# Detailed Design Report for the Improvements to the Sewage Treatment Facility and Solid Waste Management Facility The Hamlet of Kugluktuk, Nunavut

*Prepared by*

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## Appendices

This Detailed Design Report also includes the following separately bound companion documents:

- Solid Waste Management Facility Operation and Maintenance (O&M) Plan
- Sewage Treatment Facility Operation and Maintenance (O&M) Plan
- Environmental Emergency Contingency Plan
- Monitoring Program and Quality Assurance/Quality Control Plan
- Large-scale detailed Design Drawings prepared for the Construction Tender.

# 1.0 Introduction

The Department of Community and Government Services, Government of Nunavut (GN-CGS), retained Nuna Burnside Engineering and Environmental Ltd. (Nuna Burnside) on behalf of the Hamlet of Kugluktuk, to provide engineering services for the planning and design of sewage treatment and solid waste facilities for the Hamlet of Kugluktuk, Nunavut. The scope of work for the project was outlined in a proposal by Nuna Burnside entitled "*Sewage and Solid Waste Facilities Design, Kugluktuk, Nunavut*", dated September 2005. The proposal was prepared in response to a Request for Proposals issued by the Department of Community and Government Services of the Government of Nunavut, dated September 2005.

The project began with a field program in October 2005. This was followed by data assessment and evaluation, which was documented in a report to the GN entitled "*Schematic Design for the Improvements to the Sewage Lagoon and Solid Waste Disposal Facility, The Hamlet of Kugluktuk, Nunavut*", dated December 2006.

The report was reviewed and accepted by the GN, and Nuna Burnside was directed to prepare a Detailed Design Report.

A report entitled "*Detailed Design Report for the Improvement to the Solid Sewage Lagoon and Solid Waste Disposal Facility, The Hamlet of Kugluktuk*", dated June 2006, was submitted to the GN. Following a review and discussion of the report, the GN directed Nuna Burnside to prepare tender drawings and a construction tender. A tender document was prepared on behalf of the GN entitled "*Tender – Sewage Lagoon and Solid Waste Disposal Facility, Kugluktuk, Nunavut*", dated August 2006, and submitted to the GN. A copy of the Schematic Design Report (December 2005), Detailed Design Report (June 2006), and the tender drawings (a separate set of documents), along with a request for an amendment to the Nunavut Water Licence was submitted to the Nunavut Water Board (NWB).

This report is an updated revision of a Detailed Design Report, dated June 2006. This revised report was prepared at the request of the GN, to address issues and questions raised by the Nunavut Water Board and outlined in a letter to the Hamlet dated October 24, 2006, and subsequent discussions with both the GN and NWB. Appendix A includes a copy of the NWB Letter (A-1) and Nuna Burnside response letter (A-2), followed by a further NWB letter (A-3).

Nuna Burnside recommends that the 2003 NWB application be considered superseded by this current Detailed Design Report and accompanying application for an amendment to the Water License.

Nuna Burnside was not involved in the 2003 application, and suggests that it no longer be referenced and be considered out-of-date.

In the same fashion, we recommend that the estimate of sewage calculated in the Nuna Burnside 2005 and 2006 reports be considered the most up-to-date. Previous references in the 2004 Annual Monitoring Reports done by another party (not Nuna Burnside), are to be considered superseded.

Nuna Burnside did not work on the previous applications and reports. They were reviewed, however, Nuna Burnside chose to generate its own calculations. The calculations are based on the Nunavut Bureau of Statistics data. The Nuna Burnside generated population projections were compared to the historical data and found to be slightly higher values, which are more conservative than the population projections produced in the 2003 application.

Water supply was not part of the Nuna Burnside's work scope. It would be our assumption, that the water supply system would be upgraded and a license amendment application made when needed. The supply source is the Coppermine River and volume of supply is not likely to be a concern.

The GN is in the process of preparing a Terms of Reference for engineering study, to review options to improve in the water plant and intake system capacity, to meet the future needs of the community.

## 1.1 Scope of Work

The scope of work outlined in the Nuna Burnside proposal, which was approved by the GN, includes seven phases:

- Phase 1 – Project Initiation Phase
- Phase 2 – Preliminary Design
- Phase 3 – Detailed Design Phase
- Phase 4 – Construction Document Phase
- Phase 5 – Bidding or Negotiation Phase
- Phase 6 – Contract Administration and Construction Inspection Phase
- Phase 7 – Warranty Period/Post-Construction Monitoring.

This report details the work conducted to date, and provides the detailed design for the proposed facilities (Phase 3 above).

## 1.2 Description of Selected Preferred Alternatives

The Schematic Design Report (December 2005) prepared for the Hamlet, outlined options to improve the sewage disposal and solid waste disposal infrastructure, that would meet the needs of the community over a 20-year planning period. The options and preferred alternatives are discussed below:

### *1.2.1 Sewage Treatment Facility (Sewage Lagoon)*

The Schematic Design Report concluded that the existing lagoon and current operational methods are not currently causing a significant environmental impact, if the wetland area was considered part of the sewage treatment facility. However, the existing facilities and operations are not in compliance with the Nunavut Water Board License and Nunavut regulations.

A review of potential options included:

- Do nothing – this is not legal and environmentally negligent
- Move the facility – costly and no compelling reason to move locations
- Upgrade the existing lagoon with a new larger lagoon, and incorporate the wetland treatment area as part of the treatment system – the most cost effective and an environmentally proactive option that will meet 20-year planning requirements and will comply with Nunavut regulations.

### *1.2.2 Solid Waste Management Facility*

#### Landfill (Municipal Solid Waste Disposal Area)

An investigation of the existing Municipal Solid Waste Disposal Area (Landfill) indicated that it was not causing a significant environmental impact, however it has only a few years capacity remaining at the current operational filling rate. Also, several aspects out of compliance with the Water Board License. A review of potential options included:

- Do nothing – does not meet the Nunavut Water Board License requirements and Nunavut regulations
- Move the site – expensive and no compelling reason to move it
- Expand and rehabilitate the existing site – most cost-effective option to meet 20-year planning requirements in an environmentally proactive fashion in compliance with Nunavut regulations.

#### Bulky Metals Area

The Bulky Metals Area is not currently, nor expected to, cause a significant environmental impact. It is operating in compliance with Nunavut regulations. The growing size of the facility is a concern from a planning and aesthetics viewpoint. A review of potential options included:

- Do nothing – a potentially viable option depending on the desires of the Hamlet to let the site continue to expand
- Move the facility – expensive and there is no compelling reason to move it

- Ship the bulky metals out of Hamlet – prohibitively costly
- Bury some or all of the bulky metals in a selected part of the Solid Waste Management Facility – a cost effective, practical, and environmentally proactive solution in accordance with Nunavut regulations.

### Waste Oil and Hazardous Materials Area

Hamlet staff have done a good job segregating waste oil and hazardous materials, and stockpiling them in a segregated area, however the area is unsecured and open to unauthorized dumping. Although there is currently no evidence of a significant environmental impact, the site is very vulnerable to a spill, which could cause a potentially significant impact. The facility is not licensed or secured in accordance with regulations. The options evaluated included:

- Do nothing – not acceptable from a regulatory and environmental protection view point
- Move the facility – moving the wastes to a more secure facility is an excellent short term solution, but provides no long term solution
- Ship out of community – the simplest option, but is not cost effective or necessary for all materials
- On-site treatment – suitable for some materials such as waste oil, glycol, and paint, but not suitable for other materials such as batteries.

The most cost-effective and environmentally proactive option in accordance with Nunavut regulations would be to:

- Incinerate oil and glycol in a waste oil incinerator
- Reuse and recycle waste paint, and dry out remainder, for disposal at the landfill
- Ship the waste batteries out of the Hamlet to a southern recycling facility.

To handle these wastes in the future, a Hazardous Waste Storage Area has been included in the rehabilitation of the Solid Waste Design Management Facility. In future, the Hazardous Waste Storage Area would be operated within a controlled area of the Solid Waste Management Facility and under the Nunavut Water Board License.

### Contaminated Soil Stockpile

An investigation of the existing contaminated soil stockpile (referenced to as the landfarm) revealed that permafrost has re-aggraded into the pile. Sampling of near-surface soil indicates low levels of petroleum hydrocarbons. Test pitting and sampling on and around the stockpile indicates that it is not currently causing a significant environmental impact. The site is not controlled and not a licensed waste disposal site. Sample results indicate that some (possibly all) of the soil would be acceptable as landfill cover. Options evaluated included:

- Do nothing – site is uncontrolled and not licensed
- Move the stockpile to another site – should only be moved once to its final destination
- Ship soil out of Hamlet – cost prohibitive and not necessary
- Move soil to the landfill as cover material – cost-effective and environmentally proactive option that meets Nunavut regulations. Soil that is not suitable for placing in the landfill due to elevated levels of hydrocarbons should be placed in the landfarm. Any materials not suitable for landfilling or landfarming will be stored in the Hazardous Waste Storage Area.

## 1.3 Outline of Detailed Design Report

This report is organized in the following fashion:

**Section 1 –** Provides an introduction to the project, a description of the scope of work involved and briefly summarizes the selected preferred alternatives.

**Section 2 –** Summarizes the pertinent background information from previous reports, provides a description of the community, discusses historical climate data, presents historical and projected population data, defines common design criteria for the proposed new facilities, and discusses the agency review process.

**Section 3 –** Outlines the existing sewage storage and treatment system with a summary of its condition based on the site assessments, presents the anticipated effluent discharge criteria, and the treated effluent parameters prior to discharge from the lagoon. Section 3 also describes the details of a redesigned lagoon and the concept of including a wetland treatment area that provides secondary treatment of the effluent.

**Section 4 –** Provides a synopsis of the existing solid waste management facilities and identifies current deficiencies. The section also presents the design details of the selected preferred alternative for solid waste management.

**Section 5 –** Provides geotechnical and design details related to construction of the facilities.

**Section 6 –** Presents the Class ‘B’ estimates for the capital costs associated with constructing the proposed new facilities and addressing related issues.

**Section 7 –** Provides a summary of the CEAA environmental screening process.

**Section 8 –** Summary.

**Section 9 –** References.

This Detailed Design Report also references the following separately bound documents, which accompany the submission to the NWB:

- Solid Waste Management Facility Operation and Maintenance (O&M) Plan
- Sewage Treatment Facility Operation and Maintenance (O&M) Plan
- Environmental Emergency Contingency Plan
- Monitoring Program and Quality Assurance/Quality Control Plan
- Large-scale detailed design drawings prepared for the construction tender.

These separately bound documents are an integral part of the application submission to the NWB for an amendment to the Water License.

This report is a revised update of the June 2006 Detailed Design Report that was submitted to the Hamlet, GN and NWB. This report was prepared at the request of the GN to address issues raised by the NWB as outlined in the correspondence in Appendix A.

# 2.0 Background Information

## 2.1 Previous Reports and Documentation

The following is a list of background information that was reviewed as part of the preparation of this Detailed Design Report:

- Schematic Design Report – completed by Nuna Burnside Engineering and Environmental Ltd. in December 2005. This study established population projections and the corresponding servicing capacity required for this community. This report presented and evaluated several options that were considered for these facilities

- Water License (NWB3KUGO308) – provided by the Nunavut Water Board, stipulates the terms and conditions that the Hamlet must follow in the construction, monitoring, and operation and maintenance of the water supply, solid waste facility, and sewage infrastructure

- Inspection Reports – prepared by Indian and Northern Affairs Canada (INAC) assessing the current facilities and their compliance with the issued Water License along with any additional health and safety concerns that were observed. Reports for the following dates were available: October 29, 1996; December 1, 1998; December 1, 2002; August 26, 2002; August 3, 2003 and July 19, 2004

- Detailed Design Report of the Improvement to the Sewage Lagoon and Solid Waste Disposal Facility, The Hamlet of Kugluktuk, by Nuna Burnside Engineering and Environmental Ltd., dated June 2006

- Construction Tender and tender drawings prepared by Nuna Burnside dated August 2006

- References included in Section 9.0.

There were previous applications for an amendment to the Water Board Licence in 2003. There was also population projects and other data submitted in Annual Monitoring Reports in 2004. Nuna Burnside began work in September 2005 and reviewed the data provided by others. This document supersedes the submissions made by others.

## 2.2 Review of Initial Submission to the NWB

After review of the Schematic Design Report, the GN authorized Nuna Burnside to complete a Detailed Design Report. A Detailed Design Report dated June 2006 was submitted to the GN and forwarded to the NWB, along with an application for an amendment to the Water Board License. Tender documents and large-scale detailed drawings were prepared and also forwarded to the NWB.

A letter response from the NWB was received, dated October 24, 2006 (Appendix A-1). The letter requested additional information and identified a number of issues of concern relating to the submission. A detailed response to each item raised by the NWB was provided in a letter from Nuna Burnside, dated January 26, 2007 (Appendix A-2). After discussions between the GN, NWB, and Nuna Burnside a further letter was received from the NWB, dated March 14, 2007 (Appendix A-3).

Based on the discussions, the GN directed Nuna Burnside to prepare a revised Detailed Design Report and additional documentation, for submission to the NWB to support the application for a Water License amendment.

## 2.3 Community Information

### *2.3.1 Location*

The Hamlet of Kugluktuk (formerly known as Coppermine), is situated on Coronation Gulf at the mouth of the Coppermine River. The Hamlet is situated on a rocky area on the west side of the Coppermine River, at latitude 67°49'N, longitude 115°06'W, as shown on Figure 1.

### *2.3.2 Regulatory Approvals*

In accordance with the Nunavut Water and Nunavut Surface Rights Tribunal Act, the Nunavut Water Board (NWB) has responsibilities and authority over the use, management, and regulation of inland water in Nunavut. It is arms length from the government and licenses water taking, sewage systems, and landfills in Nunavut. Once a license is issued by the NWB, compliance and enforcement falls under the jurisdiction of the Department of Indian and Northern Affairs (DIAND).

Currently the Hamlet’s water supply, sewage disposal, and solid waste is regulated by License No. NWB3KUG0308, issued in November 20 2003 and expires November 30, 2008 (Appendix B).

It should be noted that the Water Licence applies to water intake, sewage treatment and disposal and solid waste. The scope of this project does not include water intake. This report assumes that the water intake component of the Water Licence will remain unchanged or be the subject of a future amendment.

### *2.3.3 Existing Infrastructure and Facilities*

Hamlet of Kugluktuk infrastructure includes:

- A water treatment plant, which draws water from the Coppermine River and stores it for treatment
- Trucked water to holding tanks in each building

- A sewage lagoon that receives trucked sewage collected from holding tanks in each building
- Sewage treatment via an exfiltration lagoon to a wetland discharging north to the ocean at Coronation Gulf
- A solid waste disposal facility, which includes a bulky metals disposal area
- A contaminated soil pile, a waste oil and liquid waste storage area, and a battery and other materials storage area
- Several rock and sand quarries
- Diesel powered generators
- Two wind generators (one partially dismantled and the other currently off-line)
- Barge landing area.

The Hamlet is predominately residential with a few small commercial establishments including a hotel, several construction contracting businesses, grocery store, and a variety of other small businesses. Hunting and fishing in the traditional manner is still a prime occupation for many of the inhabitants. Community buildings include a high school, an elementary school, arena, swimming pool, Hamlet office, public works yard, GN offices, and police station.

### *2.3.4 Climate Data*

Kugluktuk is affected by Arctic air masses, and experiences a maritime Arctic climate characterized by short cool summers, and long cold winters. The mean annual air temperature is -12°C. Monthly averages range from -31°C in February to 10°C in July. Kugluktuk receives about 249 mm of precipitation per year, of which 134 mm falls as rain between June and September. Prevailing winds are from the east in summer and from the southwest in winter. The mean wind speed is approximately 15 km/hr. Climate details are included in Appendix C.

### *2.3.5 Population Data*

The population data for the Hamlet of Kugluktuk was obtained from the Nunavut Bureau of Statistics, 2000 (Nunavut Community Population Projections 2000 – 2020). The population values for the years 2006 to 2026 were extracted from this document. Population values for the subsequent years of 2021 to 2031 were calculated at a projected growth rate of + 1.5 percent per annum.

The community has a total population of 1,585 for year 2006, and a projected population of 2,270 for year 2026.

## 2.4 Geology and Morphology

### *2.4.1 Terrain*

The ground surface consists of bedrock and glacial deposits. Boulders and cobbles cover some areas. Much of the surface is covered with turf consisting of various grasses, sedges, and moss underlain by a thin (10 cm to 30 cm) layer of topsoil and/or peat. In some areas such as between raised beaches, peat and organics can be much thicker.

