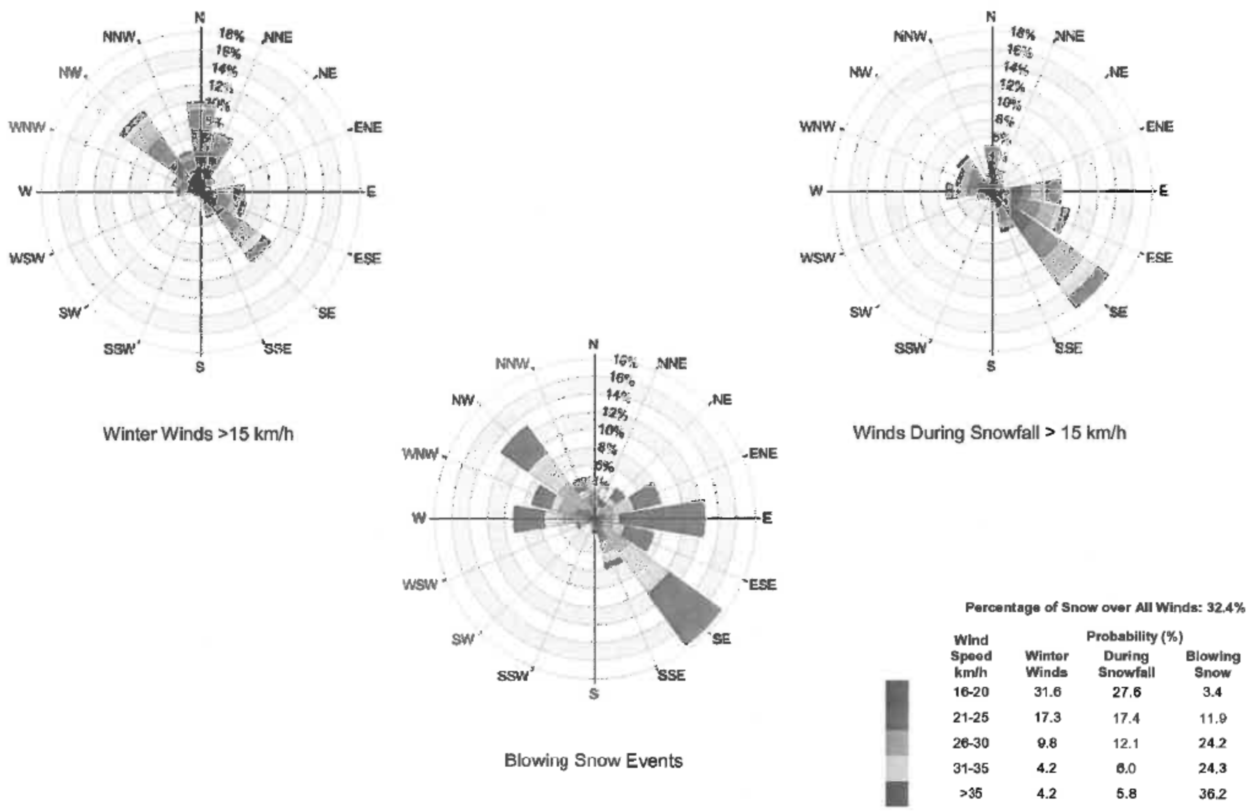
John Alberico, M.Sc., CCEP
Senior Project Manager / Principal

JD/mdlc

Appendix E

__**Site Access Comparison**__

Access road construction, hauling distances and snow removal requirements were reviewed as part of the sewage lagoon site location evaluation. This analysis was completed by measuring the approximate distance of the existing road and estimating the additional road construction that would be required to connect the proposed site with the community boundary. Additionally, in order to gain an understanding of snow removal requirements, the distance of roadway that would be susceptible to snow drifting was estimated. RWDI Inc. performed a snowdrift assessment for the proposed site locations and found that heavy snow drifting would predominantly occur on road segments which are not aligned with the prevailing winds as shown in the following **Figure**.



Wind Speed km/h	Probability (%) Winter Winds	During Snowfall	Blowing Snow
16-20	31.6	27.6	3.4
21-25	17.3	17.4	11.9
26-30	9.8	12.1	24.2
31-35	4.2	6.0	24.3
>35	4.2	5.8	36.2

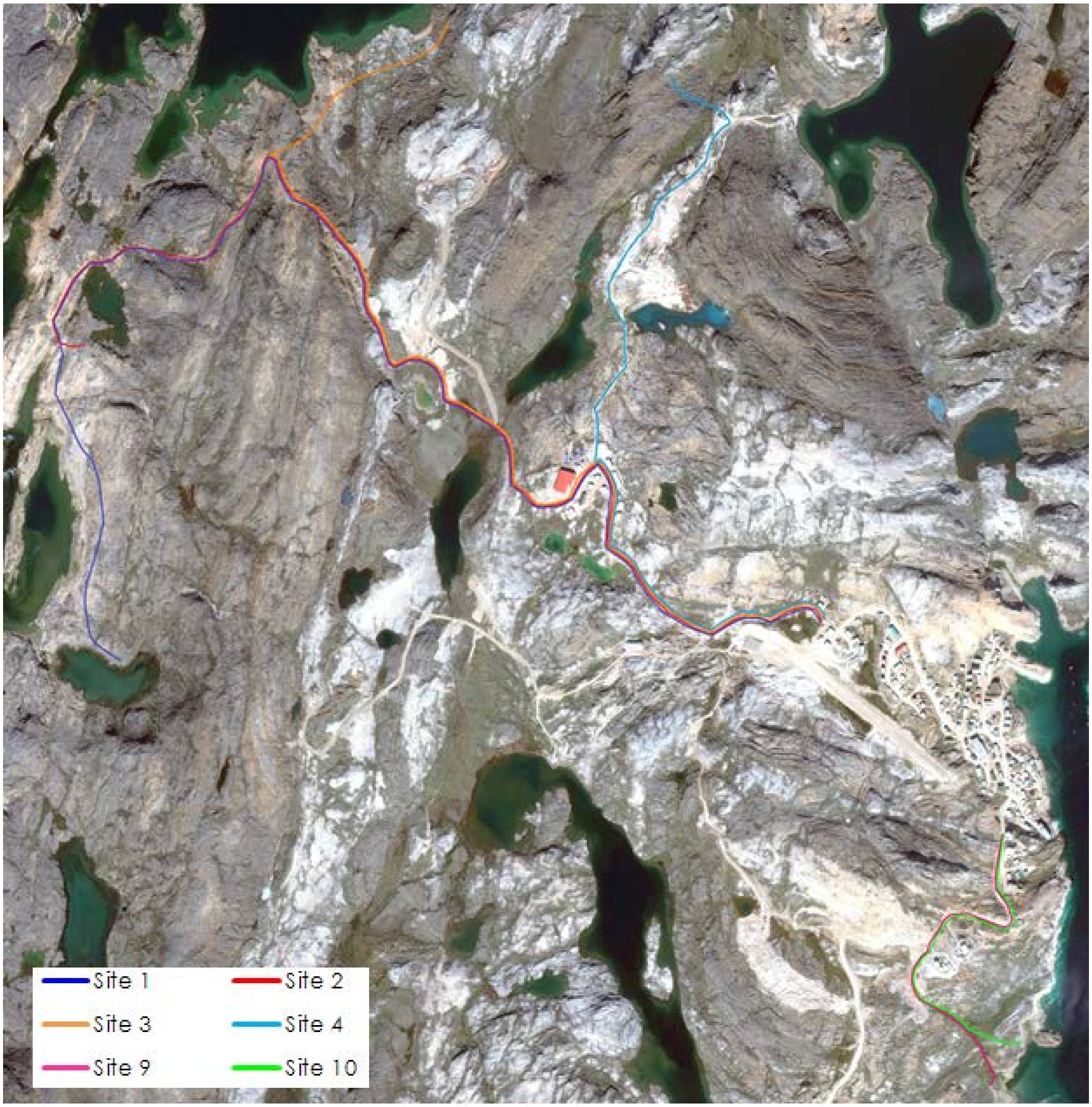
Direction Distribution (%) of Winds (Blowing From) – Kimmirut Airport (1987-2013) (RWDI Inc., 2014).

