Government of Nunavut

Cape Dorset Wastewater Treatment Feasibility Study

Type of Document
Final

Project Name
Cape Dorset Feasibility Study

Project Number
OTT-00237662-A0

Prepared By:
exp Services Inc.
100-2650 Queensview Drive
Ottawa, ON   K2B 8H6
Canada

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exp
100-2650 Queensview Drive
Ottawa, ON K2B 8H6
Canada
T: 613 688-1899
F: 613 225-7337
www.exp.com

REGISTERED PROFESSIONAL ENGINEER
D.F. McGOVERN
LICENSEE
OCT 17/17
N.W.T.

D. Farrell McGovern, P.Eng.
Consultant

Steven Burden, P.Eng.
Senior Manager – Infrastructure Services

Date Submitted:
October 2017

PERMIT TO PRACTICE
EXP SERVICES INC.
Signature
Date 2017-10-17
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NT/NU Association of Professional Engineers and Geoscientists

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1 Introduction

Exp Services Inc. (**exp**) has been retained by the Department of Community and Government Services (CGS) to complete a wastewater treatment feasibility study for the Hamlet of Cape Dorset (Hamlet). Alternative methods for the provision of wastewater treatment have been identified and an evaluation of the technical, economic and community implications of these alternatives has been conducted.

Cape Dorset is a community of approximately 1,400 people located on Dorset Island, off the southern tip of Baffin Island. Wastewater is currently hauled to a 3-cell lagoon situated approximately 1 km west of the community. Due to issues with this lagoon, a new facility was developed on a site referred to as P Lake. The facility at P Lake has not been placed into service for various reasons which include concerns arising from the access road and issues with leakage of the berms.

The scope of this study includes the following activities:

- Definition of service conditions
- Development of a list of alternative methods of addressing the wastewater management issues in Cape Dorset
- Evaluation of the feasibility of the alternatives including performance, operating requirements and life cycle costing
- Development of a weighted decision matrix as a tool to select the preferred alternative
- Recommendation of a preferred alternative
- Preparation of a report summarizing the findings of this investigation

The following report summarizes the above activities and presents a preferred alternative method for the management of wastewater in Cape Dorset.

2 Previous Investigations and Studies

2.1 Introduction

The matter of wastewater treatment for Cape Dorset has been the subject of several investigations and assessments. The project team has been provided with the following studies and investigations.

2.2 The Municipality of Cape Dorset Water Reclamation Facility; Hill Murray, January 28, 1999

This document represents a proposal for the provision, on a design-build basis, of a facility for the treatment of wastewater for the Hamlet. A suspended growth process with membrane filtration was proposed. Effluent performance of 10 mg/L for biochemical oxygen demand (BOD_5) and total suspended solids (TSS)were guaranteed. It was proposed that an expandable facility with an initial capacity of 600 m^3/day be provided. A second option that entailed treatment of "sewered" flows, while continuing discharge of trucked sewage to a lagoon, was presented. A budget estimate of $3,876,000 for treatment of 600 m3/day, plus a contingency allowance of $500,000 was proposed.

2.3 Cape Dorset Mechanical Sewage Treatment Plant Concept Design – Draft; Dillon Consulting Limited, February 2003

The introduction to this report notes that the GN had selected pre-engineered, prefabricated mechanical treatment as the long-term strategy for municipal sewage treatment. This report presents a regulatory review, system design standards, community information, treatment process, facility requirements and an implementation strategy.

The regulatory review noted that there was a water licence in place, and that this licence provided effluent criteria. The effluent from the proposed facility would discharge into the same general areas as the lagoon that was in operation at that date.

A 20-year design horizon was set for most elements of the facility. Projections of population, sewage generation and sewage strength were prepared to the year 2024. A treatment train that incorporated sewage reception, equalization, dual biological (SBR or equivalent) reactors and aerobic sludge digestion was proposed.

The implementation schedule anticipated shipment of equipment during the 2003 sealift and commissioning in spring 2004.

2.4 Sewage Treatment Alternatives for the Hamlet of Cape Dorset; Dillon Consulting Limited, August 2003

This report consolidates information developed, over a period of time, relating to the matter of sewage treatment for Cape Dorset. The report culminates in a comparison of the options of the P Lake Lagoon and a pre-engineered treatment plant. A presentation of the history surrounding the issues of sewage treatment in Cape Dorset is provided.

Shortcomings, in terms of berm stability and storage volume, for the existing lagoon are reported. It is reported that a planning study conducted in 2001 determined that a new lagoon at Site R was the most cost effective alternative. This alternative was subsequently determined to be infeasible. The 2001 study identified Site P as a potential lagoon site; it was also noted that this was a capital-intensive alternative. A third location, Site Q, was dropped from further consideration based upon the community desire to retain this site as an emergency water source.

Based upon siting challenges, a pre-engineered treatment plant was selected as the preferred treatment strategy in July 2002. The decision to re-evaluate this selection was reached in 2003, based upon experience in Pangnirtung. Costs were developed for the alternatives of a mechanical treatment plant or a lagoon at P Lake. The capital cost for the lagoon alternative was estimated at 23% more expensive than the mechanical plant. Mechanical plant annual operating costs were estimated at 6.5 times those for the lagoon. The lagoon alternative provided the lower life cycle costs for all discount rates.

A weighted matrix was prepared for the two alternatives, as a tool to capture a range of issues that are broader than cost. In addition to costs, this evaluation considered cost uncertainty, regulatory issues, process uncertainty and community acceptance. The P Lake alternative achieved the higher score in this evaluation.