The land area around Kugluktuk is underlain by permafrost estimated at several hundreds of metres thick. There is no permafrost under major water bodies such as Coronation Gulf. A deep zone of non-permafrost probably exists as a talik beneath the Coppermine River. The depth of the active layer over most of the land area is dependent on vegetation cover, soil type, and moisture conditions. Test pitting in the vicinity of the sewage lagoon and landfill found the top of the permafrost in early October to be approximately 0.9 m below surface. Test pit logs are included in Appendix D.

### *2.4.2 Bedrock Geology*

Figure 3 displays the bedrock geology of Kugluktuk. The bedrock in the area consists of Proterozoic fine grained sedimentary and meta-sedimentary (shale) of the Rae Group. These have been intruded by the Coronation Sills, which are composed primarily of granular gabbro.

A northeast trending ridge of bedrock dominates the topography from Heart Lake to the mouth of the Coppermine River.

Both gabbro and shale have been quarried locally for construction materials.

### *2.4.3 Surficial Geology*

Figure 4 displays the surficial geology of the Kugluktuk area. The area is dominated by the effects of isostatic rebound following the last glaciation, and deposits related to the discharge of the Coppermine River.

West of Kugluktuk (between the sewage lagoon and the ocean) is an area of raised beach ridges comprised of poorly-graded medium-grained sand. More varied fine to coarse sediments are found in the Hamlet and along the west side of the Coppermine River. Sand is quarried at a pit located near the west end of the runway. Another area used for extraction of sandy construction material is located near the east end of the runway.

### *2.4.4 Local Geological Resources for Construction*

The evaluation of the existing sewage lagoon and solid waste facility included examining local sand pits and rock quarries. In addition, test pitting was conducted in the area of the facilities, as shown on Figure 5. Test pit logs are included in Appendix D. The results of the geotechnical analysis of selected soil samples are included in Appendix E.

The results of the test pitting and soil testing program indicates that there is approximately 1.0 m of surficial medium-grained, poorly-graded sand overburden, that could be excavated to supply construction material in the immediate vicinity of the facilities. Very little coarse-grained material or fine clay-rich material was observed locally. Local contractors indicate coarse aggregate is available from off-shore islands, and must be trucked to the community during the winter from the Seven Mile Island quarry.

To date, no significant quantities of gravel resources have been identified close to the Hamlet road network.

Approximately 10,000 $m^3$ of unsorted blast rock is stockpiled in the Gabbro Quarry, approximately 300 m west of the Bulky Metals area, as shown on Figure 3. The quarry face is in good condition, and there is a huge remaining resource of rock, which could be blasted for production of coarse aggregate or rubble materials. A crusher/screener has been used by contractor to stockpile aggregate for specific projects such as the airport surfacing.

The poorly-graded medium sand overburden has been pushed into berms using a bulldozer at the landfill site and existing sewage lagoon. The existing sewage lagoon also has a portion of its berm constructed from cobble and small boulder-sized fragments from the rock quarry. This results in rapid exfiltration of the sewage from the lagoon. Geotechnical assessment of the local medium-grained sand indicates it would be suitable for berm construction, provided it was densely compacted, remained unsaturated and protected from erosion. Compaction would need to be carried out using specialized equipment, and ongoing testing and monitoring of the placed materials would be required (refer to Appendix D.)

In summary, there appears to be sufficient geotechnical resources in the immediate proximity of the sewage lagoon and solid waste disposal facility, to meet expected construction needs providing the detailed design takes into account the nature of the local materials.

## 2.5 Design Criteria

The sewage treatment facility and solid waste disposal facility have common design criteria that must be satisfied when implementing improvements. The common criteria includes:

**Population Projection –** The upgrades to the facilities must meet the projected needs of the community for a 20-year design life following commissioning of the works. The population value used in design calculations is for the year 2026.

**Arctic Conditions –** The facilities must be designed to operate in and withstand extreme cold temperatures and other harsh climatic conditions such as prolonged daylight during the summer months, which may degrade liners.

**Cost Effective –** All designs must be cost effective to implement, both in terms of the capital and operation and maintenance costs.

**Simplicity –** The upgrades must be simple to operate yet effective.

**Environmentally Sound –** The proposed design solutions should reduce environmental impacts and ideally enhance the environmental conditions at the proposed sites and surrounding areas

## 2.6 Agency Review

As part of the approval process, the GN will submit the design to the NWB for review. Other agencies could be involved in the review including:

- Indian and Northern Affairs Canada (INAC)
- Office of the Fire Marshall, Nunavut
- Department of Community and Government Services – Technical Services Division, Government of Nunavut
- Environment Canada (EC)
- Department of Fisheries and Oceans Canada (DFO).

A Water License is required by the Nunavut Water Board for the construction and operation of water, sewage, and solid waste facilities in the territory of Nunavut. The Hamlet is operating the existing facilities under the current water license NWB3KUGO308, which expires on November 30, 2008. The license includes requirements for regular sampling and reporting. The license also provides sewage quality criteria for the point of discharge. The proposed new designs and upgrades to the sewage and solid waste facilities, requires an amendment to the Water Board License.

A Detailed Design Report was submitted to the NWB in July 2006 accompanied by large-scale design drawings prepared for the tender, the Schematic Design Report (December 2005) and an application for an amendment to the Water Board Licence. The NWB provided a response to their review in a letter dated October 24, 2006 (Appendix A-1). Nuna Burnside provided a letter, dated January 26, 2007, responding in detail to each item raised by the NWB (Appendix A-2). Following a response by the NWB in a letter dated March 14, 2006 (Appendix A-3), the GN directed Nuna Burnside to prepare a revised Detailed Design Report and accompanying documents, and to a re-submit for a Water License amendment.

# 3.0 Sewage Treatment Facility

## 3.1 Existing Conditions

At present, the Hamlet of Kugluktuk operates a single-cell sewage lagoon with the effluent discharged to a natural wetland, which eventually discharges into the Coronation Gulf. This existing sewage lagoon is located approximately 4 km west south-west of the community (Figure 2). It is accessed from the community by Coronation Drive, and is located out-of-sight of the community near the solid waste landfill facility and the bulky metals disposal area. It is adjacent to the waste battery and waste oil storage area (Figure 6). There are no documented complaints of odours from the lagoon.

Sewage is collected daily by a tanker truck from holding tanks located at the houses and occupied buildings, including the commercial and institutional buildings. The sewage is collected from the holding tanks via external discharge ports on the exterior wall of these buildings. A truck operated by two Hamlet staff transport the sewage to the lagoon and the operator discharges the sewage from the truck onto one of two culverts used as a spillway. The spillway is used to prevent bank erosion during the discharge of the sewage into the lagoon.

Currently, the sewage is only temporarily contained within the lagoon, and discharges rapidly via an exfiltration berm to a small intermittent stream that follows a natural meandering course over 1.5 km to Coronation Gulf. This stream traverses through a natural occurring wetland, which currently provides some level of treatment to the effluent being discharged from the lagoon (Figure 2).

The existing unlined lagoon was constructed in 2003 by Hamlet staff during a heavy equipment operator-training course. The lagoon area is approximately 60 m by 40 m with an approximate depth of 2 m. The estimated interior area is 2,324 $m^2$ and with a depth of 2.0 m, the volume is estimated to be 4,648 $m^3$ (Figure 5).

The lagoon is currently providing a high degree of solids retention, although during the summer, there is rapid flow through the berm (exfiltration). The rapid exfiltration is due to the berm being constructed partially of rock rubble from the local quarry. The water levels in the lagoon are therefore not significantly above the natural surface water level in the drainage stream. With this continued exfiltration the majority of the lagoon volume is unusable.

The point of exfiltration into the wetland stream is currently considered to be the point of discharge under the Water License. The only treatment provided for determining compliance with the Water Board guidelines takes place within the lagoon itself.

**Table 1:**
**Summary of Sewage Report Data for the Hamlet of Kugluktuk, Nunavut (2004 - 2005)**

| **Parameter** | **Units** | | | | | | | | | | | **Current Data** | | | **Nunavut Requirements** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample Date** | | 22-Jul-04 | 14-Oct-04 | 14-Oct-04 | 10-Aug-04 | 10-Aug-04 | 09-Sep-04 | 09-Sep-04 | 23-Jun-04 | 23-Jun-04 | 04-Oct-05 | 04-Oct-05 | 04-Oct-05 | 04-Oct-05 | **Existing** | **Proposed** |
| **Sample ID** | | | KUG-2 | KUG-4 | KUG-2 | KUG-4 | KUG-2 | KUG-4 | KUG-2 | KUG-4 | WS1 | WS2 | WS3 | WS4 | **Criteria** | **Criteria** |
| **Total Metals - CCME** | | | | | | | | | | | | | | | | |
| **Total Trace Metals** | | | | | | | | | | | | | | | | |
| Silver | mg/L | nd | | | | | | | | | nd | nd | nd | nd | | |
| Aluminum | mg/L | 75 | | | | | | | | | 1.78 | 0.2 | 0.21 | 0.1 | | |
| Arsenic | mg/L | nd | 4 | nd | nd | 1 | 2 | 3 | nd | nd | 0.0015 | 0.0008 | 0.0012 | 0.0012 | | |
| Boron | mg/L | | | | | | | | | | 0.14 | 0.05 | 0.06 | nd | | |
| Barium | mg/L | 10.4 | | | | | | | | | 0.016 | 0.019 | 0.023 | 0.013 | | |
| Beryllium | mg/L | nd | | | | | | | | | nd | nd | nd | nd | | |
| Cadmium | mg/L | nd | 0.1 | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | | |
| Cobalt | mg/L | 0.4 | | | | | | | | | nd | nd | nd | nd | | |
| Chromium | mg/L | nd | 5.7 | 2.5 | 0.6 | 0.8 | 0.6 | nd | 0.5 | 1.2 | nd | nd | nd | nd | | |
| Copper | mg/L | 3.3 | 49.2 | 8.9 | 2.6 | 1.7 | 4.6 | 7.6 | 3.3 | 4.1 | 0.075 | 0.016 | 0.021 | 0.003 | | |
| Mercury | mg/L | nd | nd | nd | 0.04 | nd | nd | nd | nd | nd | nd | nd | nd | nd | | |
| Lithium | mg/L | 1.5 | | | | | | | | | nd | nd | nd | nd | | |
| Molybdenum | mg/L | nd | | | | | | | | | nd | nd | nd | nd | | |
| Nickel | mg/L | 0.6 | 9.7 | 2.2 | 1.5 | 2.4 | 2 | 2.7 | 0.8 | 1.8 | h | 0.002 | 0.003 | 0.003 | | |
| Lead | mg/L | 0.1 | 4.7 | 0.4 | 0.1 | 0.2 | 0.2 | 1.4 | 0.2 | 0.6 | 0.0026 | 0.0006 | 0.0007 | 0.0002 | | |
| Antimony | mg/L | 0.5 | | | | | | | | | 0.0023 | 0.0012 | 0.0007 | nd | | |
| Selenium | mg/L | nd | | | | | | | | | 0.0009 | nd | nd | nd | | |
| Tin | mg/L | | | | | | | | | | nd | nd | nd | nd | | |
| Titanium | mg/L | 2.8 | | | | | | | | | 0.01 | 0.011 | 0.015 | 0.003 | | |
| Thallium | mg/L | 0.4 | | | | | | | | | nd | nd | nd | nd | | |
| Uranium | mg/L | nd | | | | | | | | | 0.0001 | nd | nd | nd | | |
| Vanadium | mg/L | 0.5 | | | | | | | | | 0.002 | nd | nd | 0.001 | | |
| Zinc | mg/L | nd | 63 | 20 | nd | nd | nd | 22 | 11 | | 0.14 | 0.018 | 0.022 | nd | | |
| **Total Major Metals** | | | | | | | | | | | | | | | | |
| Calcium | mg/L | 8.5 | 251 | 14 | 38.1 | 25.6 | 15.9 | 45.6 | 30 | 6.6 | 19.9 | 17 | 18.1 | 19 | | |
| Potassium | mg/L | 1.3 | 7.6 | 3.6 | 1.66 | 2.86 | 2.3 | 2 | 1.97 | 2.08 | 23 | 6.9 | 13.2 | 4.8 | | |
| Magnesium | mg/L | 7.1 | 118 | 10.8 | 21.2 | 12.1 | 11.5 | 21.1 | 12.3 | 4.9 | 10.6 | 11.8 | 12.3 | 13.9 | | |
| Sodium | mg/L | 16.7 | 106 | 30.8 | 19.2 | 31.2 | 28.2 | 18.5 | 12.6 | 14.8 | 95 | 46 | 57 | 40 | | |
| Iron | mg/L | 1810 | 11500 | 3550 | 262 | 2530 | 1550 | 5050 | 809 | 2391 | 1.16 | 1.42 | 4.82 | 6.14 | | |
| Manganese | mg/L | 122 | | | | | | | | | 0.143 | 0.153 | 0.225 | 0.551 | | |
| Ammonia-N | mg/L | 1.21 | 7 | 14 | 0.018 | 4.34 | 6.1 | 0.006 | 0.006 | 2.68 | 94 | 22.5 | 34.3 | 12.4 | | |
| Bio Oxygen Demand (BOD) | mg/L | | 19 | 11 | 3 | 4 | 4 | 4 | 5 | 8 | 276 | 68 | 81 | 8 | 120 | 45 |
| MF - Fecal Coliforms | CFU/100mL | 150 | 900 | 500 | 8 | 56 | 7240 | 119 | 240 | 3400 | 1.30E+07 | 1.90E+06 | 1.50E+06 | 4.00E+03 | 1.00E+06 | 2.00E+03 |
| Oil and Grease | mg/L | | nd | nd | nd | nd | | | nd | nd | 22 | | 7 | nd | No visible sheen | No visible sheen |
| Phenols | mg/L | nd | 1.1 | 1.6 | nd | 0.5 | | | 4.4 | | 0.465 | 0.098 | 0.119 | 0.029 | | |
| Total Suspended Solids | mg/L | 6 | 1540 | 4 | nd | 4 | 14 | 6 | 6 | 18 | 95 | 14 | 34 | 7 | 180 | 45 |
| pH | pH | 7.69 | 7.54 | 7.25 | 8.22 | 7.49 | 7.22 | 7.51 | 7.61 | 7.2 | 7.4 | 7.4 | 7.5 | 7.5 | between 6 and 9 | 6.5 - 9 |
| Total Phosphorous (T-PO4) | mg/L | 0.24 | | | | | | | | | | | | | | 1 |
| Total Kjeldahl Nitrogen (TKN) | mg/L | | | | | | | | | | | | | | | 10 |

Historic water quality sampling results from 2004 and 2005 are displayed on Table 1. The results show current conditions with respect to NWB Water License criteria. Sample locations are shown on Figure 18.

The sample data on Table 1 references the following sampling points:

- KUG-2 – NWB Water License sampling point for discharge into the lagoon
- KUG-4 – NWB Water License sampling point for the effluent discharge from the lagoon (current final discharge sampling point)
- WS-1 through WS-4 – Nuna Burnside sampling points in the wetland area.

As shown on Table 1, the criteria for BOD has historically never been exceeded, except at one station in the wetland. The level of fecal coliforms tends to exceed the discharge criteria until partway down the flow path.

The current effluent quality criteria for sewage discharged by the Hamlet of Kugluktuk is prescribed in the Water License NWB3KUG0308 issued on November 20, 2003.
The final discharge point for the sewage effluent from the lagoon is described in the Water License as KUG-4, as shown on Figure 6. The effluent criteria as monitored at the lagoon discharge point (KUG-4) is presented below in Table 2.

Table 2: Nunavut Water Board Effluent Discharge Quality Criteria
(As per the Hamlet of Kugluktuk Water License)

| Parameters | NWB License Limits (mg/L) |
|---|---|
| Biological Oxygen Demand (BOD) | 120 |
| Total Suspended Solids (TSS) | 180 |
| pH | 6-9 |
| Faecal Coliforms (FC) | $1 \times 10^6$ C.F.U./ 100 ml |
| Oil and Grease | No visible sheen |

Historically, prior to the construction of the lagoon in 2003, the Hamlet employed a "honey bag" system for sewage handling and disposal. A former honey bag pit remains next to the west berm of the lagoon (Figures 5 and 7). A 2003 NWB application makes reference to a 17,000 $m^2$ area between the air strip and Coronation Gulf, formerly used as a honey bag pit. Hamlet staff could provide no clarification regarding such a site. If such a site is identified in the future, it will be assessed and remediated as part of another scope of work and approvals process.

The Schematic Design Report evaluated three options:

- Do nothing
- Move the sewage treatment facility to another location
- Upgrade the existing lagoon with a new larger lagoon, with the incorporation of a wetland treatment area.

These options were presented, discussed and analyzed in detail in the Schematic Design Report.