Access roads that were not orientated in the prevailing northwest – southeast direction were considered to be located within a potential drift zone. The following **Table** shows a comparison of access roads requirements for each site.

Comparison of access road requirements for the potential sewage lagoon sites.

Location	Existing Road (km)	New Road (km)	Total Distance (km)	Drift Zone (km)
Site 1	3.41	0.93	4.34	2.4
Site 2	3.29	0.06	3.35	1.7
Site 3	2.39	0.46	2.85	1.0
Site 4 (west)	2.24	0.34	2.58	1.5
Site 4 (east)	1.87	0.32	2.19	1.3
Site 7	1.99	0.00	1.99	1.2
Site 9	0.65	0.37	1.02	0.5
Site 10	0.65	0.29	0.95	0.4

Site 1 is the furthest location from the community and will require the most snow clearing to maintain a clean access road. Site 9 and 10 are the closest sites to the community and will consequently require the least hauling distance and least amount of snow clearing. Two access road options were considered for Site 4. It was found that the approach from the east required less development, less travel distance and less overall snow clearing. However, if Site 4 is selected as the site to be developed, a closer review of the topography should be conducted to ensure that the recommended access point would be the most efficient option of the two approaches. The access for Site 7 has already been constructed and is anticipated to require a moderate level of snow clearing in comparison to the other sites. The costs associated with road construction, snow removal and hauling distances could be further assessed to determine the relative importance of each of these factors. However, these factors will need to be balanced with other selection criteria such as total cost for each option, treatment efficiency and ease of operation to determine the optimal sewage treatment solution. The routes that were used to calculate the distance to each site are shown in the following **Figure**.



Proposed routes for the various sewage lagoon location options.

NUNAMI STANTEC

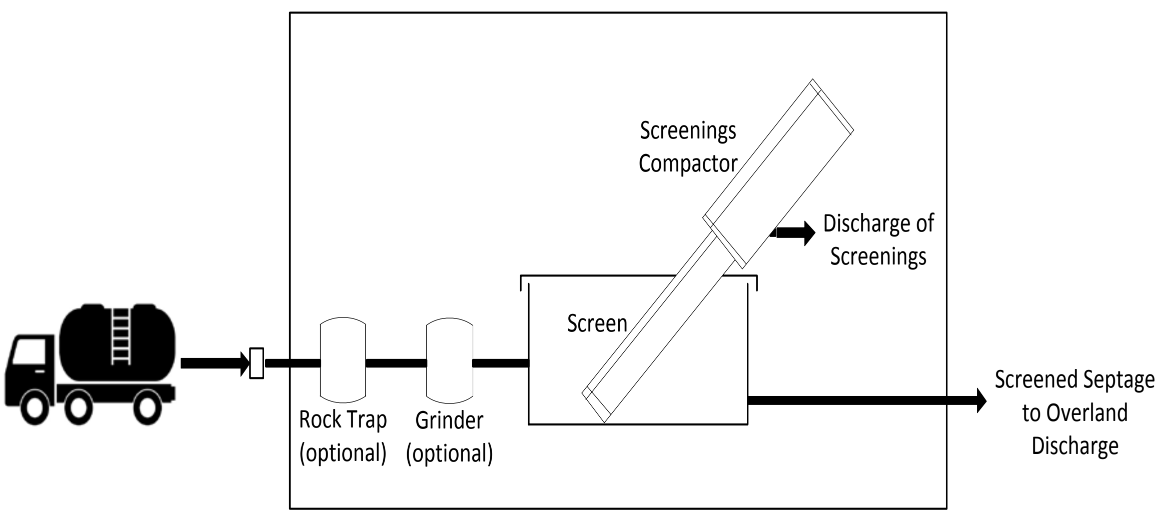
APPENDIX F

Mechanical Treatment Notes and Figures

Option 1: Septage Receiving Pretreatment

Packaged pretreatment systems are available for septage receiving to remove large debris and solids from hauled waste streams. A septage receiving pretreament system could be implemented in Kimmiruit prior to the screened wastewater stream being discharged into a wetland system for storage and treatment. The septage receiving system does not provide any biological treatment itself, but would reduce downstream maintenance needs and allow for increased treatment in the wetland system.