It was recommended that additional information for both the lake and access road, including bathymetry, topography, geology, hydrology and fish habitat should be gathered. It was also noted that re-evaluation of mechanical treatment may be warranted should the development of the lagoon alternative prove not feasible.

A schedule that started with site investigations in 2003 projected construction in 2004/2005.

The concept design report for mechanical treatment of February 2003 is incorporated as an appendix of this report.

2.5 Cape Dorset Sewage Lagoon – Existing Site Expansion; Dillon Consulting Limited, September 26, 2003

This letter report presents a capital cost for the development of a lagoon on the site of the existing lagoon that is suitable for the community needs to 2025. A three-tiered lagoon system is proposed. A cost estimate, inclusive of engineering and contingencies of $35,585,000 is presented.

2.6 Cut-off Trench Excavation, Sewage Lagoon Berms Construction Monitoring, Cape Dorset NU; AMEC, August 20, 2007

This letter report summarizes construction observations made between July 2 and July 12, 2007. AMEC was retained by Dillon Consulting to inspect cut-off trenches for two sewage lagoon berms. It was concluded that the cut-off trenches have been excavated into hard frozen soils to depths specified in the Dillon Design Drawing 111.

2.7 Additional Geotechnical Analysis for P-Lake Lagoon, Cape Dorset; AMEC, August 21, 2007

This letter report presents a review of geothermal conditions for the berms based on as-built information and an evaluation of berm stability. It reports the understanding that a bentonite liner, embedded at a minimum of 2 m below original ground, was to be provided.

It was concluded that seepage under the berm was very unlikely if the liner was installed in accordance with the Dillon drawing. Factors of safety of between 1.3 and 1.8 were reported for circular and planar failures for the berm and road slopes.

It is noted that field drilling and slope stability analysis was not carried out during the preparation of the 2005 geotechnical report.

2.8 Independent Geothermal Evaluation of Proposed Design; BGS Engineering Inc., January 18, 2008

This memorandum presents an independent geothermal analysis prepared for the Nunavut Water Board. It is noted that the as-built configuration differed from the design drawings and from the cross section assumed during earlier geothermal modeling. Several conclusions are presented in this memorandum. These include the opinion that the as-built berms are suitable for the proposed operating conditions. Among the conclusions is the comment that permafrost containment by the bedrock is expected, provided the joints are ice saturated.

2.9 Temperature Data Review for Sewage Lagoon Dyke, Cape Dorset, Nunavut; AMEC, March 26, 2010

This letter report was prepared at the request of the Municipal Planning Engineer. This report provides a review of temperature data and a comparison with predicted dyke temperature. The opinion is presented that there is agreement between the data and the predicted temperatures. It was also noted that the active layer on September 29, 2010 was thicker than predicted. Temperatures that were higher than those reported in the Canadian Normals was presented as an explanation for this variation.

It was concluded that the west and east dykes were in a frozen state.

2.10 Dam Safety Review; exp Services Inc., August 22, 2013

A dam safety review was conducted for the sewage lagoons and water supply. No concerns were noted about the active lagoon, the emergency lagoon and the water source. Specific safety concerns were noted with the 2007 (P Lake) lagoon including the north berm road and the site access road. Leakage of the west berm was also noted. It was concluded that the 2007 lagoon should not be used until the safety concerns relating to the liner are addressed, and the lagoon and access road are improved.

2.11 Cape Dorset Sewage Lagoon Feasibility Study; Stantec, March 31, 2015

This report provides a feasibility study for the rehabilitation of the P Lake sewage lagoon. A summary of investigations and studies undertaken from 2003 to 2013 is provided. It is reported that the lagoon has not been placed into service. Reported issues related to both the lagoon and the method of conveyance of sewage to the lagoon. Lagoon related issues include:

- Leakage from the retention berm
- Concerns for the potential for leakage to the east
- Freeze of the decanting arrangements
- Surface runoff entering the lagoon. Total inflow is estimated at 21,876 m^3.
- The risk of wind dispersion of sewage

Concerns are expressed regarding the conveyance of sewage to the lagoon using the existing access road. These concerns include steep gradients, a hairpin curve, erosion, snow accumulation and poor visibility.

The estimated annual sewage generation is reported as 90,800 m^3 for the year 2034. Lagoon design volume is reported as 96,100 m^3. It is estimated that the lagoon capacity will be reached in 2022 when an allowance for runoff inflow is included.

A modest program of lagoon improvements that include berm leak repair is proposed. It is noted that there is a significant risk that a program to seal the leaks may not be successful. The recommended actions include attempting to plug the leak, grouting the existing decanting pipe and drainage improvements. The cost of these works is estimated at $260,000. The cost of reconstruction of the berm is estimated at $5.1 million.

The development of a secondary treatment cell downstream of the existing lagoon is examined. This may be attractive if lagoon capacity is reached. Provision of a secondary cell could provide the opportunity to contain all of the sewage, together with runoff inflows. Higher treatment performance is possible. There would no longer be a need for a repair of the existing berm leak. It is estimated that the creation of a secondary cell would cost $3.7 million.