The Schematic Design Report concluded that considering access, available land, site constraints, the remoteness of the present site to the community, availability of suitable soils, simple operation, and the anticipated costs, the community should continue to use a lagoon-based system for sewage treatment and consider a new lagoon to be constructed adjacent to the existing lagoon. The Schematic Design Report also recommended that a wetland treatment system be formally incorporated into the design of the facility.

## 3.2 Nunavut Sewage Lagoon Design References

### *3.2.1 Documents*

The requirements for the design and operation of sewage lagoons in Nunavut can be found in the following documents:

- G. W. Heinke, D. W. Smith and R. Gerard, 1990. Guidelines for Disposal of Sewage in Coastal communities of the NWT
- Nunavut Water Board Guidelines for the Discharge of Domestic Wastewater in Nunavut, 2000
- Cold Regions Monograph, 3rd Ed., 1992
- G.W. Heinke, D. W. Smith and R. Finch, 1998. Guidelines for the Planning, Design and Operation and Maintenance of Sewage Lagoon Systems in the NWT.

It should be noted that, although these documents were developed prior to the division of Nunavut from the North West Territories (NWT), these documents have generally been the accepted guidelines followed by the regulatory agencies in Nunavut.

### *3.2.2 Regulatory Comparative Criteria*

Nuna Burnside examined current NWB licence requirements for sewage effluent as well as the discharge criteria in a variety of other jurisdictions. Nuna Burnside project staff included Mr. A. James (Jim) Wall, who worked for the NWB for several years prior to joining Nuna Burnside. Based on the review of various effluent criteria and input from Mr. Wall as to what future criteria might be, Nuna Burnside developed the “Anticipated Nunavut Water Board Criteria” as follows:

| Regulatory Parameter | NWB License Limits | Anticipated NWB Guidelines |
|---|---|---|
| BOD (mg/L) | 120 | 45 |
| TSS (mg/L) | 180 | 45 |
| T-$PO_4$ (mg/L) | N/A | 1 |
| TKN (mg/L) | N/A | 10 |
| FC (CFU/dL) | $1 \times 10^4$ | $2 \times 10^2$ |

Since the sewage treatment facility was being designed for a minimum 20-years of life, Nuna Burnside felt it was prudent to use more stringent criteria for the effluent discharge than what is currently required. This higher standard of compliance provides a significant level of environmental protection and conservative engineering.

In collaboration with scientists throughout the world, Canada has declared 2007/2008 International Polar Year. This has prompted a number of scientific studies, including concerns about the impact of global warming and human impacts to the Arctic. One Canadian Science and Research Project is entitled "*Constructed Wetlands for Treatment of Wastewater in Arctic Communities*", led by the Centre for Alternative Wastewater Treatment at Fleming College. In light of available information and increasing concerns about the sensitivity of the Arctic, Nuna Burnside has designed the Sewage Treatment Facility to meet more stringent effluent discharge criteria than is currently required. A brief cost/benefit analysis indicates no significant extra cost will be incurred in creating a design to meet these more stringent standards.

## 3.3 Projected Sewage Quantity

In trucked service communities, it is normally assumed that the sewage generated is equivalent to the water consumption. Accordingly, the daily and annual sewage generation rates for the Hamlet of Kugluktuk are assumed to be equal to the water consumption rates.

As referenced previously, the Government of Nunavut has adopted the standards of the Government of the North West Territories (NWT) Department of Municipal and Community Affairs. The NWT has developed a standard for water consumption in communities of less than 2,000 residents on trucked services. The consumption rate is estimated a 90 L/person/day. By year 12 of the 20-year design planning period, the population will reach 2,000 people. To account for changing life styles and the growing population, a slightly higher consumption rate will be used over this 20-year design period. Therefore, for Kugluktuk, a rate of 100 L/person/day as an average over the 20-year life is used. The following formula modified from the NWT Standard is used:

***Water Use (L/person/day) = 100 L/person/day x (1.0 + 0.00023 x population)***

Where the factor 0.00023 multiplied by the population represents the commercial and industrial water use.

Based on the above criteria, the projected annual volume of sewage generated at the end of 10 years (2016) is 101,578 $m^3$, while the 20-year (2026) annual volume is 126,113 $m^3$.

Table 3 provides a summary of the sewage generation rate for the Hamlet of Kugluktuk over the 20-year design period.

The design objectives and for a new Sewage Treatment Facility are:

- Meet the expected sewage volume requirements for the 20-year design period
- Provide approximate structures for easy cost-effective use in all weather
- Have an effluent chemistry that meets current NWB and Environment Canada Guidelines, and meets reasonably foreseen future guideline requirements that may become the standard within the 20-year design period.

## 3.4 Sewage Chemistry

The chemistry of the sewage is an important factor when developing a design or a new Sewage Treatment Facility, to meet the regulatory discharge criteria over the 20-year design life. The Hamlet of Kugluktuk's sewage is primarily from household domestic sources. There is a small amount of commercial and institutional sources (restaurants, hotels, administration buildings, etc.), however the volume and chemistry of these discharges are not expected to significantly alter the overall chemistry of the sewage sent to the Sewage Treatment Facility. As outlined in the previous section, the anticipated volume of the sewage has been calculated. To determine the anticipated chemistry of the sewage, a number of assumptions are made based on published data and site specific data.

The assumptions shown in Table 4 are values employed with wastewater treatment systems. It is accepted that the values are dependent on variables such as location (latitude and longitude), climate conditions, temperature, water use, plant operating experience, etc. There are typical ranges of values provided in "*Wastewater Engineering – Metcalf & Eddy – 4th Edition*"- Table 3-12. The values used for our assumptions are based on selected conservative low-levels to be expected for northern climes such as the Northwest Territories and Nunavut. The assumptions were also compared to the values included in the Ontario Ministry of Environment document "*Guidelines for the Design of Water Treatment Plants and Sewage Treatment Plants*". The values in Table 4 have been selected to be site and climate-specific and conservative.

# Table 3
## Projected Sewage and Sludge Generation Rates for the Hamlet of Kugluktuk, Nunavut

| Planning Year | Calendar Year | Total Population[1] | Projected Sewage generation[2] (lpcd) | Projected Volume (litres/day) | Projected Volume (litres/year) | Projected Sludge Quantity (kg/annum) | Sludge Volume[3] ($m^3$) (3%) | | Sludge Volume[4] ($m^3$) (4%) | | Sludge Volume[5] ($m^3$) (5%) | | Sludge Volume[6] ($m^3$) (10%) | | Sludge Volume[7] ($m^3$) (15%) | | Sludge Volume[8] ($m^3$) (20%) | | BOD (mg/l) | TSS (mg/l) | $T\text{-}PO_4$ (mg/l) | TKN (mg/l) | Faecal Coliforms (C.F.U./100ml) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Cumulative | | Cumulative | | Cumulative | | Cumulative | | Cumulative | | Cumulative | | | | | |
| 0 | 2006 | 1585 | 136.5 | 216,281 | 78,942,629 | 28,926.3 | 964.2 | 964.2 | 723.2 | 723.2 | 578.5 | 578.5 | 289.3 | 289.3 | 192.8 | 192.8 | 144.6 | 144.6 | 329.8 | 351.8 | 16.9 | 87.9 | 6.96E+07 |
| | 2007 | 1618 | 137.2 | 222,012 | 81,034,472 | 29,528.5 | 984.3 | 1,948.5 | 738.2 | 1,461.4 | 590.6 | 1,169.1 | 295.3 | 584.5 | 196.9 | 389.7 | 147.6 | 292.3 | 328.0 | 349.8 | 16.8 | 87.5 | 6.92E+07 |
| | 2008 | 1653 | 138.0 | 228,145 | 83,273,074 | 30,167.3 | 1,005.6 | 2,954.1 | 754.2 | 2,215.6 | 603.3 | 1,772.4 | 301.7 | 886.2 | 201.1 | 590.8 | 150.8 | 443.1 | 326.0 | 347.8 | 16.7 | 86.9 | 6.88E+07 |
| | 2009 | 1686 | 138.8 | 233,980 | 85,402,593 | 30,769.5 | 1,025.7 | 3,979.7 | 769.2 | 2,984.8 | 615.4 | 2,387.8 | 307.7 | 1,193.9 | 205.1 | 795.9 | 153.8 | 597.0 | 324.3 | 345.9 | 16.6 | 86.5 | 6.85E+07 |
| | 2010 | 1720 | 139.6 | 240,043 | 87,615,768 | 31,390.0 | 1,046.3 | 5,026.1 | 784.8 | 3,769.5 | 627.8 | 3,015.6 | 313.9 | 1,507.8 | 209.3 | 1,005.2 | 157.0 | 753.9 | 322.4 | 343.9 | 16.5 | 86.0 | 6.81E+07 |
| 5 | 2011 | 1760 | 140.5 | 247,245 | 90,244,352 | 32,120.0 | 1,070.7 | 6,096.7 | 803.0 | 4,572.5 | 642.4 | 3,658.0 | 321.2 | 1,829.0 | 214.1 | 1,219.3 | 160.6 | 914.5 | 320.3 | 341.7 | 16.4 | 85.4 | 6.76E+07 |
| | 2012 | 1793 | 141.2 | 253,242 | 92,433,157 | 32,722.3 | 1,090.7 | 7,187.5 | 818.1 | 5,390.6 | 654.4 | 4,312.5 | 327.2 | 2,156.2 | 218.1 | 1,437.5 | 163.6 | 1,078.1 | 318.6 | 339.8 | 16.3 | 85.0 | 6.73E+07 |
| | 2013 | 1827 | 142.0 | 259,472 | 94,707,414 | 33,342.8 | 1,111.4 | 8,298.9 | 833.6 | 6,224.2 | 666.9 | 4,979.3 | 333.4 | 2,489.7 | 222.3 | 1,659.8 | 166.7 | 1,244.8 | 316.9 | 338.0 | 16.2 | 84.5 | 6.69E+07 |
| | 2014 | 1859 | 142.8 | 265,385 | 96,865,621 | 33,926.8 | 1,130.9 | 9,429.8 | 848.2 | 7,072.3 | 678.5 | 5,657.9 | 339.3 | 2,828.9 | 226.2 | 1,886.0 | 169.6 | 1,414.5 | 315.2 | 336.2 | 16.1 | 84.1 | 6.65E+07 |
| | 2015 | 1893 | 143.5 | 271,719 | 99,177,554 | 34,547.3 | 1,151.6 | 10,581.4 | 863.7 | 7,936.0 | 690.9 | 6,348.8 | 345.5 | 3,174.4 | 230.3 | 2,116.3 | 172.7 | 1,587.2 | 313.5 | 334.4 | 16.0 | 83.6 | 6.62E+07 |
| 10 | 2016 | 1928 | 144.3 | 278,295 | 101,577,760 | 35,186.0 | 1,172.9 | 11,754.2 | 879.7 | 8,815.7 | 703.7 | 7,052.5 | 351.9 | 3,526.3 | 234.6 | 2,350.8 | 175.9 | 1,763.1 | 311.8 | 332.5 | 15.9 | 83.1 | 6.58E+07 |
| | 2017 | 1965 | 145.2 | 285,308 | 104,137,484 | 35,861.3 | 1,195.4 | 12,949.6 | 896.5 | 9,712.2 | 717.2 | 7,769.8 | 358.6 | 3,884.9 | 239.1 | 2,589.9 | 179.3 | 1,942.4 | 309.9 | 330.6 | 15.8 | 82.6 | 6.54E+07 |
| | 2018 | 2000 | 146.0 | 292,000 | 106,580,000 | 36,500.0 | 1,216.7 | 14,166.3 | 912.5 | 10,624.7 | 730.0 | 8,499.8 | 365.0 | 4,249.9 | 243.3 | 2,833.3 | 182.5 | 2,124.9 | 308.2 | 328.8 | 15.8 | 82.2 | 6.51E+07 |
| | 2019 | 2041 | 146.9 | 299,911 | 109,467,392 | 37,248.3 | 1,241.6 | 15,407.9 | 931.2 | 11,555.9 | 745.0 | 9,244.7 | 372.5 | 4,622.4 | 248.3 | 3,081.6 | 186.2 | 2,311.2 | 306.2 | 326.7 | 15.7 | 81.7 | 6.47E+07 |
| | 2020 | 2076 | 147.7 | 306,725 | 111,954,570 | 37,887.0 | 1,262.9 | 16,670.8 | 947.2 | 12,503.1 | 757.7 | 10,002.5 | 378.9 | 5,001.2 | 252.6 | 3,334.2 | 189.4 | 2,500.6 | 304.6 | 324.9 | 15.6 | 81.2 | 6.43E+07 |
| 15 | 2021 | 2107 | 148.5 | 312,835 | 114,184,737 | 38,455.3 | 1,281.8 | 17,952.6 | 961.4 | 13,464.5 | 769.1 | 10,771.6 | 384.6 | 5,385.8 | 256.4 | 3,590.5 | 192.3 | 2,692.9 | 303.1 | 323.3 | 15.5 | 80.8 | 6.40E+07 |
| | 2022 | 2139 | 149.2 | 319,082 | 116,465,007 | 39,032.1 | 1,301.1 | 19,253.7 | 975.8 | 14,440.3 | 780.6 | 11,552.2 | 390.3 | 5,776.1 | 260.2 | 3,850.7 | 195.2 | 2,888.1 | 301.6 | 321.7 | 15.4 | 80.4 | 6.37E+07 |
| | 2023 | 2171 | 149.9 | 325,470 | 118,796,633 | 39,617.6 | 1,320.6 | 20,574.3 | 990.4 | 15,430.7 | 792.4 | 12,344.6 | 396.2 | 6,172.3 | 264.1 | 4,114.9 | 198.1 | 3,086.1 | 300.1 | 320.2 | 15.3 | 80.0 | 6.34E+07 |
| | 2024 | 2203 | 150.7 | 332,002 | 121,180,905 | 40,211.9 | 1,340.4 | 21,914.7 | 1,005.3 | 16,436.0 | 804.2 | 13,148.8 | 402.1 | 6,574.4 | 268.1 | 4,382.9 | 201.1 | 3,287.2 | 298.7 | 318.6 | 15.3 | 79.6 | 6.30E+07 |
| | 2025 | 2236 | 151.4 | 338,683 | 123,619,146 | 40,815.1 | 1,360.5 | 23,275.2 | 1,020.4 | 17,456.4 | 816.3 | 13,965.1 | 408.2 | 6,982.5 | 272.1 | 4,655.0 | 204.1 | 3,491.3 | 297.2 | 317.0 | 15.2 | 79.2 | 6.27E+07 |
| 20 | 2026 | 2270 | 152.2 | 345,514 | 126,112,716 | 41,427.3 | 1,380.9 | 24,656.1 | 1,035.7 | 18,492.1 | 828.5 | 14,793.6 | 414.3 | 7,396.8 | 276.2 | 4,931.2 | 207.1 | 3,698.4 | 295.6 | 315.4 | 15.1 | 78.8 | 6.24E+07 |
| | 2027 | 2304 | 153.0 | 352,501 | 128,663,012 | 42,048.7 | 1,401.6 | 26,057.7 | 1,051.2 | 19,543.3 | 841.0 | 15,634.6 | 420.5 | 7,817.3 | 280.3 | 5,211.5 | 210.2 | 3,908.7 | 294.1 | 313.7 | 15.0 | 78.4 | 6.21E+07 |
| | 2028 | 2339 | 153.8 | 359,648 | 131,271,469 | 42,679.4 | 1,422.6 | 27,480.3 | 1,067.0 | 20,610.3 | 853.6 | 16,488.2 | 426.8 | 8,244.1 | 284.5 | 5,496.1 | 213.4 | 4,122.1 | 292.6 | 312.1 | 15.0 | 78.0 | 6.18E+07 |
| | 2029 | 2374 | 154.6 | 366,958 | 133,939,561 | 43,319.6 | 1,444.0 | 28,924.3 | 1,083.0 | 21,693.3 | 866.4 | 17,354.6 | 433.2 | 8,677.3 | 288.8 | 5,784.9 | 216.6 | 4,338.7 | 291.1 | 310.5 | 14.9 | 77.6 | 6.15E+07 |
| | 2030 | 2409 | 155.4 | 374,435 | 136,668,802 | 43,969.4 | 1,465.6 | 30,390.0 | 1,099.2 | 22,792.5 | 879.4 | 18,234.0 | 439.7 | 9,117.0 | 293.1 | 6,078.0 | 219.8 | 4,558.5 | 289.6 | 308.9 | 14.8 | 77.2 | 6.11E+07 |
| 25 | 2031 | 2445 | 156.2 | 382,084 | 139,460,748 | 44,629.0 | 1,487.6 | 31,877.6 | 1,115.7 | 23,908.2 | 892.6 | 19,126.6 | 446.3 | 9,563.3 | 297.5 | 6,375.5 | 223.1 | 4,781.6 | 288.0 | 307.2 | 14.7 | 76.8 | 6.08E+07 |

**Reference:** Nunavut Bureau of Statistics, 2000. "Nunavut: Community Population Projections 2000 - 2020".

**Note:** 1) The Nunavut document referenced above was utilized up to 2020. A population growth of 1.5% was applied to the subsequent years (2021 - 2031).