Different variations of septage pretreatment systems are available and may include a rock trap, grinder, screen, screenings dewatering and grit handling. The mechanical equipment would be housed in a shelter with a camlock connection provided outdoors for haulers. The septage is screened and the unwanted solids are captured in an auger screen where they are transported to a compactor prior to being bagged for disposal. Electrical power connection is required.



Stantec

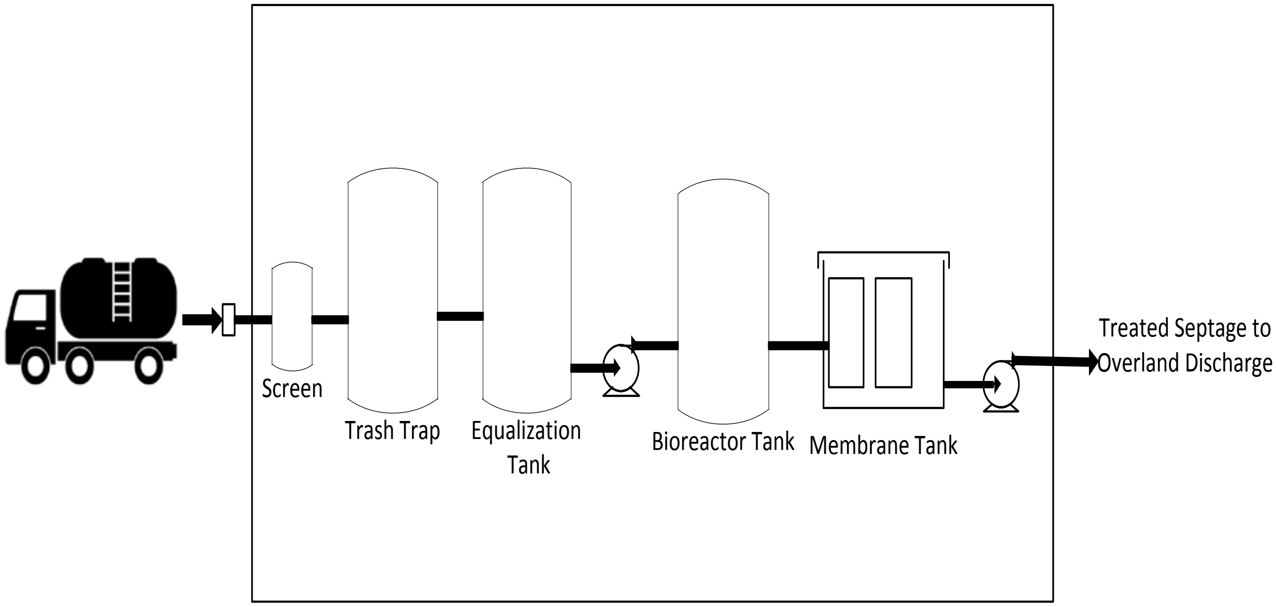
Opinion of Probably Cost:

Item	Description	Subtotal	Total
1	**Site Preparation**		**$ 100,000**
2	**Process Equipment**		**$ 522,000**
	a) Equipment Cost from JWC	$ 140,000	
	b) 50% install	$ 70,000	
	c) Wash Water System	$ 40,000	
	d) 30% Electrical	$ 75,000	
	d) 20% Piping and Valving	$ 50,000	
	e) Shipping	$ 60,000	
	f) 20% General Requirements	$ 87,000	
3	**Building**		**$ 109,000**
	a) Concrete $1,100/m3 concrete x 38m2	$ 41,800	
	b) Superstructure $1,750/m2 superstructure x 16m2	$ 28,000	
	c) 30% HVAC	$ 20,940	
	c) 20% General Requirements	$ 18,148	
4	**Onsite-Utilities (electrical service)**		**$ 120,000**
	a) 600 m total. $10,000 per pole @ 50 m each.	$ 120,000	
5	**Engineering & Contingency (40%)**		**$ 341,000**
	Total		**$ 1,192,000**

Option 2: Membrane Bioreactor

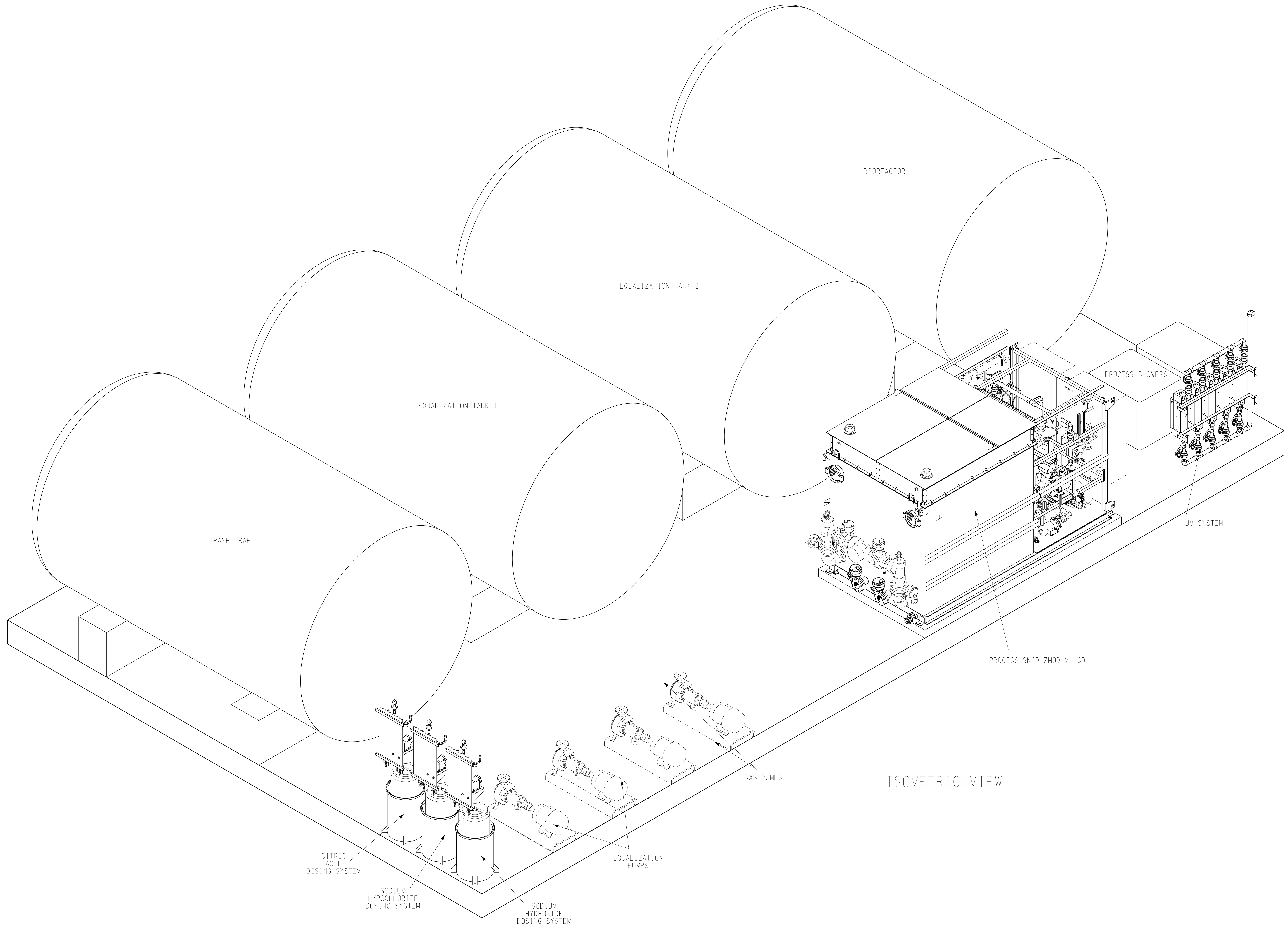
Membrane Bioreactors (MBR) are a secondary treatment process which combine a suspended growth biological reactor with solids removal via micro or ultrafiltration. MBRs are able to achieve a higher level of treatment compared to other secondary treatment options. MBRs have higher operation and maintenance costs associated with energy for aeration, chemical costs for membrane cleaning and membrane replacement costs.