The issue of conveyance of sewage to the lagoon is examined in detail. A program of road improvements was developed with an estimated cost of $6.3 million. Provision of snow sheds would raise this estimated cost to $7.5 million. Following this expenditure, there would remain concerns about the safety, serviceability and community acceptance of the access road. As an alternative, the option of a sewage lift station was investigated. The proposed mechanism for freeze protection of the forcemain involves draining the contents to the lift station at the end of each pump cycle. The cost of the alternative is estimated at between $6.1 and $7.5 million, depending on the location of the lift station.

The overall recommendations of this report may be summarized as follows:

- Sealing of the berm leak with bentonite should be considered, and the decant piping should be grouted.
- Construction of the secondary cell is recommended if sealing of the berm is not successful.
- Improvements of the drainage system to reduce the inflow of runoff are proposed.
- A lift station is proposed as the method to convey sewage to the lagoon.
- A program of access road improvements is provided, should the Hamlet prefer improvements to the access road instead of a lift station.

The cost of the recommended course of action is $6.4 million. A further $3.7 million would be required if a secondary cell is constructed.

3 Service Conditions

3.1 Served Population

The Nunavut Bureau of Statistics has published population projections for all of the communities in Nunavut for the period 2014 to 2035. This data indicates an annual population growth rate of 1.5%. This rate of population growth has been used to extrapolate the population projection to the end of the design period in 2041. This population estimate is presented in Table 3.1 of this report.

3.2 Water Consumption

The *Water and Sewage Facilities Capital Program Standards and Criteria* (July 1993) provides criteria for the estimation of water consumption. For communities that make use of trucked water and sewage services, the base residential water consumption rate (RWU) is assumed to be 90 litres per capita day (l/c/d). In addition, an allowance must be made for non-residential water uses such as commercial, institutional and industrial demands. The total community water use per capital (PCC) is estimated using the following formula.

PCC = RWU (1.0 + 0.00023 x Population) – for populations of less than 2,000

PCC = RWU (-1.0 + 0.323 x ln(Population)) – for populations between 2,000 and 10,000

Where: PCC is per capita consumption, and

RWU = 90 litres per capita-day

The estimated water demand over the design of this project is summarized in Table 3.1.

Table 3.1 - Population and Water Consumption Estimate

Year	Population	Water Consumption			
		RWU (L/capita/day)	**PCC** (L/capita/day)	**Average Day Consumption** (L/day)	**Annual Consumption** (m^3)
2021	1,643	90	124	204,000	74,400
2026	1,752	90	126	221,000	80,700
2031	1,838	90	128	235,000	85,900
2036	1,931	90	130	251,000	91,600
2041	2,042	90	132	270,000	98,600

3.3 Wastewater Treatment Design Criteria

The Hamlet, serviced by a trucked water distribution and wastewater collection system, tends to result in lower water use per capita (and lower wastewater volume generated per capita). The "per capita" contribution of BOD and TSS would be expected to be similar as in the southern part of the country (which will result in higher concentrations). Flow and loading criteria would be as follows:

Flow	270,000 L/d (trucked over an 8-hr day) – Equalization is required
Influent BOD	163.4 kg/d (equivalent to 605 mg/L)
Influent TSS	183.8 kg/d (equivalent to 680 mg/L)

3.4 Effluent Requirements

The Guidelines for the Discharge of Treated Municipal Wastewater in the Northwest Territories (NWT Water Board, 1992) provide some direction regarding required effluent quality. These guidelines provide a maximum BOD of 120 mg/L and a maximum TSS of 180 mg/L for discharges into a marine environment with flow falling in the range of 150 to 600 litres per capita day. This flow criterion is felt to be appropriate as lagoon alternatives as discharged is performed on a seasonal basis over a short period of time.

In those instances where discharge is less than 150 litres per capita per day the 1992 guidelines provide a maximum BOD of 100 mg/L and a maximum TSS of 120 mg/L. These criteria would be applicable to alternatives with discharge throughout the year, such as mechanical treatment processes.

3.5 Climate

Climatic data for Cape Dorset was obtained from the Canadian Climate Normals. The following information is drawn from the Normals for Cape Dorset.

- Annual average daily temperature: -8.9^{o}C
- Average daily temperature for February: -25.4^{o}C
- Average daily minimum temperature for February: -28.7^{o}C
- Lowest observed temperature (December 30, 1971): -42.8^{o}C
- Average wind speed: 17.8 km/h
- Maximum hourly wind speed: 109 km/h

The annual average temperature indicates that Cape Dorset is situated in a region of continuous permafrost. The lowest observed temperature suggest that freeze prevention methods must be functional to -43^{o}C.

4 Alternatives

4.1 Introduction

The following alternative methods of providing wastewater treatment for Cape Dorset have been considered.

- Rehabilitate P Lake
- Lagoon on new site
- Mechanical treatment

The alternative of rehabilitation of P Lake requires that several issues be addressed. These include the provision of a water retaining structure capable of managing the projected wastewater generation over the design period of 20 years. The examination of this alternative must consider the questions of providing a safe and reliable method of conveying sewage to the lagoon.

The evaluation of the alternative of the provision of a new lagoon on a new site must identify an appropriate site and define the scope of works required on that site. As a first step, a review of constraints such as zoning, topography, setbacks from housing and airport issues must be undertaken. Following the identification of a site, the scope of works required to develop that site can be developed.

The alternative of mechanical treatment entails the application of some biological, chemical or physical process to enhance wastewater prior to discharge. The evaluation of this alternative requires the selection of a treatment process that is suitable for application in Cape Dorset, definition of the scope of works required to support this process, and the identification of a site for this facility.