2) The projected sewage generation is based on a slight modification of the NWT water usage formula. The formula [100 L/c/d x (1 + 0.00023 x population)] is used to reflect water usage on a trucked system in a community of less than 2,000 persons grow

3) A value of 3% dry solids is assumed for the liquid sludge accumulating at the bottom of the lagoon.

4) A value of 4% dry solids is assumed for the liquid sludge accumulating at the bottom of the lagoon.

5) A value of 5% dry solids is assumed for the liquid sludge accumulating at the bottom of the lagoon.

6) A value of 10% dry solids is assumed for the liquid sludge accumulating at the bottom of the lagoon.

7) A value of 15% dry solids is assumed for the liquid sludge accumulating at the bottom of the lagoon.

8) A value of 20% dry solids is assumed for the liquid sludge accumulating at the bottom of the lagoon.

The quantity of sludge generated over the design period has been calculated based on the population projections (Table 3) and a sludge generation rate of 50 gms/head/day. This quantity was assumed to accumulate as liquid sludge (at 3 percent dry solids) at the bottom of the lagoon. This volume of liquid sludge is calculated and shown in Table 3, as cumulative volume of sludge.

In the later stages of lagoon life, capacity and efficiency would be improved by removing the sludge.

Table 4: Assumptions for the Calculation of Effluent Concentrations of BOD, TSS, T-$PO_4$, TKN and Faecal Coliforms

| Parameter | Generation Rate |
|---|---|
| Sludge Generation Rate | 50 grams/person/day |
| BOD Generation Rate | 45 grams/ person/day |
| TSS Generation Rate | 48 grams/ person/day |
| Total-$PO_4$ Generation Rate | 2.3 grams/ person/day |
| TKN Generation Rate | 12 grams/ person/day |
| Fecal Coliform Generation Rate | $9.50 \times 10^{10}$ CFU/100 mL/ person/day |

Based on these assumed parameters, the projected annual and cumulative sludge volumes and the design concentrations of Biological Oxygen Demand (BOD), Total Suspended Solids (TSS), Total phosphate (T-$PO_4$), Total Kjeldahl Nitrogen (TKN) and faecal coliforms (FC) in the lagoon effluent are calculated, as shown in Table 3. These calculated values are shown to be decreasing over the planning period since the projected sewage volume generated over the same period leads to a ‘dilution effect’ with respect to these five parameters.

## 3.5 Lagoon Storage Volumes Required

A lagoon with sufficient capacity to retain the estimated annual generated sewage volume for the projected 20th year is required.

In addition to sewage generated by the Hamlet of Kugluktuk, the volume of precipitation and the rate of evaporation must also be considered in establishing the capacity of the lagoon. It is assumed that water evaporates from a sewage lagoon at the same rate as from a lake. It is also assumed that sublimation rates, which is the evaporation from a frozen surface, is not a significant factor. The impact of runoff is not considered a factor, as the lagoon berms will be above grade.

The annual evaporation rate for the Hamlet of Kugluktuk is estimated at approximately 200 mm/year. Climate normal data from the Environment Canada website was obtained, indicating that the average annual precipitation for the Hamlet of Kugluktuk is 249.4 mm/year (climate data is included in Appendix C). This net addition of approximately 49 mm/year of precipitation over the surface of the lagoon will contribute to the total volume requirement of the lagoon. With the proposed design of the sewage lagoon, the surface area would be a minimum of 51,557 $m^2$ and the net addition from precipitation would be 2,526 $m^3$/year. This volume needs to be accounted for in the lagoon design.

The volume of accumulated sludge must also be considered in determining the total storage. Calculations for the various years are presented in Table 3. The proposed design is based on removing the sludge from the bottom of the lagoon (desludging) at regular intervals of approximately seven to ten years. The estimated maximum accumulated sludge volume using a conservative value of 3 percent dry solids is approximately 11,754 $m^3$ (Table 3) at year 2016. Under operational conditions, this value of dry solids is likely to be higher, and together with biological sludge degradation due to stabilization and digestion of the solids by conversion to biogas, will result in a smaller volume of sludge accumulating in the bottom of the lagoon.

In reality, the value of dry solids can range from 3 to 5 percent. With these reduced sludge volumes, the time to consider desludging of the lagoon will be lengthened. A 5 percent dry solids is most likely to occur and with sludge degradation over a period of approx. 10 years the sludge volume will be in the range of 4,937 $m^3$.

The design value of 5 percent dry solids is therefore assumed for the accumulating sludge volume. The height of the sludge accumulation in the lagoon will be monitored at intervals to ensure accumulation does not exceed the set height for the sludge level. This height is presently set at 0.3m from the bottom of the lagoon floor. Refer to the Sewage Treatment Facility O&M Plan for details on desludging procedures.

The total lagoon volume required in year 2026, with allowances for net precipitation and cumulative sludge accumulation over the specified period is:

| | |
|---|---|
| Volume of sewage in year 20 (12 months retention) | 126,113 $m^3$ |
| Volume of accumulated sludge (year 10 equivalent) | 4,937 $m^3$ |
| Annual volume of precipitation | 2,526 $m^3$ |
| **Total Volume Required (Rounded)** | **133,576 $m^3$** |
| | |
| Volume available in existing lagoon | 4,648 $m^3$ |

As the existing lagoon will not be operational in the future, the existing lagoon volume is not included in the calculations. The existing lagoon will be decommissioned once the new facility is commissioned.

As a result the proposed new lagoon will be designed to contain:

**Minimum Operational Volume of 133,600 m$^3$**

The dimensions of the proposed new lagoon are shown in Appendix F, where the total depth is 4 m to top of berm, and TWL is at 3 m height.

The proposed dimensions and layout of this proposed lagoon is shown in Figure 6.

Detailed Design Calculations of the idealized lagoon displaying dimensions is shown in Appendix F.

## 3.6 Estimated Lagoon Discharge Quality

The volume and quality of the sewage generated by the Hamlet of Kugluktuk over the 20-year design period has been calculated. The next step is to determine the quality of the effluent that will be discharged from the lagoon. This is based upon annual discharge of the lagoon and desludging once or twice over the 20-year design life.

Based on the lagoon dimensions outlined in Appendix F, two scenarios are considered. The first scenario looks at the quality of effluent that is expected when a new lagoon is commissioned. The second scenario considers the effluent quality at the end of the 20-year design period.

After the new lagoon is commissioned, the sewage generation is anticipated to be approximately 63 percent of the 20-year design flow, and therefore initially there will be a higher efficiency of treatment.

Table 4 compares a 70 percent carbon-removal efficiency in the sewage characteristic parameters, based on published treatment efficiencies for similar systems. These values are compared to the levels specified by the Water License. Based on these assumptions, additional treatment is warranted, particularly as the level of Faecal Coliforms (FC) exceed the NWB licence limits.

Table 5 provides removal rates for contaminants, particularly BOD and TSS, for lagoon systems with annual discharging. The lagoon treatment efficiency is expected to be closer to the 70 percent-reduction level, particularly during the period following the new lagoon commissioning. This is based on a shallow layer of wastewater being able to stand in the lagoon, for approximately one year, during which time it can undergo a high rate of reduction of the measured parameter. Later in the life of the lagoon the wastewater depth is greater, which reduces the overall efficiency. A low conservative 25 percent carbon-removal rate is used as the worst-case scenario. Effluent quality using a 25 percent carbon-removal rate is shown in Table 6. If the accumulated lagoon sludge is removed on occasion throughout the life of the lagoon (about every 5 to 10 years), the treatment efficiency will be significantly improved.

The efficiency values were based on using published values for Ontario climates (MOE Design Guidelines of Sewage Treatment, 1985), in-house experience with similar-sized lagoons in northern and sub-arctic climates, and extrapolated conservative engineering estimates. The 25 percent-removal rate in the later part of lagoon life is extremely low and is very conservative.

The facility is designed to employ the period of mid-June to mid-October (120 days) as the time window suitable for the decanting of the sewage lagoon. The exact time for decanting will depend on the local weather conditions at Kugluktuk, i.e. after the spring thaw and before the winter freeze-up. The required prior-notice period of 10 days will be provided to an Inspector and the NWB.

Table 5: Estimated Effluent Quality Assuming a 70 Percent Lagoon Carbon-Removal Efficiency (2006)

| Regulatory Parameter | Raw Sewage (2006) | Expected Lagoon Effluent Quality Prior to Wetland Treatment with 70 Percent Carbon Removal | NWB License Limits |
|---|---|---|---|
| BOD (mg/L) | 329.8 | < 98.9 | 120 |
| TSS (mg/L) | 351.8 | < 105.5 | 180 |
| T-$PO_4$ (mg/L) | 16.9 | < 5.1 | N/A |
| TKN (mg/L) | 87.9 | < 26.4 | N/A |
| FC (CFU/dL) | $6.96 \times 10^7$ | $< 2.09 \times 10^7$ | $1 \times 10^6$ |

As the sewage volume increases, so will the depth of storage along with the volume of sludge accumulation within the lagoon. Treatment efficiencies will be correspondingly reduced. Conservatively, the rates of reduction for carbon-based parameters could be as low as 25 percent. Under these conditions, the effluent quality shown in Table 6 is conservatively expected.

Table 6: Estimated Effluent Quality Assuming a 25 Percent Lagoon Carbon-Removal Efficiency (2026)

| Regulatory Parameter | Predicted Raw Sewage (2026) | Expected Lagoon Effluent Quality (2026) | NWB License Limits |
|---|---|---|---|
| BOD (mg/L) | 295.6 | < 221.7 | 120 |
| TSS (mg/L) | 315.4 | < 236.6 | 180 |
| $T\text{-}PO_4$ (mg/L) | 15.1 | < 11.33 | N/A |
| TKN (mg/L) | 78.8 | < 59.1 | N/A |
| FC (CFU/dL) | $6.24 \times 10^7$ | $< 4.68 \times 10^7$ | $1 \times 10^6$ |

In order to meet current Nunavut Water Board (NWB) licensing requirements, additional treatment is necessary.

## 3.7 Wetland Treatment Area

As discussed above, the expected effluent discharge quality from the sewage lagoon is not expected to meet the current and anticipated future NWB criteria. Additional treatment of the primary effluent discharged from the lagoon is required. This secondary treatment will be accomplished through the use of a Wetland Treatment Area.

### *3.7.1 Overview*

Wetland Treatment Systems have been widely used in Nunavut and throughout Canada, especially in small remote communities, as an effective process for sewage effluent treatment. In most cases, wetland systems are developed in combination with sewage lagoons.

The proposed Sewage Treatment Facility Design for Kugluktuk consists of two components:

- **Lagoon** – a facultative lagoon, which provides retention time for the settlement of solids aerobic and anaerobic processes, which decomposes the sewage through microbial activity

- **Wetland Treatment Area** – which receives the seasonal discharge of the treated effluent from the lagoon for final treatment via filtering and biological digestion by plants and micro-organisms in the wetland.

The Wetland Treatment Area can be a designated portion of an existing natural wetland, or an engineered and constructed area artificially created to mimic a natural wetland. In many cases, it is a combination of creating engineered enhancement to an existent natural wetland system.

Wetland systems operate by dispersing sewage lagoon-treated effluent over an area of sufficient size, to allow natural processes such as sedimentation, adsorption by soil particles, uptake, and digestion of nutrient components by plants, microbial decomposition of complex molecules, physical entrainment in changing flow regimes, and dilution by intermixing with the natural water system. The Wetland Treatment Area is considered the Secondary Treatment System for the effluent discharged from the Primary Treatment System (the facultative lagoon). The Wetland Treatment Area is designed as a part of the Sewage Treatment Facility and the land area is formally set aside for this land use, and all other land use that could be a conflict with this use is prohibited in the designated Wetland Treatment Area.

### *3.7.2 Existing Wetland Treatment System*

#### *3.7.2.1 Kugluktuk*

There is a natural wetland area downstream of the existing lagoon at Kugluktuk (Figure 18). The existing lagoon provides virtually no retention time. Sewage is discharged via an exfiltration berm and migrates into a wetland area, and flows a meandering path approximately 1.5 km to Coronation Gulf. The raw sewage discharging from the lagoon does not meet regulatory guidelines, however samples collected at locations downstream in the wetland, including the discharge point at the shore of Coronation Gulf, indicate that regulatory criteria is being achieved within the wetland.

Although the wetland area is currently not formally part of the Sewage Treatment Facility, it is acting to mitigate the impacts of raw sewage being discharged from the lagoon. The current discharge rate of raw sewage into the wetland from the lagoon is approximately 62 percent (2006) of the total 20-year discharge volume (2026) currently being designed (Table 3).

The field investigation indicated that the flow path of the raw sewage through the wetland resulted in enhanced plant growth, and a visible increase in height, density, and "greening" of the vegetation in the upper reaches of the wetland. This visible vegetative enhancement, caused by the nutrient load from the sewage, declined along the downstream flow path, indicating a lessening of the nutrient load, with distance downstream. Approximately half way along the flow path to Coronation Gulf, the effect was no longer visually discernable. Water-quality sampling results mirrored these observations.

In summary, at Kugluktuk from a qualitative perspective, the discharge of raw sewage into the wetland at a rate that is 62 percent of the year 2026-design rate is being effectively reduced to regulatory criteria levels within the wetland prior to discharge into

Coronation Gulf. This is based on observations and data for the summer season. The impact in other seasons is unknown and is of concern, which is why annual retention and discharge only during the summer when the wetland is biologically active is the proposed new design for the Sewage Treatment Facility.

#### *3.7.2.2 Other Communities*

Nuna Burnside staff examined wetland treatment areas in a number of other communities in Nunavut as part of other project work. These include:

- **Qikiqtarjuaq –** retention lagoon discharges during the summer to a plateau wetland that meanders towards the ocean. Good primary treatment is achieved in the lagoon. A second lagoon to increase capacity has been designed. The Wetland Treatment Area has been included in the application to amend the water license

- **Repulse Bay –** limited retention and discharge of sewage into a meandering valley wetland. Very little environmental impact information available. The wetland area is not included in the water license

- **Gjoa Haven –** a 2.1-ha surface area lagoon discharges into meandering stream/wetland that travels 1.6 km to the ocean. Very little impact information is available. The wetland is not included in the water license. The wetland system appeared to be providing seasonally effective treatment to the effluent from the lagoon

- **Arviat –** A wetland treatment system for Arviat was evaluated by FSC in 2005 (Journal of Northern Territories, Water and Wastewater Association, 2006). FSC concluded that an upgraded lagoon system discharging to a natural wetland would meet NWB guidelines

- **Coral Harbour –** A wetland treatment system for Coral Harbour was evaluated by Jacques Whitford in 2004 and 2005 (Journal of Northern Territories, Water and Wastewater Association, 2006). The article concluded:

  *"The tundra wetland at Coral Harbour has successful treated the community's wastewater for over 20-years. While the detention cell constructed at the head of the system in 2003 was intended to provide for settling of solids and pre-treatment prior to an annual release, its failure to detain wastewater has not prevented the tundra wetland from achieving compliance with existing and anticipated effluent quality criteria. With further analysis in 2006, it is expected that the community will apply to have the tundra wetland recognized as part of the sewage disposal facilities in its next water licence."*

This was the same conclusions Nuna Burnside came to when examining a similar situation at Kugluktuk.

The Coral Harbour wetland treatment system is the topic of a current academic study by Fleming College in cooperation with the GN.

It is hoped the findings will assist in developing, maintaining, and understanding wetland treatment systems.

### *3.7.3 Year 20 Sewage Lagoon Effluent Quality*

As the wastewater volume increases, so will lagoon depth and the volume of sludge accumulation within the lagoon. Treatment efficiencies will be correspondingly reduced. Conservatively, the rates of removal for carbon-based parameters would be reduced to as low as 25 percent in year 20 when the lagoon is holding near-maximum capacity. Under these conditions, effluent quality prior to wetland treatment is expected to be as shown on Table 7:

Table 7: Estimated Effluent Quality Prior to Wetland Treatment, Assuming a 25 Percent Lagoon Carbon-Removal Efficiency (2026)

| Regulatory Parameter | Raw Sewage 2026 (Predicted) | Expected Lagoon Effluent Quality Prior to Wetland Treatment with 25 Percent Carbon Removal |
|---|---|---|
| BOD mg/l | 295.6 | < 222 |
| TSS mg/l | 315.4 | < 237 |
| T-$PO_4$ mg/l | 15.1 | < 11 |
| TKN mg/l | 78.8 | < 59 |
| Fecal Coliforms CFU/100 ml | $6.24 \times 10^7$ | $< 4.7 \times 10^7$ |

As discussed in the previous section, based on historical sampling it is likely that the actual effluent concentrations will be lower than these predicted values, however the predicted concentrations will be used in the calculations for determining the size of the wetland treatment area.