Skid mounted MBR systems complete with all required pretreatment components are available for shipment within pre-engineered buildings/sea cans. Septage haulers would hook up to a camlock connection outside of the building. Inside the building the septage would flow through a trash trap to capture floatables and heavy objects followed by an equalization tank. Septage is pumped from the equalization tank to bioreactors for biological treatment and then to the MBR module for further treatment and solids separation. The membrane modules require periodic chemical cleaning to mitigate fouling. Electrical power connection as well as an odour control and solids handling system is required.



Opinion of Probable Cost:

Item	Description	Subtotal	Total
1	**Site Preparation**		**$ 100,000**
2	**Process Equipment**		**$ 2,892,000**
	a) Equipment Cost from GE	$ 1,000,000	
	b) 50% install	$ 500,000	
	c) Wash Water System	$ 40,000	
	d) 30% Electrical	$ 462,000	
	d) 20% Piping and Valving	$ 308,000	
	e) Shipping	$ 100,000	
	f) 20% General Requirements	$ 482,000	
3	**Building**		**$ 1,128,000**
	a) Concrete $1,100/m3 concrete x 180m2	$ 198,000	
	b) Superstructure $1,750/m2 superstructure x 300m2	$ 525,000	
	c) 30% HVAC	$ 216,900	
	c) 20% General Requirements	$ 187,980	
4	**Onsite-Utilities (electrical service)**		**$ 120,000**
	a) 600 m total. $10,000 per pole @ 50 m each.	$ 120,000	
5	**Engineering & Contingency (40%)**		**$ 1,696,000**
	Total		**$ 5,936,000**



ISOMETRIC VIEW

REV	DESCRIPTION	ECO	DWN	APVD	DATE	CHKD
A	PRELIMINARY – NOT FOR CONSTRUCTION		JSP	JG	12FEB13	MA

TOLERANCES UNLESS NOTED
DECIMALS .X; .XX ± 0.50; .XXX
ANGLES ± 0.5
FRAC ± 1/2"

DIMENSIONS IN INCHES DO NOT SCALE — THIRD ANGLE

DRAWN BY	JSP	DATE 12FEB13
CHECKED BY	MA	DATE 12FEB13
APPROVED BY	JG	DATE 12FEB13
APPROVED BY		DATE

GE
Water & Process Technologies
GLOBAL HEADQUARTERS : TREVOSE, PA USA +1-215-355-3300 WWW.GEWATER.COM

CLIENT/JOB: BINGHAM WWTP
FILE: MICROSTATION
TITLE: PLOT PLAN LAYOUT ISOMETRIC VIEW
MATERIAL:
SIZE: D
DRAWING NO.: 762236-AG-01
REV: A
PROJECT: 762236
SCALE: 1:32
SHEET: 3 OF 3