4.2 Rehabilitate P Lake

4.2.1 P Lake Lagoon Description

The site for the P Lake sewage lagoon was identified in a 2001 study by Dillon Consulting (Dillon 2001) as Site P. Site P was described as a small lake located to the south of the community at the top of a steep rock face. The site was originally discounted on the basis of a high development cost associated with the construction of the access road and the steep grades and rock excavation requirements. In 2003, Dillion Consulting were retained to evaluate the alternative for providing sewage treatment for the Hamlet. This study compared the alternative of a mechanical plant to the development of a sewage lagoon at Site P. Provision of a lagoon at P Lake was the preferred alternative.

The P Lake lagoon was created through the construction of a 5 m high gravel berm with a bentonite geomembrane keyed into the rock below the berm at one side of a natural valley. Rock escarpments on the other sides of the lagoon form a natural impervious barrier for the remaining sides of the lagoon. The rock escarpments and the bentonite liner frozen into the subsurface below the berm were intended to act as the containment mechanism. The sewage lagoon also included an outlet structure comprising of a pipe through the berm with a valve chamber in the middle of the berm. A truck discharge location was created on the eastern side of the sewage lagoon. An access road to the berm for maintenance and operation was provided along the northern escarpment of the sewage lagoon.

Access to the P Lake sewage lagoon site is by a 920 m long access road which includes a short radius switchback.

4.2.2 Summary of Lagoon Requirements

Section 3 of this report presents the service conditions that a rehabilitated lagoon must satisfy, including served population and estimated sewage production. A rehabilitated lagoon system at the P Lake site must accommodate the annual sewage production, which is estimated at 98,600 m^3. In addition, an allowance for runoff that cannot be redirected away from the lagoon is required. For the purposes of this study it will be assumed that effluent criteria, as presented in section 3.4 of this report, are applicable.

4.2.3 Current Status

The lagoon at the P Lake has not been placed in service due to issues with leakage of the berm and safety concerns relating to the access road. Nunami Stantec prepared a report entitled *Cape Dorset Sewage Lagoon Feasibility Study* (Stantec 2015). This report provides a feasibility study for the rehabilitation of the P Lake sewage lagoon. The feasibility issues examined included both the provision of a sewage lagoon on the site and the conveyance of sewage to that lagoon.

Issues identified with the P Lake sewage lagoon in the Stantec 2015 report include:

- There was leakage through the western berm, which was confirmed through a dye tracer study.
- Community concerns have been expressed regarding potential seepage through the side of the lagoon towards the Town.
- The lagoon drawdown pipe and control valve is susceptible to freeze.
- Surface runoff from precipitation and from spring snowmelt may enter the lagoon reducing the available storage.
- Water from the active layer of the soils surrounding the lagoon may drain into the lagoon and reduce available storage.
- Wind disbursement of sewage at the truck discharge location is possible due to the orientation of the discharge chute relative to the predominant winter winds.
- The Hamlet also expressed concerns with regards to leakage from the P Lake lagoon contaminating the potable water supply at T Lake. This issue was resolved when it was determined that the water source lake is higher in elevation than the P Lake site.

There are issues with the conveyance of sewage to the lagoon site arising from the access road. Stantec 2015 noted the following concerns with the access road:

- The road is steep with road grades in excess of 8%
- The road is narrow with a driving surface of 7.5 m
- The road has an unsafe hairpin turn (switchback)
- The road experiences erosion during spring melt
- The road experiences snow drifting issues in the winter
- Visibility along the road is poor at times after dark

Safety concerns were also expressed with regards to the service road along the lagoon berms. These concerns include the following:

- Steep slopes on the south east section

- Erosion caused by spring runoff

Stantec 2015 examined repairs to the existing including sealing of leaks and drainage improvements. There is a significant concern that the methodology proposed to seal the berm will not yield a water-containing structure. It is also noted that improvements to the existing lagoon will not provide sufficient volume to meet the requirements noted above. For these reasons, a program that is limited to improvements to the existing lagoon will not be carried forward for further consideration.

4.2.4 Lagoon Rehabilitation and Expansion

The Stantec 2015 report presents two options for rehabilitation and potential expansion for the wastewater system. They include:

- Containment berm reconstruction
- Construct secondary treatment cell

The option of containment berm reconstruction includes:

- Deconstruction of the existing sewage lagoon berm
- Stockpiling the existing granular material
- Removal of the vertical geomembrane
- Sealing the subgrade to ensure any leaks through the subgrade material have been addressed
- Reconstruction of the berm including the addition of a new impervious liner, similar to the original design

Under this alternative, the capacity of the sewage lagoon could be increased marginally through either increasing the height of the berm or relocation of the berm. This option provides some potential for increased capacity. The new design horizon leads increased population and flow requirements. It is highly unlikely that all runoff could be diverted from the facility. Based on these two issues, it is unlikely that this option will provide sufficient additional capacity to meet the Hamlet's requirements for the design horizon of 2041. The alternative that is limited to reconstruction of the existing berm will not be retained for further consideration.

The proposed construction of a secondary treatment cell would include the construction of a new berm to the west of the existing P Lake lagoon creating a second cell. It is proposed in Stantec 2015 that much of this granular material will be obtained from the existing berm. This would reduce the overall capacity of the existing cell but the volume of the new cell would more than offset this loss. Sufficient capacity to meet the long-term requirements of the Hamlet can be provided.

This option will be carried forward for further consideration as it appears to have the potential to meet the requirements of the project.