### *3.7.4 Effluent Quality After Wetland Treatment*

Currently the Water Board License for the sewage lagoon does not include a description of a Wetland Treatment Area, it only specifies effluent discharge quality requirements.

Upgrading the lagoon to be in compliance with current Water Board requirements (and anticipated future regulatory requirements), and development of a Wetland Treatment Area is necessary. Recent investigations and sampling have shown that there is a continuous improvement in water quality along the discharge flow path. A Wetland

Treatment Area has already developed naturally downstream of the lagoon discharge. Development of an additional wetland treatment area should be achievable by controlling the flow path of the discharge.

### *3.7.4.1 Current Conditions*

The current effectiveness of the wetland treatment area is illustrated by the results of the sampling conducted on October 4, 2005. Table 8 displays the results of the sampling of WS-1 located immediately downstream of the lagoon (almost raw sewage), and WS-4 which is located at the downstream discharge point near Coronation Gulf (Figure 18). Also displayed are the "anticipated" guideline criteria.

Table 8: October 4, 2005 Effluent Results Compared to Anticipated Guidelines

| Regulatory Parameter | Anticipated NWB Guidelines | WS-1 (Raw Sewage) | WS-4 (Wetland Treatment Area) |
|---|---|---|---|
| BOD (mg/l) | 45 | 276 | 8 |
| TSS (mg/l) | 45 | 95 | 7 |
| T-P04 (mg/l) | 1.0 | 0.24 (July 2004 sampling by FSC) | NA |
| TKN mg/l | 10 | 94 | 12.4 |
| Faecal Coliforms (CFU/100 ml) | 2,000 | 13,000,000 | 4,000 |
| pH | 6.5-9 | 7.40 | 7.5 |

The results indicate that the wetland treatment area is currently providing treatment of raw discharged sewage with almost no retention time. A significant improvement in the quality of the effluent entering the wetland treatment area would be experienced if a new lagoon is constructed to provide up to 12 months of retention time.

### *3.7.4.2 Effluent Treatment Via Input*

Positioning the new lagoon discharge as shown on Figure 6, and directing the discharge into the small seasonal ponds which drain into the existing wetland treatment area, would add an additional 5 ha to the wetland treatment area.

The ponding will be enhanced with small berms and ditching to maximize the surface area of the ponds and maximize the length of the flow path. The ponds will be shallow (less than 0.3 m deep) and provide secondary retention of the effluent discharged from the lagoon. The ponding is expected to provide a degree of treatment in two ways:

- Microbial decomposition of sewage in a similar fashion as in the lagoon and in a similar fashion as in the wetland treatment area

- Infiltration of the effluent into the underlying sand overburden and migration through the subsurface.

The area around the sewage lagoon is comprised of poorly-graded medium sand from raised beaches. Test pitting in the area revealed groundwater perched on top of the permafrost. (See test pit logs in Appendix D). Groundwater was intersected between 0.4 m and 0.9 m below surface. Permafrost was intersected approximately 0.9 m below surface.

Ponding observed in the imagery collected on July 1, (Figure 6) had seeped into the ground during the summer. No stressed vegetation was observed suggesting the ponds are of short duration. It is expected that the ponds and wetland area outlined in Figure 6 will encourage infiltration of the standing effluent into the underlying sand. Geotechnical data is included in Appendix E. To determine the approximate hydraulic conductivity of the sand the Hazen $d_{10}$ method is used:

$$K = Ad_{10}^2$$

The $d_{10}$ value is taken from the grain size gradation curve as determined by sieve analysis. For K in cm/sec and $d_{10}$ in mm, the coefficient A is equal to 1.0. In this case $d_{10}$ for various test pit samples are:

- Test Pit 3 – 0.10
- Test Pit 4 – 0.25
- Test Pit 5 – 0.20
- Test Pit 7 – 0.22

  Average 0.19

The hydraulic conductivity is estimated as 0.036 cm/sec.

This is a very high hydraulic conductivity based on saturated conditions.

It would be expected that a significant portion of the effluent would infiltrate into the subsurface especially in the 6 ha area of the natural ponds. Subsurface flow would occur in the 0.9 m thick active zone and would include dilution into the perched groundwater above the permafrost. The infiltrated effluent will be partially diluted by the groundwater and migrate in a down gradient direction following the topography. It is expected that the base of the active layer through which groundwater flow would occur would mirror surface topography and direct groundwater along a similar path as the surface water drainage system. Horizontal groundwater flow velocity can be calculated as follows:

$$V = \frac{Ki}{n}$$

where:

V = average linear velocity
K = hydraulic conductivity
i = hydraulic gradient (change in head over distance)
n = effective porosity (estimated at 0.30)

"i" can be estimated to be similar to topographic gradient as shown in Figure 6. This is the approximate 25-m fall from the lagoon to the ocean, a distance of approximately 1,800 m. Therefore "i" is estimated at 0.014.

$$V = \frac{0.036\ (0.014)}{0.3}$$

V = 0.00168 cm/sec
V = 520 m/year

Although this is a high groundwater velocity, it is slow compared to surface water flow. In Kugluktuk flow would only occur in the active layer for those months of the year (June through September) when the active layer is thawed. The actual flow rate would more likely be approximately 177 m/4 month active season.

Infiltration and migration through the sand provides a long resident time in the subsurface, which will allow natural reduction processes to treat the effluent even at the low groundwater temperatures in the active layer. Groundwater seepage into the wetland treatment area was observed in October 2005 suggesting groundwater discharge was contributing to the base flow in the stream.

By encouraging effluent infiltration into the subsurface in the area of the prepared wetland treatment ponds, the amount of surface discharge to the wetland area will be reduced. The resulting effect is to create a 5-ha septic bed.

Without site specific studies, it is difficult to determine what amount of the effluent discharge that will infiltrate into the sand from the 5-ha area of the ponds and subsequently move via the groundwater flow path, however a rough prediction can be calculated.

The sandy soil has an estimated hydraulic conductivity (K) of approximately $3.6 \times 10^{-2}$ cm/sec.

This would correspond to a Percolation Time (T) of 4 – 12 mins/cm. For a leaching bed or absorption trench type septic system load rates of approximately 10 $l/m^2$/day would be typical. In this case the 5 ha of shallow ponds at the top of the wetland treatment area could potentially allow significant effluent infiltration as follows:

Area (50,000 $m^2$) x 10 l/day = 500,000 l/day (500 $m^3$/day).

Through the active season (mid-June to mid-October) of 120 days, infiltration of approximately 60,000 l of effluent could occur. This would move via a subsurface flow path in the sand, and eventually discharge to surface further down the drainage basin,. The process of migrating through the sand will provide a relatively long residence time and allow for effluent treatment by natural reduction processes.

There was very little literature readily available for review, evaluating the effectiveness of effluent infiltration and treatment through sandy soils in the active layer in Nunavut. This process does have significant potential, and it is recommended that it be monitored for scientific purposes once this lagoon and sewage treatment system is constructed at Kugluktuk. Nuna Burnside proposes that the potential for infiltration of effluent be recognized and monitored, so wetland treatment area requirements are minimized and only developed as needed. The sandy raised beaches appear to offer a unique opportunity to treat a significant portion of the sewage lagoon effluent.

#### *3.7.4.3 Wetland Treatment Area Requirements*

In order to determine the Wetland Treatment Area that will be needed to effectively treat the primary treated effluent from new sewage lagoon, a predictive model modified from a model developed by the Alberta Department of the Environment (ADE) is used (Alberta Environment, March 2000).

The modified ADE model can be used to determine the wetland area needed to treat a given hydraulic load (design flow) and effluent chemistry, based on achieving specified regulatory guidelines. The ADE model was originally designed for more moderate climates, so a temperature correction factor is applied to the model for a lower average temperature during the period of active discharge. As shown in Appendix C, the average temperature in Kugluktuk for the period mid-June through mid-September is approximately 6.5 ºC. To be conservative 5ºC is used in the modified ADE model used for Kugluktuk.

The guideline document (Alberta Environment, March 2000), includes a series of tables and check sheets of issues and functions to be examined when investigating the possibility of using a natural wetland for wastewater treatment.

A description of the model with assumptions and calculations is included in Appendix E.

A comparison of the results, anticipated guideline criteria, and expected effluent quality is displayed on Table 9.

Table 9: Estimated Wetland Treatment Area Required

| Regulatory Parameter | Predicted Lagoon Effluent (2026) | Current NWB License Limits | Anticipated NWB Guidelines (Design Criteria) | Minimum Wetland Area Required to Meet Anticipated Nunavut Water Board Guidelines |
|---|---|---|---|---|
| BOD mg/l | 295.6 | 120 | 45 | 8.9 ha |
| TSS mg/l | 315.4 | 180 | 45 | 0.4 ha |
| $T\text{-}PO_4$ mg/l | 15.1 | N/A | 1 | 31.9 ha |
| TKN mg/l | 78.8 | N/A | 10 | 14.0 ha |
| Fecal Coliform CFU/100 ml | $6.24 \times 10^7$ | $1 \times 10^4$ | 2,000 | 26.6 ha |

The results of the modified ADE wetland predictive model indicate that to meet Anticipated Nunavut Water Board Guidelines for $T\text{-}PO_4$ approximately 32 ha of wetland treatment area is required. The wetland area currently utilized (Figures 6 and 18) is approximately 10 ha.

#### *3.7.4.4 Additional Wetland Treatment Areas*

As shown in Table 1, historic sampling results show sewage effluent concentrations for regulated parameters are significantly less than the predicted effluent quality shown in Table 9 especially for $T\text{-}PO_4$. This suggests that the predicted values in Year 20 are very conservative and hence, the required wetland treatment area calculated using the ADE model is very much larger than will be actually needed.

To address this issue we recommend the following strategy:

- Enhance the development of the existing wetland treatment area and proposed additional 5 ha of pond area (Figures 6 and 18)
- Monitor raw effluent and quality of final discharge from wetland treatment system as per the requirements of the water license
- Based on the findings of the actual sample results from the new lagoon and wetland treatment system, predict the need for an additional wetland treatment area and develop the additional area prior to it being required

- It is not considered prudent to develop the currently predicted requirement of 32-ha of wetland treatment area based on the application of the modified ADE model for T-$PO_4$ because current actual results are significantly less than predicted

- There is currently insufficient effluent discharge to allow for the full 32 ha wetland treatment system to be developed at this time.

As shown on Figure 18 there are several other similar-sized natural drainage systems that could be used for a wetland treatment area. In addition the low lying areas between the raised beach ridges could be used. This is a large land area that could be used to meet the needs of additional wetland treatment area. Hamlet staff has indicated they have no plans for this area and it is acceptable that the areas be set aside for a future wetland treatment area should it be required.

At this point we do not recommend constructing the ditching required to use these additional lands. They should be developed only when needed. Costs to create ditches in the raised beach sand are expected to be low and will not require sophisticated engineering.

When needed, a drainage pathway could be established in the low-lying, seasonally-ponded area between one of the raised beach ridges to direct effluent approximately 700 m to the northwest, into an area with several meandering drainage systems. The drainage systems could be developed into a wetland treatment area, to provide the additional area needed to treat the discharge to the anticipated Nunavut Water Board guidelines.

### *3.7.5 Summary*

The Wetland Treatment Area has been designed to provide secondary treatment during the active biological season for the treated discharge from the primary treatment lagoon.

For the purposes of this site, the wetland area is considered to be a natural wetland that is gradually modified via the gradual annual increase in lagoon discharge to become an "engineered" wetland. Physical changes to flow paths and other features will only be made, should the annual field monitoring indicate the need for further engineering.

The wetland system for Kugluktuk has been designed based on the Alberta Wetland model with significant revisions and conservative estimates related to the active layer (0.9 meters) and lower ambient temperatures (5°C) than historically recorded (see climate data in Appendix C).

In addition, the system has been designed to meet discharge criteria significantly more stringent than current NWB discharge criteria, as shown in Table 10:

Table 10: Current NWB Criteria and Detailed Design Criteria

| Parameter | Current NWB License Requirements | Design Criteria |
|---|---|---|
| BOD (mg/L) | 120 | 45 |
| TSS (mg/L) | 181 | 45 |
| T-$PO_4$ (mg/L) | N/A | 1 |
| TKN (mg/L) | N/A | 5 |
| FC (CFU/dL) | $1 \times 10^4$ | $2 \times 10^3$ |

The confidence in the model is based on several factors:

- Monitoring of the current lagoon system, which allows almost immediate discharge of sewage into the wetland through permeable lagoon walls, shows a well-established wetland vegetation system and very little environmental impact. The proposed design greatly improves on this system of treatment and discharge

- It is our understanding that the modified model has been used previously for communities in Nunavut that have received NWB approval based on that approach including Coral Harbour and Arviat

- The model is developed using significantly more stringent discharge criteria than that currently required by the NWB

- Annual monitoring will provide confirmation to the model and allow ample opportunity to modify the system should future concerns be noted

- Currently the discharge of 62 percent of the 20-year design volume of raw sewage directly to the wetland is being reduced prior to discharge from the wetland in the summer

- The model indicates that the 20-year design volume of primary treated effluent from the lagoon will be effectively treated in the wetland

- Monitoring and engineering contingency plans to increase the flow path and expand the treatment area provide an extra measure of confidence.

Onsite run-off and leachate-impacted surface water from the landfill will be retained in a pond and allowed to infiltrate/evaporate in-place. The underlying sandy soil promotes infiltration during the summer when the permafrost thaws. Other times of the year everything is frozen. Diversion of overland flow around the waste area will limit the amount of impacted surface water. The diverted run-off will be directed to the wetland to increase dilution.

Sampling of the groundwater immediately down-gradient of the existing landfill berm showed no landfill impacts. Based on the size of the site, lack of current impacts, limited period of thawed subsurface flow, no significant impacts to the wetland are anticipated. Migration of landfill contaminants in the subsurface (when thawed) provides a natural attenuation prior to surface discharge in the wetland beyond. This subsurface natural attenuation zone is the downgradient area between the fill and the nearest sensitive receptor (surface water body). As the landfill expands and permafrost moves into the waste, the amount of waste which generates leachate will be limited to the top approximately 1.0 m, which seasonally thaws. No significant landfill impacts to the wetland are expected. The wetland monitoring program will act as monitors for landfill impacts.

The wetland will not be physically altered or engineered beyond what has been shown. Some minor changes to flow patterns to maximize the effectiveness may be made in the future, if required. The wetland will simply develop in small increments each year, as the volume of lagoon discharge increases year to year. The small increase in discharge each year allows for a slow natural increase in vegetation and wetland capability.

## 3.8 Sewage Treatment Facility Detailed Design

The preferred design alternative to upgrade the current sewage treatment system for the Hamlet of Kugluktuk includes the development of a new sewage lagoon cell and the employment of a wetland treatment area.

The following sections describe the design details of this recommended option.

### *3.8.1 Sewage Lagoon*

The proposed lagoon cell will be sited immediately northwest of the existing lagoon. The existing lagoon will be retained 'as is' and continue to be in operation until the new lagoon is constructed and in operation. A partial common berm will be shared between the two lagoon cells, as will the access road leading up to the present truck turnaround area at the existing sewage lagoon. This configuration will minimize the land-use for road access and also construction of the new cell.

As shown in Appendix F (Detailed Design Calculation of a New Sewage Lagoon), a lagoon with 134,900 $m^3$ usable volume capacity is required and this can be achieved with the following configuration:

| | |
|---|---|
| Perimeter Lengths | |
| North A/B | 205 m |
| West B/C | 242 m |
| South C/D | 292 m |
| East D/A | 189 m |
| Surface Area | 51,924 $m^2$ |

- Total Depth (includes 1m freeboard) 4 m
- Required free board allowance 1 m
- Allowance for solids accumulation at bottom of lagoon 0.3 m
- Entire base of lagoon is flat
- Slope of berms inside of lagoon 3:1
- Slope of berms outside of lagoon 3:1
- Outside berms to match the existing ground elevations as indicated on drawings.
- Top width of berm 3.0 m.

The berms for this new lagoon cell will be constructed with the material borrowed from a site approximately 1.0 km from the proposed lagoon. As part of the design analysis, the estimated volume of borrow material for the earthworks for the lagoon cell was minimized by establishing a calculated bottom elevation (at 199.5 m) and alignment of the sewage cell construction at the selected site. The estimated volume of borrow material is 80,000 $m^3$.

The requirements for rock material during the construction stage will be provided from a rock quarry located less than a kilometre east of the selected lagoon site.