P/N 1161662-RHP01

REV	DESCRIPTION	ECO	DWN	APVD	DATE	CHKD
A	PRELIMINARY – NOT FOR CONSTRUCTION		JSP	JG	12FEB13	MA

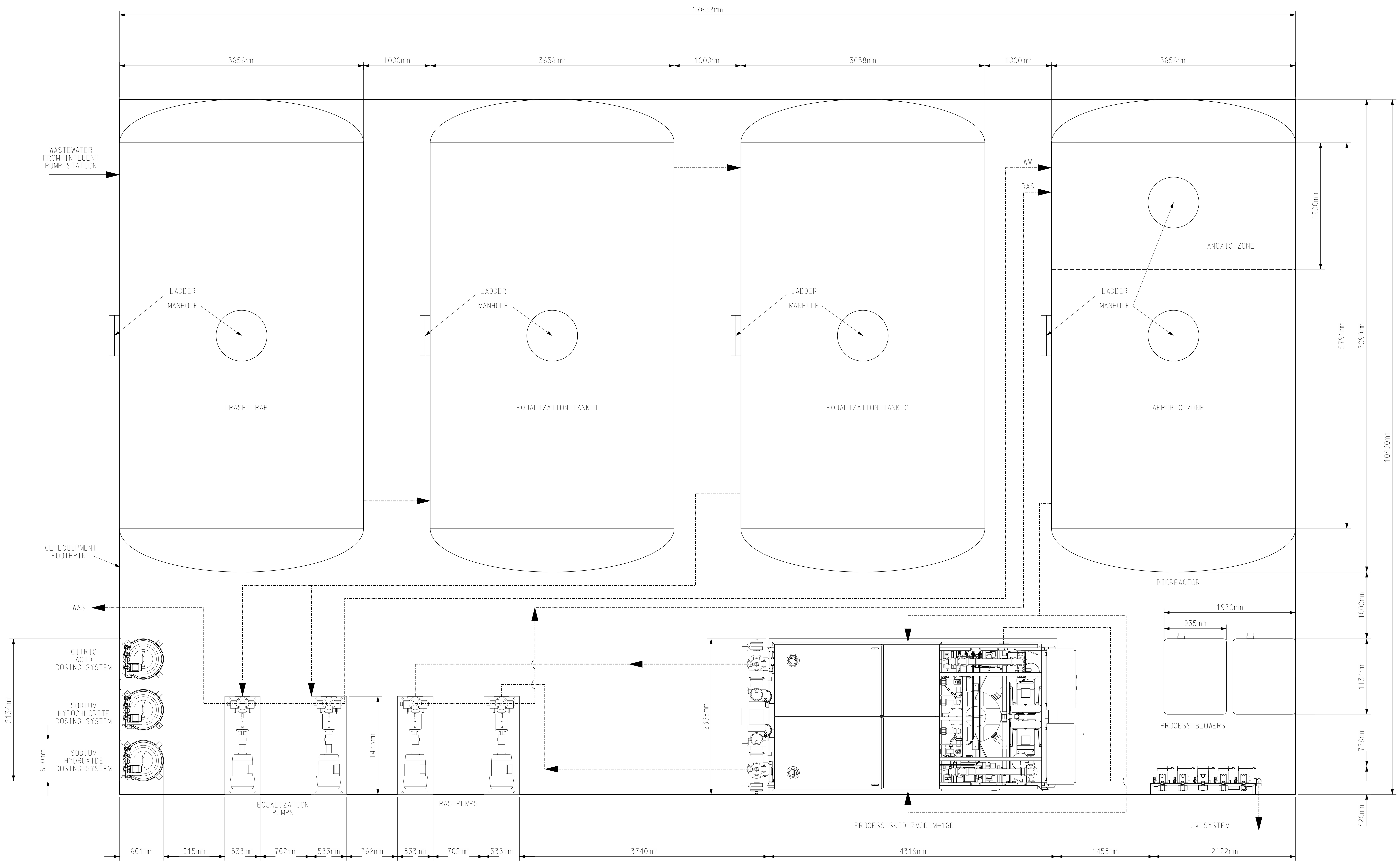
TOLERANCES UNLESS NOTED
DECIMALS .X .XX ± 0.50 .XXX
ANGLES ± 0.5
FRAC ± 1/2"
DIMENSIONS IN INCHES DO NOT SCALE
THIRD ANGLE

DRAWN BY JSP	DATE 12FEB13
CHECKED BY MA	DATE 12FEB13
APPROVED BY JG	DATE 12FEB13
APPROVED BY	DATE

GE Water & Process Technologies
GLOBAL HEADQUARTERS : TREVOSE, PA USA +1-215-355-3300 WWW.GEWATER.COM

CLIENT/JOB: BINGHAM WWTP
FILE: MICROSTATION
TITLE: PLOT PLAN LAYOUT ELEVATIONS
MATERIAL:
SIZE: D
DRAWING NO.: 762236-AG-01
REV: A
PROJECT: 762236
SCALE: 1:32
SHEET: 2 OF 3

P/N 1161662-RHP01



PLAN VIEW

REV	DESCRIPTION	ECO	DWN	APVD	DATE	CHKD
A	PRELIMINARY – NOT FOR CONSTRUCTION		JSP	JG	12FEB13	MA

TOLERANCES UNLESS NOTED
DECIMALS: .X ± 0.5; .XX ± 0.50; .XXX
ANGLES: ± 0.5
FRAC: ± 1/2"
DIMENSIONS IN INCHES
DO NOT SCALE
THIRD ANGLE

DRAWN BY	JSP	DATE	12FEB13
CHECKED BY	MA	DATE	12FEB13
APPROVED BY	JG	DATE	12FEB13
APPROVED BY		DATE	

GE Water & Process Technologies
GLOBAL HEADQUARTERS : TREVOSE, PA USA +1-215-355-3300 WWW.GEWATER.COM

CLIENT/JOB: BINGHAM WWTP
FILE: MICROSTATION
TITLE: PLOT PLAN LAYOUT
MATERIAL:
SIZE: D
DRAWING NO.: 762236-AG-01
REV: A
PROJECT: 762236
SCALE: 1:32
SHEET: 1OF3