4.2.5 Sewage Conveyance Improvements

4.2.5.1 Introduction

Stantec 2015 presents two alternative methods for conveyance of sewage to the lagoon site.

- Reconstruction and realignment of the access road

- Provision of a sewage lift station.

4.2.5.2 Access Road Improvements

Stantec 2015 noted the existing road is deficient in the gradient through a hairpin curve, radius for a hairpin curve and recommended carriageway width. For the purposes of this feasibility study, options that approach the Transportation Association of Canada (TAC) guidelines will be considered.

The Stantec 2015 examines a total of five road improvement alternatives. The alternative, described as Option B3, seemed closest to meeting the TAC guidelines. The guidelines are not fully satisfied and the capital cost of this scheme is estimated at $6.3 million, with a further allowance of $1.2 million for snow sheds, should such be provided.

The concept of sewage conveyance through road improvements will not be carried forward because a road suitable for safe all-season movement of sewage collection trucks cannot be provided.

4.2.5.3 Provision of a Sewage Lift Station

The concept of a lift station to convey sewage to the lagoon has been developed in Stantec 2015. The scope of the required works includes a sewage reception facility, sewage storage tank, pumps and a forcemain. It was proposed that the forcemain drain back to the lift station at the end of each pump cycle as a means of reducing the risk of freeze. The cost of a lift station and forcemain was estimated at $6.1 million.

The concept of a lift station is, upon initial view, attractive as this scheme resolves the requirements for a road that is suitable for sewage haul trucks. On closer examination, some serious concerns arise, especially with regards to the risk of freeze of the forcemain. Various scenarios can be postulated that represent a risk of freeze. The forcemain piping will cool towards ambient temperature between pump cycles. There are instances, such as following a weekend, or following a blizzard when the forcemain would be out of service for a long period, thus leading to very low piping temperature. The only source of heat to rewarm the piping is the pumped sewage. The initial portion of the sewage pumped through the forcemain would be continuously cooled by the piping. The modest quantity of heat energy found in the first portion of the pumped flow would not be sufficient to warm the full length of the piping to above the freeze point. It is likely that there will be sufficient heat loss from the sewage to cause freeze. This would, in turn, cause the freeze of a substantial portion of the forcemain. This suggests that some active form of freeze prevention should be considered.

The risk of freeze can be reduced by pre-heating the piping prior to pumping sewage. This is the strategy that has been used to maintain the serviceability of the water supply pipeline in Cape Dorset. The only practical method for pipe preheating involves electrical heat tracing. Installation of the heat trace within the piping is attractive from a thermodynamic point of view, but there are some substantial technical and reliability challenges with this approach. Placement of the heating cable in a channel bonded to the exterior of the HDPE piping and fully contained within the insulation system is a technically simpler approach. The reliable maintenance of the piping above freezing will likely require continuous operation of the heat trace for 8 or 9 months annually.

One notable feature of the lift station and forcemain concept is the vulnerability, from a freeze point of view, due to single point failure. Some examples of potential failures that could cause freeze include:

- Failure of a portion of the heat trace cable
- Failure of the drain mechanism

- Loss of electrical supply to the heating cables
- Lack of available volume in the sewage storage tank to accommodate drainage of the forcemain

It is likely that freeze of the forcemain will occur, on occasion over the life of the facility. This is consistent with the experience with the water supply pipeline. This would require thawing of the frozen portion of the forcemain and resolution of the cause of freeze prior to a return to service. During the interim, the sewage alternatives available to the community are truck haul to the P-Lake lagoon or disposal at some other site. History suggests that truck haul to the P-Lake lagoon would be very unlikely.

The equipment within a lift station would include piping, valves, heating and ventilation, and freeze prevention equipment for the sewage held in the storage tank. A system of automated controls would be necessary. All of this mechanical, electrical and control equipment would require staff training, ongoing maintenance and ongoing support to the local staff.

In summary, the alternative of a sewage lift station reduces the need for an access road that is suitable for sewage trucks. Provision of a robust and reliable freeze prevention scheme for the forcemain would present a significant technical challenge and occasional freeze of the forcemain in this scenario is likely. The lift station would represent a somewhat complex facility requiring ongoing operation attention. At this juncture, the alternative of provision of a sewage lift station will be retained, despite the concerns regarding technical feasibility. It is noted that the failure of the lift station due to forcemain freeze will likely arise over the life of the facility. On this basis, an alternative location for the disposal of sewage must be available should this alternative be implemented.

4.2.6 Summary

The project concept of rehabilitation of the P Lake lagoon represents two broad areas of activity; provision of a suitable lagoon; and, provision of a suitable method for the conveyance of sewage to the lagoon. Various schemes for the rehabilitation of the sewage lagoon have been evaluated. The only scheme that will provide both the required volume and water containing berms entails the rehabilitation and expansion of the existing lagoon. The preferred method of conveying sewage to the lagoon appears to be a sewage lift station. It is noted that there are significant technical challenges associated with freeze protection for the forcemain, and that freeze on an occasional basis is likely. Provision of a sewage lift station will not set aside the requirements for road improvements as continuing road access is necessary for maintenance, repairs and sampling.