Figure 8 displays the layout of the new lagoon and the existing lagoon.

Figure 9 displays sections A-A, B-B showing the lagoon floor, berms, and slopes.

Figure 10 contains details such as the gate-valve on the discharge outlet chamber, berm construction, overflow detail, etc.

This proposed new lagoon cell will be lined on the inside slopes and bottom as shown on Figure 10.

### *3.8.2 Sewage Lagoon Construction*

The dimensions and the berm requirements for a new sewage lagoon adjacent to the existing lagoon were calculated. A schematic layout is displayed on Figure 8, showing the location, orientation, and shape as part of the detailed design.

Class B costing will include constructing the lagoon, as shown on Figures 8, 9, and 10, with the following details:

- The existing access road will be realigned so the existing lagoon can continue to be accessed by trucks during the construction of the new lagoon. The existing access road leading to the existing sewage lagoon will be widened (westwards) which will also have a truck off-loading pad adjacent to the two culverts discharging into the new sewage lagoon
- The 3:1 interior side slopes will be covered with a 60 mil HDPE liner
- The purpose of the liner is to prevent exfiltration through the sand berms

- The liner will be held in place on the top of the berm by blast rock
- Blast rock will be used to armour the outside face of the berm
- The existing lagoon will remain in-place and continue to have road access as the new lagoon is being constructed
- Approximately 1,000 linear metres of ditching will be constructed around the lagoon to divert surface water
- Fencing will be provided around the new sewage lagoon. The perimeter fence will be located on top of the berm, comprising of a galvanized chain-link fence at 1.8m high. Fence posts will be set approximately 3m apart with concrete footings set into the permafrost (at least 1.5m depth). There will be a gate at the discharge culverts, located next to the truck off-loading pad
- Approximately 950 linear metres of berm will be constructed
- Excess material could be used for landfill cover, road base or graded into the natural landscape
- Blast rock to hold the liner in place and armour for the outside slope face of the berms will be placed 0.3 m deep.

A cost estimate based on the design details as outlined herein are provided in Appendix H.

### *3.8.3 Sewage Tanker Truck Offloading Area, Road Access and Fencing*

The sewage tanker truck off loading area will be reconstructed in order to allow the tanker trucks to back-up and discharge into the lagoon cell. A 1-m diameter smooth-wall culvert will be cut into half lengthwise and laid down on the berm of the new lagoon cell to act as a spillway (on flume) and prevent erosion of the berm during the off-loading of the trucks. There will be two spillways, approximately 5 m apart, to provide access for two trucks at the same time (Figure 8).

The existing road leading to the present sewage lagoon will be used, but widened to 9 m at the approach to the off-loading location next to the spillways.

The entire perimeter of the lagoon site will be fenced with access gates at the truck off-loading point and the effluent discharge outlet. The fence will be chain-link, galvanized steel, 1.8 m high with approximately 3-m inter-post distance. The posts will be fixed in concrete that reaches into the permafrost, estimated to be at a depth of approx. 1.5 m. The outlet pipe will be 300 mm diameter P.E. with flow-control via a gate-valve.

### *3.8.4 Site Drainage and Grading*

The entire site will be re-graded to ensure that there is positive drainage away from the sewage lagoon and access road. A cut-off drainage trench will be constructed around the perimeter of the proposed lagoon cell to ensure the diversion of surface water around the site and minimize the potential for surface water from flowing into the sewage lagoon cell. Slopes are 3:1 to ensure that surface water does not enter into the lagoon with the exception of the truck discharge area. Natural drainage patterns will be utilized as much as possible in order to reduce the amount of excavation required and modification of the existing topography. The elevation of the berms, particularly the two located to the south and east, will be increased to a minimum of 0.5 m above the elevation of the existing ground in order to create a drainage pattern for all surface water run-offs coming from the access road (Figures 8 and 9).

### *3.8.5 Lagoon Effluent Discharge*

The effluent from the lagoon will be decanted each year during the period of mid-June to mid-October as per the Sewage Treatment Facility Operation and Maintenance Plan (provided as a separate document). The discharged lagoon effluent will be decanted by gravity evenly across the adjacent tundra wetlands into an expanded wetland area for final polishing treatment as the flow meanders along an approximate 1.5-km pathway towards Coronation Gulf. The effluent control out of the lagoon will be via a gate-valve with a manual gear-actuator leading to the 300 mm diameter P. E. discharge pipe. The discharged effluent flows on to the rip-rap on filter-cloth located at the bottom of the outside slope.

### *3.8.6 Wetland Treatment Area and Exfiltration Berm*

A Wetland Treatment Area of at least 32 hectares (ha) has previously been described as an essential component of the proposed treatment system. Since a naturally occurring wetland already exists in the area, the intention is to allow the lagoon effluent to discharge over land in a sheet flow fashion and allow vegetation and other biological systems characteristic to wetland areas to develop. This is similar to the approach used by the existing lagoon system.

The discharge of the primary effluent from the lagoon to the wetland area will be achieved by the construction of an exfiltration berm made of native rock type material located just beyond the toe of the berm to the west side of the lagoon. At the toe of the slope of this exfiltration berm will be a 300-mm perforated drainage pipe capped on both ends. The perforations will be spaced further apart where the piping connects into the outlet piping and closer together on either end. This is designed to achieve the desired flow pattern and will enhance the treatment effectiveness of the wetland.

The Wetland Treatment Area will develop naturally, as effluent flow increases gradually. As described in the Sewage Treatment Facility O&M Plan, should monitoring indicate the need for an increased area of wetland, the following options will be implemented:

- Addition of berms and ditching to slow the migration along the flow path, increase the flow length, and increase the contact area with vegetation

- Addition of ditching to expand the Wetland Treatment Area to the small drainage basins to the west, to increase the size of the area

- Control the daily effluent discharge flow rates to as low as possible during the period of optimum discharge.

The Sewage Treatment Facility O&M Plan provides details for site staff to manage the Wetland Treatment Area.

The existing ATV trail will be bridged in the area where it crosses the Wetland Treatment Area flow path near the discharge into Coronation Gulf. The bridge will consist of large boulder and cobbles placed at a narrow point, where the stream cuts through a beach ridge. The bridge will be made from natural materials, with sufficient flow-through (exfiltration) capacity to void ponding. Signage and markers will be placed, so the bridge can be used in all seasons.

### *3.8.7 Signage*

This design also includes the provision of proper site signage. A sign will be posted at the entry to the facility indicating the following:

- Name of the Facility (i.e. Hamlet of Kugluktuk Sewage Treatment Facility)
- Trespassing Prohibited (i.e. “Danger - Keep Out’)
- Health Hazard
- Emergency Contact Information (Hamlet of Kugluktuk Operations Department, phone number, etc.).

Signs will be posted at appropriately spaced intervals around the perimeter of the Wetland Treatment Area. These signs will indicate the following:

- Name and Purpose of the Facility (i.e. Wetland Treatment Area)
- Trespassing Prohibited (i.e. “Danger - Keep Out’)
- Health Hazard
- Emergency Contact Information (Hamlet of Kugluktuk Operations Department, phone number, etc.).

Signs will also be placed at all monitoring locations including the Final Discharge Point of the sewage treatment facility. This will be the location where Final Discharge Point samples will be collected to monitor the compliance of effluent from the sewage treatment system to the regulations imposed by the NWB water license. The sign will include the following information:

- Name of Facility
- Surveillance Network Monitoring Program Location Code.

All signs will be in both English and Inuinnaqtun, and will include the logos of the Hamlet of Kugluktuk and of the Government of Nunavut.

### *3.8.8 Lagoon Maintenance and Desludging*

The Sewage Treatment Facility O&M Plan provides details directing site staff, regarding the operation and maintenance of the lagoon. At some point, estimated at between year 7 and 10, and at least two other occasion during the 20-year design period, the lagoon will require desludging. Desludging will involve the following tasks:

- Timber coverage of the berm face and liner to protect them from damage
- Entry into the lagoon with a small crawler loader dozer or wheeled equipment
- Implementation of extreme caution such as rubber pads on blades and sharp parts of the equipment to prevent damage to the liner
- Scraping the sludge to the south end of the lagoon where it can be pumped out using a sludge pump
- Dewatering of the sludge using a dewatering process or similar equipment
- Transferring the dewatered sludge to the landfill for use as cover
- Returning the liquid portion of the dewatering process back into the lagoon.

The Sewage Treatment Facility O&M Plan provides the details for site staff. The sludge will be tested as per the process outlined in the Solid Waste Management Facility O&M Plan.

The operation will be conducted in accordance to Section 7 of the Guidelines for the discharge of Domestic Wastewater in Nunavut, 2000.

### *3.8.9 Decommissioning of Existing Lagoon and Honey Bag Pit*

An old, no longer used, honey-bag pit is reported to be located along side the outside berm of the active sewage lagoon (Figure 7). It cannot be decommissioned without damaging the existing lagoon, so it will remain and be decommissioned with the existing lagoon.

Decommissioning of the existing lagoon (and honey-bag pit) will consist of transferring any sewage in the old facility to the new lagoon. Any sludge and honey-bag materials will be covered with a layer of clean soil after the new lagoon system has been functioning according to design. This will occur at least one year after the new lagoon is in operation. Alternatively the sludge may be transferred to the landfarm for drying and natural treatment followed by use as cover in the landfill. A sampling and assessment program will be conducted to identify the most cost effective solution. Sludge quality will be required to meet the guidelines and soil quality criteria outlined in the Solid Waste Management Facility O&M Plan.

There is a reference in the 2003 NWB License application to a 17,000 $m^2$ honey-bag site. Hamlet staff could offer no clarification about this site. This site is not part of the current scope of work. Should a site be discovered, a separate workplan and NWB submission will be made to address its decommissioning. For the purposes of this project, only the honey bag pit next to the lagoon will be decommissioned.

Costs are included in Appendix H.

## 3.9 Abandonment and Restoration

Part G of the Water License (Appendix B), requires the submission of Abandonment and Restoration Plan at least six months prior to abandoning any facilities and construction of new facilities to replace existing ones. This Detailed Design Report provides the required information for the existing facilities.

The Sewage Treatment Facility consisting of the lagoon and Wetland Treatment Area, has been designed to meet the required 20-year design period. It is expected that it could continue to operate for a significant period of time beyond 20-years. Desludging on a regular basis would extend its life as it approaches year 20. Once sewage volume exceeds the capacity of the lagoon, the lagoon can be expanded or an additional lagoon constructed. As shown in Figures 2 and 4, there is a large area to the northwest where a new lagoon could be located. In addition, there is significant land area consisting of small drainage streams among raised beaches, which could be further developed to increase the size of the Wetland Treatment Area.

In the future, should the Sewage Treatment Facility no longer be required, abandonment would be straight forward as follows:

- Drain the lagoon during the discharge period
- Desludge the lagoon (as described previously)
- Remove the liner and appurtances for disposal to the Solid Waste Management Facility
- Open the berms to allow natural drainage
- Contour the area to match the surrounding tundra
- Berms would be regraded or left standing
- The Wetland Treatment Area would return to natural conditions.

The Sewage Treatment Facility O&M Plan provides details for site staff. The O&M Plan includes a short term and long-term planning process, which would prompt the Hamlet to prepare for expansion and closure as the facility reaches the later years of its design life.

# 4.0 Solid Waste Management Facility

## 4.1 Overview

Solid waste in the Hamlet of Kugluktuk generally falls into the following categories:

1. **Hazardous Wastes –** including batteries, waste oil, waste antifreeze, and other materials not suitable for landfilling

2. **Bulky Metals –** equipment machinery and metal materials no long deemed salvageable or recyclable by the Hamlet

3. **Municipal Solid Waste –** the remaining waste materials.

The Solid Waste Management Facility comprises both storage and disposal. Bulky metals and non-hazardous municipal solid waste is disposed of by containment and burial. Hazardous materials are stockpiled until they can be treated (i.e. incineration) or shipped out of the community for proper disposal in the south.

The current Solid Waste Management Facility has been in use for approximately 15 years, and operates under Water Board License NWB3KUGO308 issued November 20, 2003, which expires on November 30, 2008. A copy is included in Appendix B.

There have been previous submissions of documents to the NWB, including applications for a Water Board License amendment in 2003. The context of these previous applications is considered out dated and is superseded by the information provided herein.

Solid waste disposal in Nunavut is regulated by the Nunavut Water Board. The following guidelines are applicable:

- Northwest Territories, Municipal and Community Affairs, "Guidelines for the Planning, Design, Operations, and Maintenance of Modified Solid Waste Sites in the Northwest Territories", dated April 2003

- Public Health Act, "Consolidation of General Sanitation Regulations", R.R.N.W.T., 1990.

Management of hazardous waste must be in accordance with:

- "Environmental Guideline for General Management of Hazardous Waste in Nunavut", Government of Nunavut, January 2002

- "Environmental Guidelines for Waste Batteries", Government of Nunavut, January 2002
- "Environmental Guidelines for Waste Antifreeze". Government of Nunavut, January 2002.

## 4.2 Landfill (Municipal Solid Waste Disposal Area)

### *4.2.1 Existing Conditions*

The existing landfill site is located approximately 4.5 km southwest of the Hamlet (Figure 2). Details of the site inspection and waste composition assessment are included in the Schematic Design Report.

The existing landfill covers an area of approximately 1.2 ha. It is surrounded by a fenced enclosure with two un-gated access points off the road to the sewage lagoon. Fencing is approximately 1.5 m high and is of post and wire construction that is generally in good condition (Figure 5).

The landfill was developed on a slight slope, however, as filling progressed, a tipping face gradually developed. The area containing waste is approximately 8,220 $m^2$ and the quantity of waste is estimated to be 12,330 $m^3$.

Currently, operations involve tipping the waste that arrives off a ramp into a 1.5 m deep pit. After being tipped, the waste is ignited and burnt. Residual materials and ash are subsequently crushed and pushed out of the pit to another area of the site by a loader on a regular basis. The waste is further compacted through the process of progressively pushing it with a loader and eventually incorporating it into the working face.

Cover is applied irregularly and an inspection of the waste indicates cover materials (soil) makes up only approximately 10 percent of the waste content. There was large area of exposed waste visible at the surface and no cover material was stockpiled on site at the time of the site visit.

Hamlet staff indicated they had no significant problems with operating the area, and no concern about blown litter, scavengers, surface water flow, or other issues. They collect litter from the site perimeter occasionally, but reduce the chance for blown litter by keeping the waste in the pit and burning it regularly (daily).

With regards to these practices, the following issues were noted:

- The area is reaching capacity and there is not sufficient space for long term filling;
- There is no mechanism to minimize the runoff of contaminated water from the area;
- Less cover is applied to the area than optimum; and
- Filling appears to be undertaken without an overall plan or strategy.

The current practice of burning municipal waste is not considered a good management practice, and is illegal in many parts of Canada. However, it is generally accepted in Nunavut, Section 27 of the Public Health Act for Nunavut states: *"Every incorporated municipality shall provide adequate waste disposal grounds for the disposal of all garbage…and shall cause such waste materials to be burned, buried or covered with a layer of earth …..*". Given the site conditions, most notably the climate and the potential for scavengers (i.e., bears) we understand the Hamlet's position that options other than burning are not practicable. Options could be supplied at a later time, however, for the present and near future, burning appears to be the most effective and practical manner to operate the landfill.

The Schematic Design Report (2005) reviewed potential alternatives. The preferred alternative involves site expansion, improvements of the site and overall improvements in the operational procedures to address the issues noted above, and to accommodate the waste in a more efficient and environmentally protective manner during the 20-year design period. Figure 6 displays current conditions and the proposed expansion. The calculated landfill area required for 20-years of waste disposal is presented in Table 11 and is based on the following assumptions:

- A solid waste generation rate of $0.015m^3$/person/day based upon a review of available literature including "Guidelines on the Planning, Design, Operation and Maintenance of Modified Solid Waste Sites", NWT, 2003. The value was also supported by field observations and in-house experience with solid waste generation rates at small isolated communities.

- A projected population growth rate of 1.5 percent based on Nunavut Bureau of Statistics Projections 2000 – 2020.

- An estimate of approximately 16 percent of all wastes being non-combustibles, based on waste composition description in the NWT (NWT, 2003) and field observations at the existing landfill site.

- A 40 percent reduction in combustible waste, due to open burning based on field observations, NWT estimates and in-house experience.

- A 50 percent reduction in waste volume due to compaction using a loader or small dozer on a monthly basis. This is based upon field observations and in-house experience. A 3:1 compaction rate is suggested in the NWT, 2003 document, however we suggest being more conservative given the limited time heavy equipment is on the site and the long winter season.