P/N 1161662-RHP01

NUNAMI STANTEC

APPENDIX G

Lagoon Costs, Figures, and Notes

Kimmirut Sewage Treatment Study

Site 9A Impermeable Berm Lagoon System

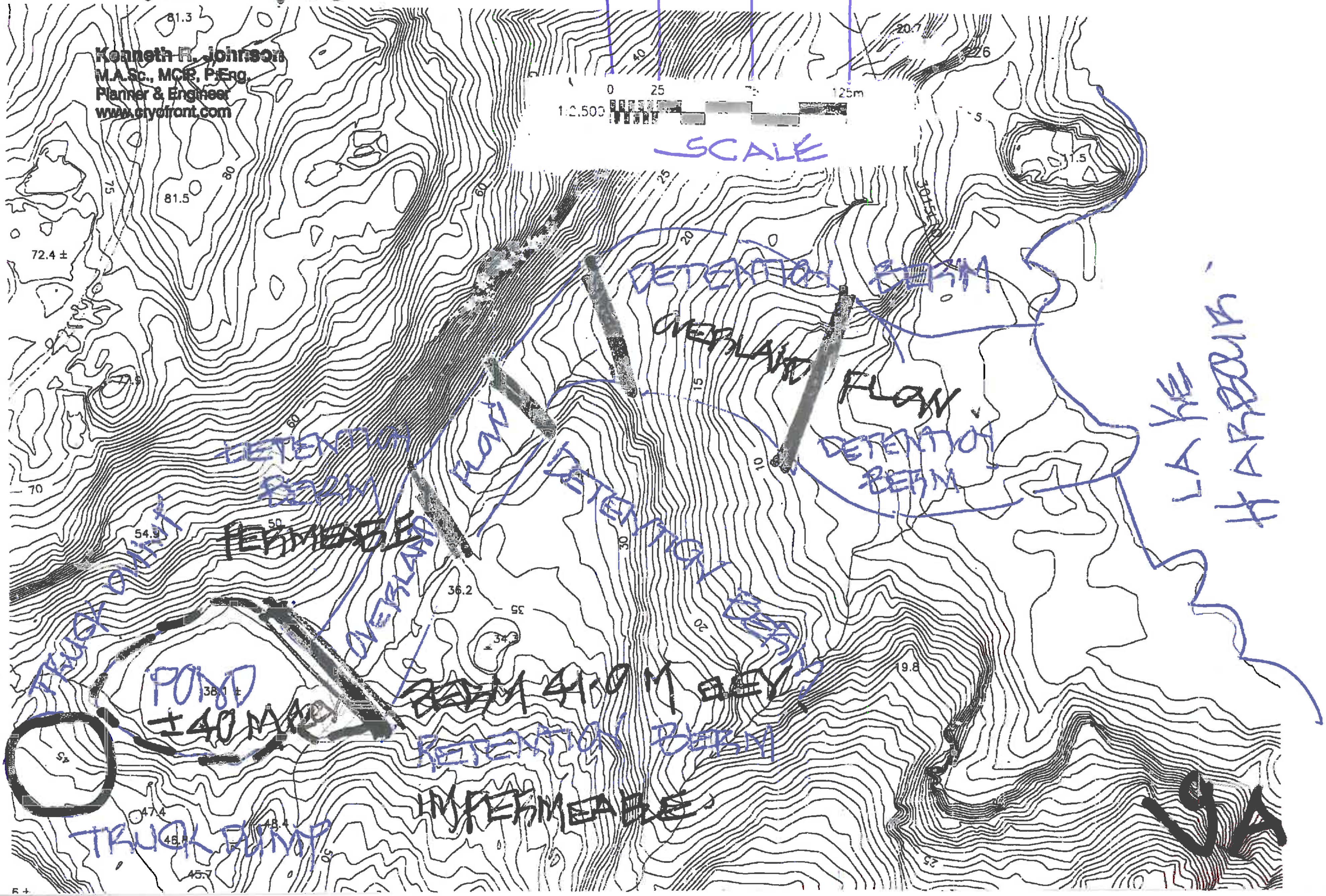
No.	Description	Unit	Quantity	Unit Cost	Estimated Cost
1	New Access Road	m	370	$ 500	$ 185,000
2	Existing Access Improvement	m	650	$ 200	$ 130,000
3	Truck Turnaround	sum	1	$ 45,000	$ 45,000
4	Truck Discharge	sum	1	$ 27,000	$ 27,000
5	Detention Berm	m	280	$ 550	$ 154,000
6	Retention Berm	m	80	$ 1,450	$ 116,000
7	Pond Spillway	sum	1	$ 38,000	$ 38,000
8	Decant System	sum	1	$ 135,000	$ 135,000
9	Overland Flow Development	sum	1	$ 50,000	$ 50,000
10	Contingency (40%)				$ 352,000
Total					$ 1,232,000

Notes:

1. Pond characteristics
   - Area - 9,500 square metres
   - Depth - 2.5 metres
   - Volume - 24,000 cubic metres
   - Sludge and surface water allowance - 2,000 cubic metres
2. Elevations
   - Top of impermeable berm - 41 metres
   - Top of pond - 40 metres
3. Reference unit costs from Cambridge Bay wastewater improvements with construction completed in 2012.