4.3 Lagoon at New Site

4.3.1 Introduction

As is noted in Section 2 of this report, considerable effort has been invested in the efforts to identify a suitable site for a wastewater lagoon. These efforts lead to the selection of P Lake as the best alternative site. A facility has been developed on this site. This existing lagoon has not been placed into service due to leakage and access issues. The leakage could likely be resolved through efforts such as the reconstruction of the berms. This would not resolve the concerns relating to access and conveyance of sewage to the lagoon. Improvements to lagoon access are expected to be costly and it is anticipated that the safety concerns related to access cannot be fully resolved. This indicates that there is merit in examining the possibility of the identification of a site for a new wastewater lagoon.

4.3.2 Site Requirements

A site for a new wastewater lagoon must be sufficient in size and have appropriate topography. The following parameters have been used to develop an initial estimate of the required lagoon footprint.

- Storage volume for the annual sewage generation of 98,600 m^3 must be provided.
- The lagoon must provide 1 m of sludge storage, 2 m of working depth and 1 m of freeboard.
- Lagoon berms must have a minimum top width of 4 m.
- Internal and exterior berm slopes will be 3:1.

Based upon the above, a footprint of 200 m square is required to provide the necessary storage. This estimate incorporates the assumption that there will not be a requirement of accommodate surface drainage into a lagoon. It is further assumed that precipitation and evaporation will be comparable in volume.

The feasibility of the development of a lagoon on a site is strongly impacted by site topography. Site gradients should be less than 5%, and the maximum feasible site gradient is 10%.

4.3.3 Constraints Map

4.3.3.1 Introduction

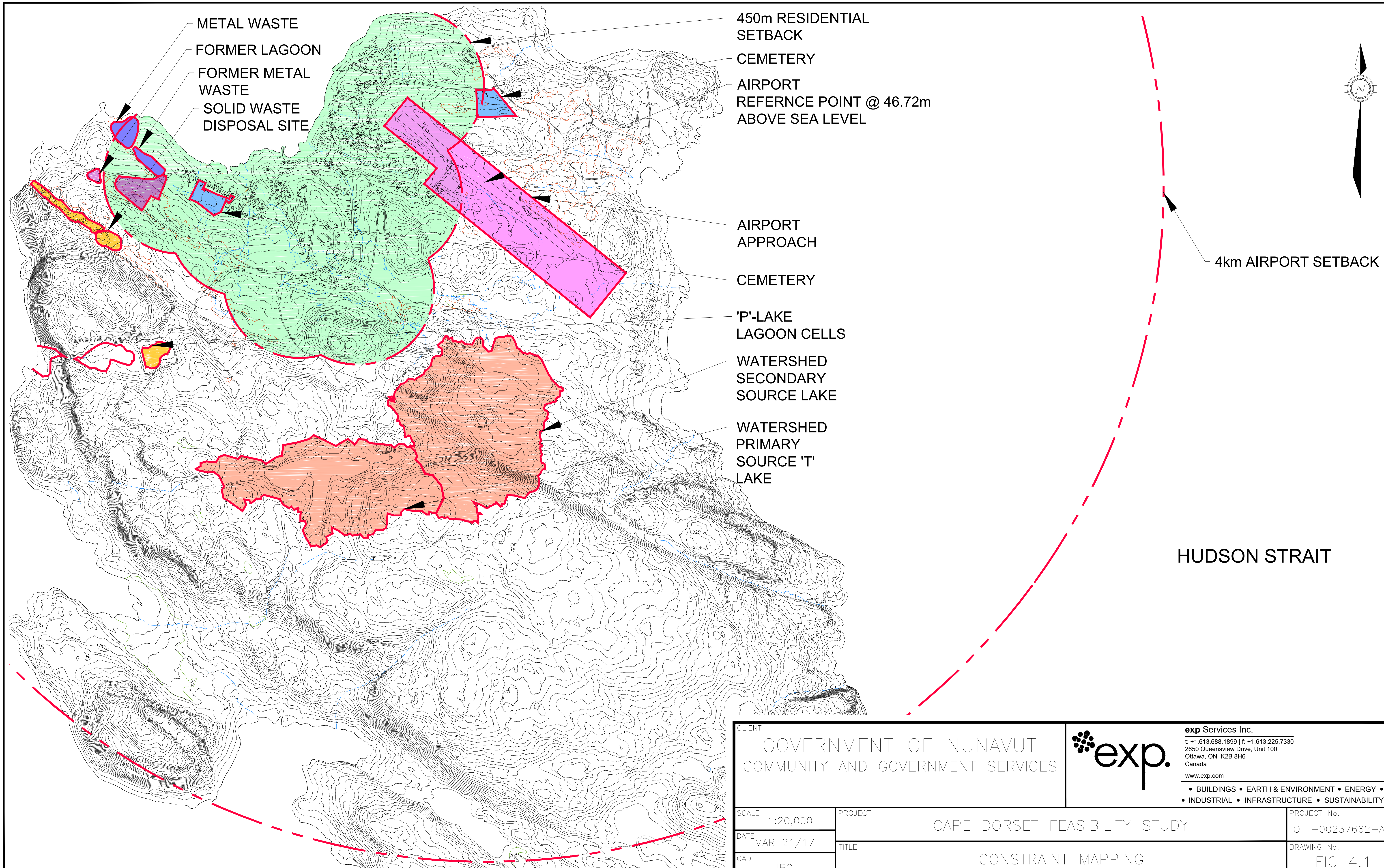
A constraints map was developed to identify those locations in the community where it is not appropriate to develop a new wastewater lagoon. Various sources of information have been consulted during the preparation of this constraints mapping.