- Application of cover material at a 4:1 fill to cover ratio. This is the recommended best practice. Field observations indicate this is currently not the practice. Based on the availability of equipment to stockpile and distribute cover materials, the 4:1 ratio may not be achieved. In that case, the landfill life may extend beyond 20-years. The 4:1 ratio is recommended in the Solid Waste Facility O&M Plan.

#### *4.2.2 Recommended Design Improvements*

The recommended design improvements are summarized on Figure 11 and described in the sections that follow.

The north part of the Solid Waste Management Facility will be expanded to an area of 3.0 ha (from the current 1.2 ha), which will include capacity for the Municipal Solid Waste Disposal Area (landfill), Hazardous Waste Storage Area and Landfarm (Figure 11).

The Solid Waste Management Facility will include the Municipal Solid Waste Disposal Area (landfill), Hazardous Waste Storage Area and Landfarm on the north side of Coronation Road and the Bulky Metals Area on the south side of Coronation Road. The Bulky Metals area will also include areas for materials segregation for reuse and recycling.

A 3 m high landfill perimeter berm will be constructed around three sides of the estimated extent of the facility. This will mark-off the final extent of the waste and cover and allow for controlled and organized development of the area. The top of the landfill perimeter berm will be 1 m wide, and the inside and outside slopes will be 3:1. The landfill perimeter berm will be constructed using locally obtained soil and will be capped with a layer of blast rock from the quarry.

A water retention area will be constructed in the north portion of the area to facilitate temporary storage and testing of any potentially impacted runoff from the fill area. The water retention area has been sized to contain a 30-mm storm event or equivalent quantity of snow runoff. Native materials (sand) will be used to construct 1-m high berms around the perimeter of the water retention area. A 2-m deep invert (i.e., gap) will be cut into the landfill perimeter berm at the lowest point to facilitate water drainage into the water retention area. A 0.5-m deep drainage invert will be constructed at the north side of the berm (Figure 11).

The water retention area has been designed to accommodate a 30-mm storm event, see climate data in Appendix C. Assuming the 30 mm falls all within the landfill and retention area footprint (26,986 $m^2$ for landfill and 1,318 $m^2$ for water retention area), the total volume of runoff that could accumulate in the water retention area would be 849.0 $m^3$. With a berm height of 1.0 m, the retention area capacity is approximately 1,000 $m^{3.}$ The storm event volume is approximately 85 percent of total water retention capacity.

In order to assess the impact of the existing landfill area on the downgradient, environment test pits were dug to permafrost at two locations adjacent to the north berm in Appendix D. Groundwater samples were collected as discussed in the Schematic

Design Report. No significant impact was detected. Based on the current and proposed future size of the fill area, and the limited period of time when subsurface flow could occour, no significant impacts to the local groundwater is anticipated. Surface water sampling in the wetland down stream of the landfill detected no evidence of a landfill related impact.

Site staff indicated that the site does not hold any significant quantity of surface water behind the berms that interferes with landfilling. Any surface water that collects reportedly evaporates or infiltrates. There was no evidence of surface water ponding of leachate seeps during the site visit. The site berms act to restrict direct run-off from the waste, and the proposed design includes a retention area and a sampling point prior to discharge. The landfill site is unlined, and any seepage through berms or via the seasonally thawed active zone is expected to be limited.

Landfill leachate can only migrate in the subsurface via the active thawed upper 0.9 m of the soil profile.

As described in previous sections, the estimated groundwater velocity in the sandy active zone is approximately 177 m/4 month active season. Should leachate migrate from the landfill, it would move in a downward direction towards the wetland treatment area. As discussed, there is currently no evidence of leachate in the groundwater on the downgradient side of the berm, and the landfill site has been active at this location for approximately 15 years. This is sufficient time to determine what impact might occur downgradient. For discussion purposes, leachate quality is expected to be typical of landfills receiving municipal waste. In this case, leachate generation and chemistry would be lessened due to the burning of the waste prior to emplacement. Leachate quantities are derived from infiltrating precipitation over the exposed waste. Given the climate conditions, infiltration and run-off from the water is limited and leachate strength is low due to the burning of the waste. Should leachate impacts occur in the active layer (currently none have been noted after 15 years of filling), the leachate would migrate towards the wetland area.

The area between the landfill and the wetland stream would act as a contaminant attenuation zone (CAZ). This provides an approximate 1.5-km migration path to the ocean, which is the closest sensitive receptor. This provides a significantly large CAZ for the attenuation of any leachate. The wetland area is already designated as a Wetland Treatment Area for the Sewage Treatment Facility and is off-limits for other uses. Monitoring stations (Figure 18) located along the length of the surface flow path would detect landfill leachate impacts, should they enter the surface water regime.

Should there be a future concern, the groundwater can be monitored by installing shallow monitoring wells in locations outside of the downgradient berm. This would monitor the impacts immediately adjacent to the fill area similar to the sampling conducted during the field program (Figure 5).

# Table 11
# Waste Quantities

***Waste Generation Rates Table***
***Key Assumptions***

Starting Year: 2006 Population Growth Rate: 1.5%

Pre-2007 quantity in Landfill 12,330 $m^3$

| Planning Year | Calendar Year | Projected Population [people] | Annual Volume of Solid Waste [$m^3$] | Cumulative Volume of Solid Waste [$m^3$] | Annual Volume of Combustible Solid Waste [$m^3$] | Annual Volume of Combustible Solid Waste After Burning [$m^3$] | Annual Volume of Uncombustible Solid Waste [$m^3$] | Total Annual Volume of Uncombustible and Combusted (Burned) Solid Waste [$m^3$] | Annual Volume of Compacted Waste [$m^3$] | Annual Volume of Cover Material [$m^3$] | Total Annual Volume of Compacted Waste and Cover Material [$m^3$] | Cumulative Landfill Volume [m3] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 2006 | 1585 | 8677.9 | 8677.9 | 7289.4 | 4373.6 | 1388.5 | 5762.1 | 2881.1 | 576.2 | 3457.3 | 15,787.27 |
| | 2007 | 1618 | 8858.6 | 17536.4 | 7441.2 | 4464.7 | 1417.4 | 5882.1 | 2941.0 | 588.2 | 3529.2 | 19,316.51 |
| | 2008 | 1653 | 9050.2 | 26586.6 | 7602.1 | 4561.3 | 1448.0 | 6009.3 | 3004.7 | 600.9 | 3605.6 | 22,922.10 |
| | 2009 | 1686 | 9230.9 | 35817.5 | 7753.9 | 4652.3 | 1476.9 | 6129.3 | 3064.6 | 612.9 | 3677.6 | 26,599.67 |
| | 2010 | 1720 | 9417.0 | 45234.5 | 7910.3 | 4746.2 | 1506.7 | 6252.9 | 3126.4 | 625.3 | 3751.7 | 30,351.40 |
| 5 | 2011 | 1760 | 9636.0 | 54870.5 | 8094.2 | 4856.5 | 1541.8 | 6398.3 | 3199.2 | 639.8 | 3839.0 | 34,190.39 |
| | 2012 | 1793 | 9816.7 | 64687.1 | 8246.0 | 4947.6 | 1570.7 | 6518.3 | 3259.1 | 651.8 | 3911.0 | 38,101.35 |
| | 2013 | 1827 | 10002.8 | 74690.0 | 8402.4 | 5041.4 | 1600.5 | 6641.9 | 3320.9 | 664.2 | 3985.1 | 42,086.48 |
| | 2014 | 1859 | 10178.0 | 84868.0 | 8549.5 | 5129.7 | 1628.5 | 6758.2 | 3379.1 | 675.8 | 4054.9 | 46,141.40 |
| | 2015 | 1893 | 10364.2 | 95232.2 | 8705.9 | 5223.5 | 1658.3 | 6881.8 | 3440.9 | 688.2 | 4129.1 | 50,270.49 |
| 10 | 2016 | 1928 | 10555.8 | 105788.0 | 8866.9 | 5320.1 | 1688.9 | 7009.1 | 3504.5 | 700.9 | 4205.4 | 54,475.92 |
| | 2017 | 1965 | 10758.4 | 116546.3 | 9037.0 | 5422.2 | 1721.3 | 7143.6 | 3571.8 | 714.4 | 4286.1 | 58,762.06 |
| | 2018 | 2000 | 10950.0 | 127496.3 | 9198.0 | 5518.8 | 1752.0 | 7270.8 | 3635.4 | 727.1 | 4362.5 | 63,124.54 |
| | 2019 | 2041 | 11174.5 | 138670.8 | 9386.6 | 5631.9 | 1787.9 | 7419.9 | 3709.9 | 742.0 | 4451.9 | 67,576.45 |
| | 2020 | 2076 | 11366.1 | 150036.9 | 9547.5 | 5728.5 | 1818.6 | 7547.1 | 3773.5 | 754.7 | 4528.3 | 72,104.70 |
| 15 | 2021 | 2107 | 11536.6 | 161573.5 | 9690.7 | 5814.4 | 1845.9 | 7660.3 | 3830.1 | 766.0 | 4596.2 | 76,700.88 |
| | 2022 | 2139 | 11709.6 | 173283.1 | 9836.1 | 5901.7 | 1873.5 | 7775.2 | 3887.6 | 777.5 | 4665.1 | 81,366.00 |
| | 2023 | 2171 | 11885.3 | 185168.4 | 9983.6 | 5990.2 | 1901.6 | 7891.8 | 3945.9 | 789.2 | 4735.1 | 86,101.10 |
| | 2024 | 2203 | 12063.6 | 197232.0 | 10133.4 | 6080.0 | 1930.2 | 8010.2 | 4005.1 | 801.0 | 4806.1 | 90,907.22 |
| | 2025 | 2236 | 12244.5 | 209476.5 | 10285.4 | 6171.2 | 1959.1 | 8130.4 | 4065.2 | 813.0 | 4878.2 | 95,785.44 |
| 20 | 2026 | 2270.0 | 12428.2 | 221904.7 | 10439.7 | 6263.8 | 1988.5 | 8252.3 | 4126.2 | 825.2 | 4951.4 | 100,736.83 |
| | 2027 | 2304 | 12614.6 | 234519.3 | 10596.3 | 6357.8 | 2018.3 | 8376.1 | 4188.0 | 837.6 | 5025.7 | 105,762.49 |
| | 2028 | 2339 | 12803.8 | 247323.1 | 10755.2 | 6453.1 | 2048.6 | 8501.7 | 4250.9 | 850.2 | 5101.0 | 110,863.53 |
| | 2029 | 2374 | 12995.9 | 260319.0 | 10916.5 | 6549.9 | 2079.3 | 8629.3 | 4314.6 | 862.9 | 5177.6 | 116,041.09 |
| | 2030 | 2409 | 13190.8 | 273509.8 | 11080.3 | 6648.2 | 2110.5 | 8758.7 | 4379.4 | 875.9 | 5255.2 | 121,296.32 |
| 25 | 2031 | 2445 | 13388.7 | 286898.5 | 11246.5 | 6747.9 | 2142.2 | 8890.1 | 4445.0 | 889.0 | 5334.1 | 126,630.37 |
| | 2032 | 2482 | 13589.5 | 300488.0 | 11415.2 | 6849.1 | 2174.3 | 9023.4 | 4511.7 | 902.3 | 5414.1 | 132,044.43 |
| | 2033 | 2519 | 13793.4 | 314281.4 | 11586.4 | 6951.9 | 2206.9 | 9158.8 | 4579.4 | 915.9 | 5495.3 | 137,539.70 |
| | 2034 | 2557 | 14000.3 | 328281.6 | 11760.2 | 7056.1 | 2240.0 | 9296.2 | 4648.1 | 929.6 | 5577.7 | 143,117.41 |
| | 2035 | 2595 | 14210.3 | 342491.9 | 11936.6 | 7162.0 | 2273.6 | 9435.6 | 4717.8 | 943.6 | 5661.4 | 148,778.78 |
| 30 | 2036 | 2634 | 14423.4 | 356915.3 | 12115.7 | 7269.4 | 2307.7 | 9577.1 | 4788.6 | 957.7 | 5746.3 | 154,525.07 |
| | 2037 | 2674 | 14639.8 | 371555.1 | 12297.4 | 7378.4 | 2342.4 | 9720.8 | 4860.4 | 972.1 | 5832.5 | 160,357.55 |
| | 2038 | 2714 | 14859.4 | 386414.5 | 12481.9 | 7489.1 | 2377.5 | 9866.6 | 4933.3 | 986.7 | 5920.0 | 166,277.52 |
| | 2039 | 2755 | 15082.3 | 401496.7 | 12669.1 | 7601.5 | 2413.2 | 10014.6 | 5007.3 | 1001.5 | 6008.8 | 172,286.29 |
| | 2040 | 2796 | 15308.5 | 416805.2 | 12859.1 | 7715.5 | 2449.4 | 10164.8 | 5082.4 | 1016.5 | 6098.9 | 178,385.19 |
| 35 | 2041 | 2838 | 15538.1 | 432343.3 | 13052.0 | 7831.2 | 2486.1 | 10317.3 | 5158.7 | 1031.7 | 6190.4 | 184,575.58 |
| | 2042 | 2881 | 15771.2 | 448114.5 | 13247.8 | 7948.7 | 2523.4 | 10472.1 | 5236.0 | 1047.2 | 6283.2 | 190,858.82 |
| | 2043 | 2924 | 16007.8 | 464122.3 | 13446.5 | 8067.9 | 2561.2 | 10629.1 | 5314.6 | 1062.9 | 6377.5 | 197,236.31 |
| | 2044 | 2968 | 16247.9 | 480370.1 | 13648.2 | 8188.9 | 2599.7 | 10788.6 | 5394.3 | 1078.9 | 6473.2 | 203,709.46 |
| | 2045 | 3012 | 16491.6 | 496861.7 | 13852.9 | 8311.8 | 2638.7 | 10950.4 | 5475.2 | 1095.0 | 6570.2 | 210,279.71 |
| 40 | 2046 | 3057 | 16739.0 | 513600.7 | 14060.7 | 8436.4 | 2678.2 | 11114.7 | 5557.3 | 1111.5 | 6668.8 | 216,948.51 |

percentage remaining after burning 0.6

The existing fence along the north, west, and east side of the area will be temporarily removed and relocated or replaced. The fence will be constructed along the landfill perimeter berm at a height of 1.5 m.

Signs will be posted within the landfill to indicate that there shall be no Salvaging of Waste. The Bulky Metals Area will have a designated reuse/recycle area.

### *4.2.3 Recommended Operational Improvements*

Improved operational procedures are detailed in the Solid Waste Disposal Facility Operation and Maintenance (O&M) Plan (submitted as a separate document), which has been created to achieve the following objectives:

- Organizes and controls development of the landfill to reduce the size and therefore the potential impacts
- Optimizes the amount of cover required and the time needed to cover the material.

The progressive development of the landfill is shown schematically on Figures 12 through 16. General maintenance activities are required to ensure that the site remains in good operating order. This involves repairing damaged features, cleaning the site, and monitoring. A monitoring report will be prepared and submitted to the Nunavut Water Board once per year. Refer to the Solid Waste Disposal O&M Plan for details.

## 4.3 Bulky Metals Disposal Area

### *4.3.1 Existing Conditions*

The Bulky Materials Disposal Area is located south of the landfill and has been a repository for vehicles, heavy equipment, tanks, piping, drums, boats, and miscellaneous metal materials for over 15 years (Figure 6). To encourage reuse/recycling, Hamlet staff have recently created segregated areas for tires, appliances, bicycles, ATV’s, snowmobiles, wood and other materials. Public use of the area for reuse and recycling is encouraged. An examination of the area revealed very little materials that should have been stored or disposed of elsewhere. The footprint of the Bulky Metals Disposal Area is currently approximately 6,340 $m^2$ (Figure 6).

Hamlet staff indicated that most of the vehicles were not drained of fluids prior to being placed. However there was no evidence (staining, odours, vegetation stress, etc.) to suggest the site is causing a significant environmental impact.

#### *4.3.2 Recommended Design Improvements*

There is a large quantity of metals on-site that would not be suitable for reuse due to the age, condition or type of material. Hamlet staff have indicated that they would like to reduce the amount that is visible. To achieve this, the existing metal materials within the Bulky Metals Disposal Area will be buried in a Bulky Metals Burial Pit (Figure 17). Burial in a dedicated area (as opposed to commingling with municipal solid waste) will facilitate future excavation and reuse, should the value of metals rise and it become economically viable to ship it out as scrap. Future bulky metals will continue to be placed in the Bulky Metals Disposal Area, until a sufficient quantity has accumulated to facilitate another burial (assume in 5 to 10 years).

Efforts should be made by the community to segregate any materials that may have a future use prior to the burial (e.g., recently placed metal materials and vehicles). Tires that no longer have a reuse/recycle value may be burned with the metals, as they are bulky and would not cause an environmental impact.