KIMMIRUT

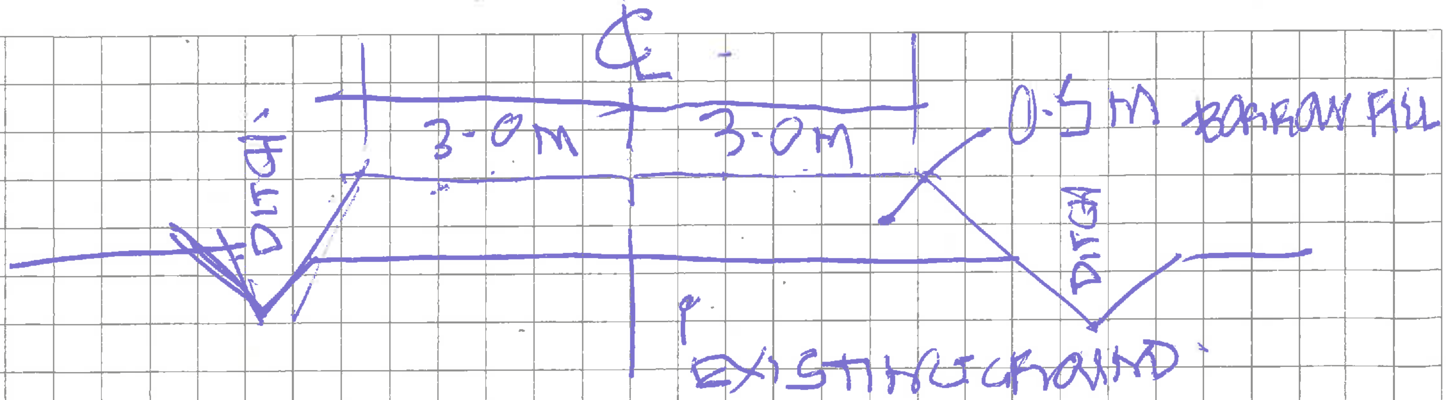
DEC 1 6 2014



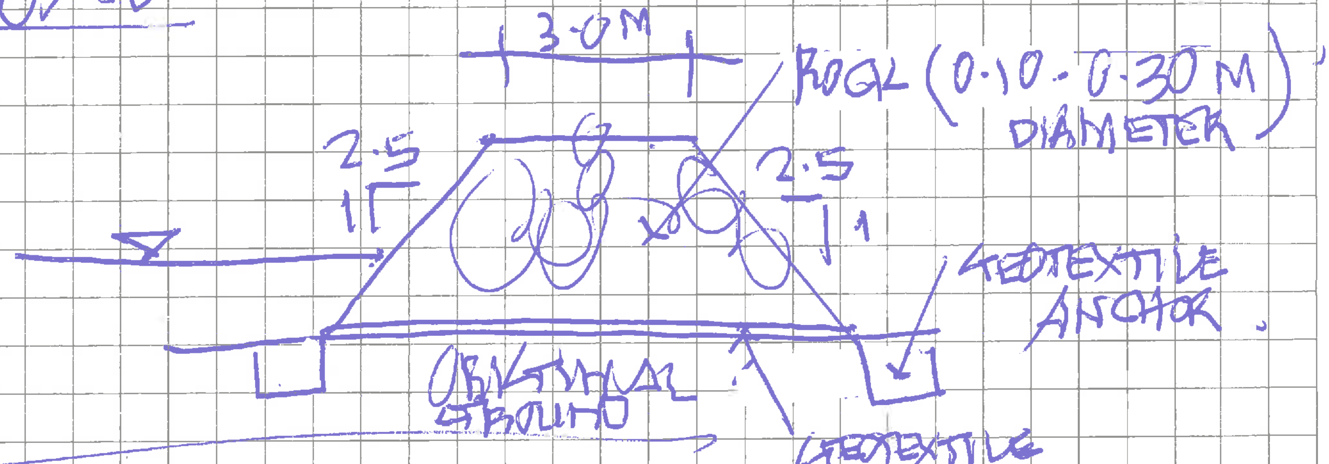
RETENTION = IMPERMEABLE
DETENTION = PERMEABLE

POND WITH IMPERMEABLE BERM

Stantec

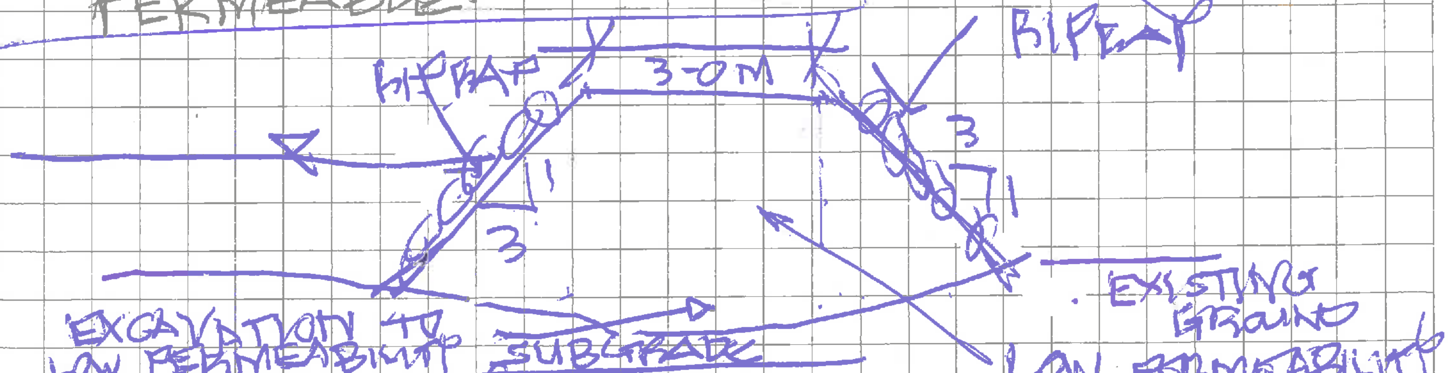


ROAD



DETENTION BERM

PERMEABLE



RETENTION BERM

LOW PERMEABILITY

KIMMIRUT DETAILS

Designed by: KRJ 2014 12 12 Checked by:

APPENDIX H

Effluent Quality Guidelines for Nunavut 2000

Table 3.3: Domestic Wastewater Effluent Quality Guidelines for Nunavut Territory, 2000

Wastewater Flow Litres/Capita Day (Lcd) & Season	Parameter	Unit	Stream, River or Estuary (a)				Lake (a)		Marine (d)	
			Dilution (b)				Residence Time or Dilution (c)		Mixing Condition	
			> 10:1 < 100:1	> 100:1 < 1000:1	> 1,000:1 < 10,000:1	> 10,000:1	Tr > 5 yr	Tr < 5 yr	Open Coastline	Bay or Fjord
< 150 Lcd Summer	BOD_5	mg/l	30	80	100	360	30	80	360	100
	TSS	mg/l	35	100	120	300	35	100	300	120
	F. Coli	CFU/dL	1,000 (e)	10,000 (e)	100,000 (e)	1,000,000 (e)	1,000 (e)	10,000 (e)	(f)	(f)
< 150 Lcd Winter	BOD_5	mg/l	No discharge	special permit	100	260	30	80	360	100
	TSS	mg/l			100	240	35	100	300	120
	F. Coli	CFU/dL			1,000,000 (e)	1,000,000 (e)	1,000 (e)	10,000 (e)	(f)	(f)
150 to 500 Lcd Summer	BOD_5	mg/l	30	40	120	120	30	40	120	120
	TSS	mg/l	35	60	180	180	35	60	180	180
	F. Coli	CFU/dL	10,000 (e)	10,000 (e)	100,000 (e)	1,000,000 (e)	1,000 (e)	10,000 (e)	(f)	(f)
150 to 500 Lcd Winter	BOD_5	mg/l	No discharge	special permit	100	120	30	40	120	120
	TSS	mg/l			100	180	35	60	180	180
	F. Coli	CFU/dL			1,000,000 (e)	10,000,000 (e)	1,000 (e)	10,000 (e)	(f)	(f)
> 500 Lcd Summer	BOD_5	mg/l	25	30	80	80	25	30	80	80
	TSS	mg/l	30	30	70	70	30	30	70	70
	F. Coli	CFU/dL	1,000 (e)	10,000 (e)	100,000 (e)	100,000 (e)	1,000 (e)	10,000 (e)	(f)	(f)
> 500 Lcd Winter	BOD_5	mg/l	No discharge	70	70	70	25	30	80	80
	TSS	mg/l		70	70	70	30	30	70	70
	F. Coli	CFU/dL		10,000 (e)	1,000,000 (e)	10,000,000 (e)	1,000 (e)	10,000 (e)	(f)	(f)

SEE TABLE 3.2 (FOLLOWING PAGE FOR FOOTNOTES).

DENOTES GUIDELINE REFERENCE FOR EFFLUENT QUALITY IN KIMMIRUT WATER LICENCE.