4.3.3.2 Community Mapping

The GN Community Data Base Mapping was used as the map base for the preparation of the constraints map. This mapping illustrated, among other features, topography and the road network. This mapping has provided the base for Figure 4.1 of this report.

4.3.3.3 Community Topography

The community base mapping provides contour information. From a review of this contour information, it has been determined that the developed area of the Hamlet represents all the land area that is accessible from the road network and that meets the maximum site gradient requirements identified early.



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exp Services Inc.
t: +1.613.688.1899 | f: +1.613.225.7330
2650 Queensview Drive, Unit 100
Ottawa, ON K2B 8H6
Canada
www.exp.com

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4.3.3.4 Cape Dorset Community Plan

The Community Plan, which was prepared in 2013, presents the development intents of the community to the year 2033. Schedule 1 of the Community Plan illustrates the locations of various land uses within the community. Of specific interest is residential development, as this is the land use with the greatest potential impact from a wastewater lagoon. Figure 4.1 illustrates the area that has been designated for residential use.

4.3.3.5 General Sanitation Regulations

The General Sanitation Regulations (RRNWT 1990, c.P-16) of the Public Health Act stipulate no building used for human habitation shall be nearer than 450 m to a waste disposal ground. The setback limit from residential land use is illustrated on Figure 4.1.

4.3.3.6 Water Supply Watershed

A mapping of the water source watershed was conducted by the Geological Survey of Canada on 2010 with the assistance of members of the community and CGS staff. This mapping exercise was conducted for T Lake(the normal water source) and Q Lake (the emergency water source lake). The limits of the watershed for both these lakes are illustrated on Figure 4.1.

4.3.3.7. Airport Zoning

The Cape Dorset Zoning Regulations are presented in SOR/2012-98. These regulations apply to lands that fall within a 4,000 m radius from a location described as the, "Airport reference point." The regulation stipulates, "A person must not use or permit another person to use any of the lands for activities or uses that attract wildlife - particularly birds - that may create a hazard for aviation safety." The zoning regulation would require the demonstration that a wastewater lagoon is not an attractant for birds that may be a risk to aviation. The limits of the applicability of the airport zoning are depicted on Figure 4.1.

4.3.3.8 Constraints Mapping Findings

The constraints mapping did not identify areas around the community that were suitable for development of a new wastewater lagoon. It is also noted that the existing three tier lagoon falls outside the setback limits of 450 m from residential development. This site falls within the area that is subject to the airport zoning requirements.

4.3.4 Summary

Development of a new wastewater lagoon requires the identification of a site large enough to accommodate a lagoon footprint that is approximately 200 m square. Following the preparation of a constraints map, it was determined that such a new site could not be identified within the area surrounding the community.

The constraints mapping indicates that the site, which is described as the three-tier lagoon site, meets the setback requirements from residential development. This site would be subject to the requirements of the airport zoning. This zoning issue would require demonstration that a lagoon is not an attractant for birds. Upgrading the three-tier lagoon will be retained for further evaluation of the feasibility of this alternative. Continuous accessibility of this site is expected to be reliable. Thus, it is not anticipated that an alternative or emergency sewage disposal site will be required.

4.4 Mechanical Treatment

4.4.1 Introduction

Mechanical wastewater treatment plants make use of various physical, chemical or biological processes to enhance wastewater quality prior to discharge. One feature of mechanical treatment is the ongoing discharge of treated effluent throughout the year. This leads an effluent discharge rate of less than 150 litres per capita. This discharge rate results in effluent criteria of BOD less than 100 mg/L and TSS less than 120 mg/L. Based on typical effluent strength for wastewater on a trucked system, these effluent criteria would require removals of approximately 85% of both BOD and TSS.

Mechanical treatment processes can be broadly categorized into those that make use of physical-chemical methods and those that incorporate a biological process.

4.4.2 Physical Chemical

One form of mechanical treatment that was considered is the physical-chemical process (also known as chemically enhanced primary treatment - CEPT) where, through chemical addition (metal salts and/or polymers), primary sedimentation is "enhanced". CEPT would likely achieve the TSS effluent requirements; however, it is doubtful that it could achieve an effluent BOD ≤100 mg/L. At best, a physical-chemical process could achieve 55-60% BOD removal whereas the removal must exceed 85-90% to result in an effluent BOD of 100 mg/L or better to satisfy the Nunavut Water Board.

The primary advantage of the CEPT process is lower power consumption compared to processes that depend upon a biological process.

The disadvantages of the CEPT process include:

- The requirement for transportation and appropriate storage of the various chemicals; and
- The sludge produced would be highly organic in nature and could pose a vector and odour problem.

Success with a physical-chemical process requires appropriate attention from the operator. Operator activities would include:

- Maintenance of mechanical equipment
- Effluent testing and adjustment of chemical dosing
- Management of the sludge generated by the process

In view of the inability of these processes to meet the anticipated BOD removal requirements, physical-chemical treatment will not be retained as an alternative for further evaluation.

4.4.3 Biological

The viable alternative for a mechanical treatment system is to consider secondary treatment. Generally, there are two forms of secondary treatment; fixed-film and suspended growth.

4.4.3.1 Fixed Film

In a fixed-film system, the biomass is grown on a media. A common fixed-film system is the rotating biological contactor (RBC). However, the RBC, like many of the fixed-film systems, operate best if they are preceded by a raw-solids removal process. Having to manage raw solids can be problematic due to odour generation and the volume of solids requiring handling. As well, a previous RBC-style installation in the north did not perform well and was eventually replaced. Fixed-film technology would not be recommended for this application.