The Bulky Metals Burial Pit will be excavated to the west of the existing bulky materials disposal site on the south side of Coronation Road (Figures 6 and 17). A ramp will be constructed such that vehicles can access the pit. Using grapples, loaders or any other equipment feasible, the bulky metals will be picked up and moved or dragged into the pit. Large solid pieces of metal (i.e. empty tanks, automobiles) should be moved as the first stage and placed along the south side of the disposal pit. Tires should be located next and placed across the bottom of the remainder of the pit. This deep burial of tires reduces the likelihood of tires migrating to the surface, as tires have a tendency to ‘float’ to the surface due to ice and frost action. Loose bulky metal, such as sheets of steel, should be placed over the tires and towards the north end of the pit and pushed against the larger pieces.

Once the material has been placed, the pit will be covered with native soils (sand). This will involve progressively blading or pushing the stockpile that was developed during the excavation of the pit. If there is not sufficient material from the excavation, it may be necessary to excavate materials from an offsite source. A perimeter ditch will be constructed around the south, west and east pit boundaries, and will be lined with blast rock. Because there will likely be considerable differential settlement, and the potential for the development of potentially dangerous sink holes, the pit will be surrounded by a post and wire fence (Figure 17).

#### *4.3.3 Recommended Operational Improvements*

After an initial burial of the current accumulated bulky metals with no future reuse/recycle value, the Bulky Metals Disposal Area can continue to operate in the basically in the same manner as it has in the past, with the following minor operational improvements:

- Staff should regularly inspect vehicles and equipment and drain fluids or hazardous materials from the vehicles as required

- Inspected vehicles or equipment should be tagged to indicate that they have been inspected and have been drained

- Periodically (every five to ten years) a bulk burial of the metals that have no further reuse/recycle value may be conducted to reduce visual impacts

- The Bulky Metals Burial Pit should be inspected yearly and rutting or erosion should be repaired as required.

Refer to the Solid Waste Facility Operations and Maintenance (O&M) Plan for details.

## 4.4 Hazardous Waste Storage Area

### *4.4.1 Existing Conditions*

Hazardous waste materials, including drums of oil, antifreeze, batteries, and paint are currently stockpiled in a lined and bermed area next to the sewage lagoon as shown on Figures 4 and 7. There is also a stockpile of contaminated soils adjacent to the area.

The site has been accumulating hazardous waste materials for approximately 10 years and contains:

- Approximately 500, 205 litre (45 gal) drums of primarily waste oil and some glycol (antifreeze) from the Hamlet Public Works Yard
- Approximately 40 smaller (10 to 25 litre) pails of paint, oil, and lubricants
- Approximately 200 used batteries.

The volume of liquid oils and glycol is estimated at approximately 10,000 litres.

Management of hazardous waste must be in accordance with the "***Environmental** Guideline for General Management of Hazardous Waste in Nunavut*", Government of Nunavut, January 2002, and related guidelines.

The main issues with the current Hazardous Waste Disposal Area are summarized below:

- It is currently located in the area proposed for use for the Sewage Treatment Facility
- It is not in a central location with respect to solid waste management
- The hazardous waste disposal area is used for permanent disposal, whereas it should be just temporary storage until wastes can be moved to a permanent disposal location
- It is not fenced or controlled.

### *4.4.2 Recommended Design Improvements*

The stockpiling and storage of hazardous waste materials in a lined central location is generally considered a good operating practice to prevent these wastes from entering the environment (either through dumping, or via leaching within the landfill.) The lined and bermed storage area provides secondary containment, further minimizing the potential for impact. However, storage is not a permanent solution, and wastes must be regularly removed and properly disposed of. In addition, the community should discourage access to this area because these materials are hazardous to human health as well as the environment.

A new Hazardous Waste Storage Area will be constructed within the perimeter of the Solid Waste Management Facility to manage wastes in a central fenced and controlled location. A perimeter fence will surround the area, to discourage public access. The area will be lined with a 60 mil HDPE geomembrane and surrounded with a perimeter berm. The bermed area will contain approximately 30 $m^3$, which exceeds 110 percent of the assumed storage capacity (Figure 11).

A required storage volume of approximately 27 $m^3$ was calculated, based on the current stockpile of hazardous waste material. A volume of 30 $m^3$ capacity is used as 110 percent of capacity.

Discussions with Hamlet staff indicate that the Hazardous Waste Storage Area should be sized to accommodate approximately five years of accumulated hazardous waste. The storage area is sized to allow the accumulation of an amount of hazardous waste that makes a back haul cost-effective, yet does not encourage a large stockpile.

A locker will be installed within the Hazardous Waste Storage Area and be outfitted with equipment to use in the event of a spill. This would comprise of absorbent pads, absorbent booms, a fire-extinguisher and standard first aid equipment. The locker would remain locked and be secured to the fence to discourage theft.

### *4.4.3 Recommended Operation Improvements*

The current method of storing wastes on skids stacked no higher than 2 drums should be continued. However, hazardous wastes must be treated or removed from the community more frequently. All wastes that have accumulated such as oils, fuels, batteries, antifreeze, solvents that cannot be treated onsite and rendered safe for landfilling or cannot be reused will be removed from the community and shipped to a proper disposal facility. Materials must be contained, manifested, and arrangements must be made with a shipper to back haul the materials to a licensed waste disposal site. In between backhauls the wastes must be safely stored.

Contractors that are working in the community, or delivering materials should not be allowed to store their hazardous waste at the Hazardous Waste Storage Area without appropriately compensating the community for the eventual disposal costs.

Refer to the Solid Waste Management Facility Operation and Maintenance (O&M) Plan for additional details.

### *4.4.4 Disposal of the Existing Hazardous Waste Inventory*

It is recommended that the existing hazardous waste inventory be handled in the following manner:

- Drums of Oil, Glycol, and Related Liquid Wastes – consume in a waste oil incinerator
- Waste Batteries – backhaul from site when resources become available. Store in the interim in a secure location at the Hazardous Waste Storage Area
- Waste Paint – offer for reuse, and if not wanted, open and dry out. Residue can go to the landfill
- Other Hazardous Materials – stockpile in a secure manner at the Hazardous Waste Storage Area until cost effective shipment south can be arranged.

The liner from the existing storage area will be removed for disposal to the landfill once the waste materials are removed. The underlying soil and surrounding area will be examined and sampled, to determine if there are any environmental impacts. Impacted areas will be assessed and remediated as needed. The area will be regraded during the construction of the new lagoon facilities.

## 4.5 Landfarm Area

### *4.5.1 Exiting Stockpile*

To the west of the sewage lagoon is a stockpile of hydrocarbon-impacted soil, locally referred to as a “landfarm” (Figure 7). It consists of an approximate 30-mil HDPE liner and geotextile cloth placed directly on the native soils or in a shallow excavation. Approximately 620 $m^3$ of hydrocarbon-contaminated soil from a pipeline spill that occurred in town has been placed on the liner and an approximate 20-mil HDPE cover was placed over the soil.

Currently the top cover has partially blown off and has degraded due to wind and age. Permafrost has re-aggraded into the pile, so less then1 m of the surficial layer was thawed during our site inspection in early October 2005. Based on measured dimensions and the assumption that the soil is piled on a liner placed on the original ground surface, the contaminated soil volume is estimated at 620 $m^3$.

Analysis of soil samples collected from the stockpile indicates that the upper layer of soil contains low levels of petroleum hydrocarbons that are below the Canadian Environmental Quality Guidelines for Soil in an Industrial Land Use. The soil would therefore be suitable for use as landfill cover. The characteristics of the soil below the active layer (approximately 1.0 m below surface) is unknown because it was frozen and could not be sampled.

Once all of the stockpiled soil has been removed, the cover and liner will be disposed of at the landfill. The underlying soil will be examined and sampled for evidence of impacts, and remediated if required. The area will be regraded during the construction of the new lagoon.

Hamlet and GN staff indicated an area in the Hamlet where there is an additional quantity of hydrocarbon-impacted soil estimated at approximately 500 $m^3$. The Hamlet plans to excavate the soil and treat it at the landfarm once it is operational. No time table or details were available regarding these plans.

### *4.5.2 Recommended Design Improvements*

Generally, the main processes that remediate hydrocarbon contamination from soils in a landfarm-type treatment system are volatization (through aeration) and aerobic degradation via naturally occurring bacteria. The current stockpile is not landfarmed because the soils are permanently frozen and compacted, and it is therefore unlikely that either of these two processes is occurring, except in the very top layer of soil.

A new landfarm area will be constructed to treat the remainder of the stockpile (if necessary) as well as hydrocarbon-contaminated soil from the Hamlet. The landfarm will consist of a bermed, dedicated area, 20 m by 60 m in area in which soils will be loosely placed to a maximum thickness of 0.6 m. The area will be lined with a HDPE geomembrane and surrounded with a perimeter berm. The upper surface of the landfarm would remain uncovered to facilitate air contact (design details are displayed on Figure 11).

### *4.5.3 Recommended Operational Improvements*

The operation of the landfarm is outlined in the Solid Waste Management Facility Operations and Maintenance (O&M) Plan. The landfarm can operate passively with limited staff action to encourage biodegradation of hydrocarbons or more actively with the maximization of moisture, nutrients, microbial colonies, and active tilling. How it will be operated will be based on a cost/benefit analysis and Hamlet preference. As long as the contaminated soil is contained within the lined landfarm, it is isolated from the environment.

## 4.6 Water Board License Requirements

Nunavut Water Board License No. NWB3KUGO308 (Appendix B) has several requirements with respect to solid waste disposal. These are described in the following sections.

### *4.6.1 Annual Report*

The license requires the submission of annual reports. An outline of regular inspections and preparation of the Annual Report is included in the Solid Waste Management Facility O&M Plan. Sampling protocols have been outlined in the Monitoring Program and Quality Assurance/Quality Control (QA/QC) Plan, provided as a separate document.

### *4.6.2 Operations and Maintenance (O&M) Plan*

As required by the license, a Solid Waste Management Facility O&M Plan has been prepared as a separate document.

### *4.6.3 Improved Surface Water Management*

The license requires that measures be taken to prevent standing water from escaping at the toe of the waste. Design improvements such as at the perimeter berm and the water retention area included as part of the preferred concept, should provide adequate containment and encourage infiltration. The Solid Waste Management Facility O&M Plan describes the method for handling standing water in the containment.

### *4.6.4 Waste Composition Study*

The license recommended that a waste composition study be completed. This has been completed, and is included within the Schematic Design Report and outlined herein in the previous sections describing the municipal solid waste composition.

### *4.6.5 Spill Contingency Plans*

The license requires completion of spill-contingency plans. These have been included in the Environmental Emergency Contingency Plan ( a separate document).

### *4.6.6 Segregation of Waste Oil and Batteries from Municipal Solid Waste*

The license recommends the segregation of waste oils and batteries from municipal solid waste. The detailed design includes a separate Hazardous Waste Storage Area to facilitate this segregation.

Operational procedures are included in the Solid Waste Management Facility Operations and Maintenance (O&M) Plan provided as a separate document.

#### *4.6.7 Installation of Fencing*

The license recommended the installation of fencing. This has been included in the detailed designs for the Solid Waste Disposal Area (landfill) which includes the Hazardous Waste Storage Area and Landfarm (Figure 11). Fencing is also part of the design for the Bulky Metals Burial Pit (Figure 17).

#### *4.6.8 Monitoring*

Figure 18 displays the existing and proposed monitoring locations. The Solid Waste Management Facility has one proposed monitoring location (KUG-2A) at the discharge of the waste retention area. Should there be the need for discharging water from the retention area, the waste will be sampled and the results compared to the appropriate regulatory guidelines. Depending on the results, pre-treatment may be necessary. The downgradient sampling status in the Wetland Treatment Area will be sampled for a range of parameters, that would indicate if the Solid Waste Management Facility was causing an environmental impact. Site monitoring is included in the Solid Waste Management Facility O&M Plan and in the Monitoring Program and QA/QC Control Plan.

### 4.7 Abandonment and Restoration

Part G of the Water License (Appendix B), requires the submission of an Abandonment and Restoration Plan at least six months prior to abandoning any facilities and constructing of new facilities to replace existing ones. This Detailed Design Report provides the required information for the exiting facilities.

The Solid Waste Management Facility has been designed for a 20-year period. Given the location of the site and the available surrounding land area, there is no significant reason this cannot be expanded to the northeast (Figure 6), and continue to operate further into the future. As shown on Figure 2 and 6, there is sufficient available land for several more fill areas of a similar size to the northeast. In addition, waste could be mounded higher than currently designed. The Solid Waste Management Facility O&M Plan provides details on the operation and staged closure of the site, over the design period and the closure cover design. The cover design includes restoration of the surface to mimic the natural surrounding tundra. The closure design also includes the Hazardous Waste Storage Area and Landfarm Area. The Bulky Metals Area will be restored by burying the metals in the burial pit, and regrading the surface to match the surrounding tundra. As outlined in the O&M Plan, maintenance and planning will be an ongoing practice. Further planning beyond the current 20-year design period will occur in stages as the site is progressively developed and filled.

# 5.0 Geotechnical Assessment and Design Details

The Detailed Design Report dated June 2006 and the tender document prepared in July 2006, was forwarded to the NWB for review. Comments and questions were received from the GN in a letter dated October 24, 2006 (Appendix A-1). A number of questions and comments specifically addressed geotechnical considerations (Sections X, XI, XII, XIII, and XIV).

To address these issues, Nuna Burnside retained the assistance of permafrost geotechnical engineers from AMEC Earth & Environmental, a division of AMEC Americas Limited (AMEC).

In coordination with Nuna Burnside and a local contractor, AMEC prepared responses to each of the geotechnical concerns. The responses are included in Appendix J.

In October 2006, Nuna Burnside staff accompanied by a construction contractor and GN staff, examined the area of the sewage lagoon, contracted test pitting, and selected soils samples.

Test pit locations (numbers TP601 through TP622) are displayed on Figure 5. Test pit logs are included in Appendix D. Grainsize analysis was conducted on five selected samples. The results are included in Appendix E.

Construction monitoring protocols are included in the AMEC report in Appendix J.

# 6.0 Cost Estimates

A Class “B” cost estimate was developed based on the design of the facilities described in this document. Appendix H provides tables with the details of the cost estimates.

The following key assumptions were made to develop these cost estimates:

- Capital costs for each of the facilities include construction, supply, delivery and installation of necessary materials and equipment

- The capital cost estimates do not include other management expenses such as operation and maintenance for the facilities, the collection and trucking of wastes to the sewage lagoon or landfill, nor do these include community training, community liaison, etc.

- Costs are based on the equipment and manpower currently available in the community as per the Hamlet’s municipal service rates by-law and discussions with the Hamlet’s Senior Administrative Officer (SAO)

- All equipment and materials on the site that are in good condition will be salvaged and incorporated or utilized in the construction to the fullest extent possible.

These assumptions together with the detailed design drawings were used to determine the corresponding costs estimates for the facilities. The estimated costs for the Sewage Treatment Facility and Solid Waste Management Facility are presented in Appendix H.

## 7.0 Environmental Screening

A Canadian Environmental Assessment Act (CEAA) Environmental Screening Report was completed for the Sewage Treatment Facility and the Solid Waste Management Facility. The CEAA Environmental Screening Report identifies potential environmental impacts and concerns, and provides procedures and mitigation actions to reduce the potential for environmental impacts. The Environmental Screening Decision Form for the Sewage Treatment Facility is included in Appendix I-1 and for the Solid Waste Management Facility in Appendix I-2.

The screening decision number for both facilities (sewage, and solid waste) is “01” which means that the project may proceed since all potentially adverse effects are mitigable with known technology, and therefore will be rendered insignificant.

## 8.0 Summary

This Detailed Design Report has been prepared as a supporting document, as part of the application for an amendment to the Nunavut Water Board License for the Hamlet of Kugluktuk. This report is accompanied by, and references, the following separately bound companion documents:

- Solid Waste Management Facility Operation and Maintenance (O&M) Plan
- Sewage Treatment Facility Operation and Maintenance (O&M) Plan
- Environmental Emergency Contingency Plan
- Monitoring Program and Quality Assurance/Quality Control Plan
- Large scale detailed Design Drawings prepared for the Construction Tender.

Report Prepared By:

**Nuna Burnside Engineering and Environmental Ltd.**

PERMIT TO PRACTICE
Nuna Burnside Engineering and Environmental Ltd.
Signature Jim Walls
Date April 30, 2007
PERMIT NUMBER: P 535
The Association of Professional Engineers, Geologists and Geophysicists of NWT/NU

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James R. Walls P. Geol. — April 30, 2007, Date

Xavier Fernandes
Xavier Fernandes, B.Sc. — April 30, 2007, Date

J Popowich
Jerry Popowich, P.Eng. — April 30, 2007, Date

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