Table 3.2: Domestic Wastewater Effluent Quality Guidelines for Northwest Territories (NWT Water Board 1992)

Wastewater Flow Litres/Capita Day (Lcd) & Season	Parameter	Unit	Stream, River or Estuary (a)				Lake (a)		Marine (d)	
			Dilution (b)				Residence Time or Dilution (c)		Mixing Condition	
			> 10:1 < 100:1	> 100:1 < 1000:1	> 1,000:1 < 10,000:1	> 10,000:1	Tr > 5 yr	Tr < 5 yr	Open Coastline	Bay or Fjord
< 150 Lcd Summer	BOD_5	mg/l	30	80	100	360	30	80	360	100
	TSS	mg/l	35	100	120	300	35	100	300	120
	P (e)	mg/l	10	-	-	-	-	-	-	-
	F. Coli	CFU/dL	1,000 (f)	10,000 (f)	100,000 (f)	1,000,000 (f)	1,000 (f)	10,000 (f)	(g)	(g)
< 150 Lcd Winter	BOD_5	mg/l	No discharge	special permit	100	260	30	80	360	100
	TSS	mg/l			100	240	35	100	300	120
	P (e)	mg/l			-	-	-	-	-	-
	F. Coli	CFU/dL			1,000,000 (f)	1,000,000 (f)	1,000 (f)	10,000 (f)	(g)	(g)
150 to 600 Lcd Summer	BOD_5	mg/l	30	40	120	120	30	40	120	120
	TSS	mg/l	35	60	180	180	35	60	180	180
	P (e)	mg/l	9	-	-	-	-	-	-	-
	F. Coli	CFU/dL	10,000 (f)	10,000 (f)	100,000 (f)	1,000,000 (f)	1,000 (f)	10,000 (f)	(g)	(g)
150 to 600 Lcd Winter	BOD_5	mg/l	No discharge	special permit	100	120	30	40	120	120
	TSS	mg/l			100	180	35	60	180	180
	P (e)	mg/l			-	-	-	-	-	-
	F. Coli	CFU/dL			1,000,000 (f)	10,000,000 (f)	1,000 (f)	10,000 (f)	(g)	(g)
> 600 Lcd Summer	BOD_5	mg/l	25	30	80	80	25	30	80	80
	TSS	mg/l	30	30	70	70	30	30	70	70
	P (e)	mg/l	2	-	-	-	2	-	-	-
	F. Coli	CFU/dL	1,000 (f)	10,000 (f)	100,000 (f)	100,000 (f)	1,000 (f)	10,000 (f)	(g)	(g)
> 600 Lcd Winter	BOD_5	mg/l	No discharge	70	70	70	25	30	80	80
	TSS	mg/l		70	70	70	30	30	70	70
	P (e)	mg/l		-	-	-	-	-	-	-
	F. Coli	CFU/dL		10,000 (f)	1,000,000 (f)	10,000,000 (f)	1,000 (f)	10,000 (f)	(g)	(g)

[a] - untreated wastewater discharges are not permitted to any inland waters, except where specified by the Water Board

[b] - dilution = minimum average monthly stream flow/average daily wastewater flow

[c] - residence time = volume of lake (m^3)/annual outflow from lake (m^3/yr)

[d] - marine outfalls are to meet the design specifications of Appendix A in the NWT Water Board Guideline for the Discharge of Treated Municipal Wastewater

[e] - guidelines for phosphorus concentrations are flexible, site specific

[f] - guidelines for fecal coliform levels are intended to limit concentrations everywhere outside initial mixing zone to < 100 CFU/dL

[g] - bacteriological standards are a concern in this environment only where discharge might affect a fishery or recreation

TABLE 4.1
MUNICIPAL WASTEWATER EFFLUENT QUALITY GUIDELINES

Wastewater Flow (Lcd) & Season	Parameter	Unit	Receiving Environment: Stream, River or Estuary (a) — Dilution (b)				Lake (a) — Residence Time or Dilution (c)		Marine (d) — Mixing Condition	
			> 10:1 < 100:1	> 100:1 < 1,000:1	> 1,000:1 < 10E4	> 10E4:1	T_r > 5 yr	T_r < 5 yr	Open Coastline	Bay or Fjord
< 150 Lcd Summer	BOD	mg/L	30	80	100	360	30	80	360	100
	SS	mg/L	35	100	120	300	35	100	300	120
	P (e)	mg/L	10	—	—	—	—	—	—	—
	F. coli.	CFU/dL	10E3 (f)	10E4 (f)	10E5 (f)	10E6 (f)	10E3 (f)	10E4 (f)	(g)	(g)
< 150 Lcd Winter	BOD	mg/L	no discharge	special permit	100	260	30	80	same	same
	SS	mg/L			100	240	35	100		
	P (e)	mg/L			—	—	—	—	—	—
	F. coli.	CFU/dL			10E6 (f)	10E6 (f)	10E3 (f)	10E4 (f)		
150 - 600 Lcd Summer	BOD	mg/L	30	40	120	120	30	40	120	120
	SS	mg/L	35	60	180	180	35	60	180	180
	P (e)	mg/L	9	—	—	—	—	—	—	—
	F. coli.	CFU/dL	10E4 (f)	10E4 (f)	10E5 (f)	10E6 (f)	10E3 (f)	10E4 (f)	(g)	(g)
150 - 600 Lcd Winter	BOD	mg/L	no discharge	special permit	100	120	same	same	same	same
	SS	mg/L			100	130				
	P (e)	mg/L			—	—				
	F. coli.	CFU/dL			10E6 (f)	10E7 (f)				
> 600 Lcd Summer	BOD	mg/L	25	30	80	80	25	30	80	80
	SS	mg/L	30	30	70	70	30	30	70	70
	P (e)	mg/L	2	—	—	—	2	—	—	—
	F. coli.	CFU/dL	10E3 (f)	10E4 (f)	10E5 (f)	10E6 (f)	10E3 (f)	10E4 (f)	(g)	(g)
> 600 Lcd Winter	BOD	mg/L	no discharge	70	70	70	same	same	same	same
	SS	mg/L		70	70	70				
	P (e)	mg/L		—	—	—				
	F. coli.	CFU/dL		10E4 (f)	10E6 (f)	10E7 (f)				

Legend: Same indicates that the summer guideline applies in winter.
Lcd is flow rate in litres per capita per day.
10E3 is 1,000; 10E4 is 10,000; 10E5 is 100,000; 10E6 is 1,000,000; 10E7 is 10,000,000.