4.4.3.2 Suspended Growth

A suspended-growth system is best defined by a typical activated sludge system. The biomass (micro-organisms) that provide the treatment are kept in suspension in a bioreactor through the energy provided by an aeration system and/or mixing system.

There are several variations of suspended growth processes including conventional activated sludge, extended aeration, sequencing batch reactors and membrane bioreactors. The primary differences between the various approaches to suspended growth processes are how waste solids are removed from the final effluent and whether the flow through the system is continuous or in a batch mode.

For municipal wastewater, the conventional activated sludge system has provided good quality treatment for decades. Conventional activated sludge incorporates an aeration tank for the suspended growth process, and a separate gravity clarifier for separation of the biomass from the effluent stream. Primary treatment is highly desirable for some variations of the activate sludge including the MBBR process. Considering the need to provide year-round protection of the process due to the harsh winters, the system should have as small a footprint as possible. Avoidance of process variations that incorporate primary treatment will reduce the required footprint. Avoidance of primary treatment also sets aside the issues associated with the management of unstabilized primary residuals (sludge), including odour both at the plant and at the disposal site. A variation on the conventional activated sludge that achieves a small footprint is the Membrane Bioreactor (MBR). This process uses a very fine pore filtering system to separate the solids from the final effluent as opposed to using gravity settling in a separate clarifier. As an additional benefit, the mixed liquor suspended solids concentration for this process is double or more than is typical of most activated sludge process variations. This results in a smaller footprint due to the high mixed liquor concentration.

Another benefit of the MBR is that it provides positive solids separation from the final effluent. Proper solids management is paramount to good wastewater treatment. If the conventional activated sludge process is not managed properly, solids can be lost via the secondary clarifier(s), which will result in high TSS in the final effluent. As well, if this loss is not contained, it can negatively affect the treatment process.

The MBR process, which is resistant to upset, can achieve the required effluent performance, including BOD, TSS and acute toxicity requirements. This performance is achieved in a footprint that is smaller than other processes, including SBR.

The evaluation of mechanical treatment is conceptual, at this time. The choice of the MBR process, at this time, will provide a conservative opinion regarding costs. The question of treatment process technology will be examined in greater detail, should mechanical treatment become the selected alternative, and should CGS advance into design of a facility.

4.4.3.3 Summary

A suspended growth process that makes use of the MBR process is the recommended alternative method for the provision of mechanical wastewater treatment. This recommendation is based upon performance, small footprint and resistance to process upset.

4.4.4 Operating Requirements

A mechanical treatment system will require more operational resources than a lagoon system, which is the current treatment. Labour, power, maintenance, consumables (e.g., chemicals), technical support, will be required if a mechanical treatment system is constructed.

An operator for any mechanical secondary wastewater treatment system should have the following attributes/capabilities:

- Working knowledge of wastewater treatment plant operation and maintenance
- Good mechanical aptitude
- Good math skills
- Safety oriented
- Good verbal and written communication skills
- Ability to troubleshoot
- Capable of collection and analysis of samples throughout the process

There is the potential for the disruption of sewage treatment due to equipment failures. This risk is usually mitigated through the use of parallel process trains. And the provision of process bypass. These measures obviate the need for an alternative wastewater disposal site.

4.4.5 Description of Preferred Process

Summary of physical works required to implement this process.

4.4.5.1 Building

A building will be required to contain the process and associated equipment. This building can be pre-engineered, prefabricated modules or site constructed. If possible, the process could be fabricated and installed in multiple shipping containers with the containers “assembled” into a treatment facility. Note that containers should be “stacked”.

4.4.5.2 Process Train

The proposed mechanical treatment system would consist of the following treatment processes:

- Truck unloading station
- Coarse and fine screening
- Equalization with pumping to the bioreactor
- Bioreactor
- Membrane tanks
- An appropriate form of disinfection, should the need be established during the course of design
- Chemical systems (as required for pH control, membrane maintenance, etc.)
- Solids management and dewatering

4.4.5.3 Equalization

The addition of an equalization tank would result in a smaller treatment facility. Without equalization, the system would have to be sized to treat the flow as it is unloaded from the trucks. It is anticipated that sewage will be delivered to the plant over an 8-hour period. Equalization would allow treatment to be extended over a 24-hour period resulting in a system approximately one-third the size. The MBR is also better suited for the stop-start nature of the trucked flows and where there can be no-flow days due to inclement weather.

4.4.5.4 Residuals Management

The waste solids generated by a treatment system must be managed. This includes dewatering and disposal. The need for the disposal of waste solids is anticipated to occur less frequently that weekly. The only viable alternative for ultimate disposal of dewatered residuals is land filling. Disposal of waste solids at the landfill is not currently anticipated to lead to substantial concerns, such as odours, as the landfill is sufficiently distant from the residential area of the community. Issues relating to residuals disposal will require careful consideration, should this alternative be advanced into design.

4.4.5.5 Location

It is currently anticipated that the mechanical treatment system would be located adjacent to the existing lagoon site. This will allow the continued use of the existing outfall into Telik Inlet.

4.4.5.6 Site Requirements

The site requirements will generally depend on the final location chosen. The geotechnical nature of the site will dictate the required type of foundation. Alternatives could include thermosyphons, piles or foundation on bedrock.

The site should allow easy access by the large wastewater hauls trucks into and out of the site. Power, in the form of 575 VAC, 3 phase, 60 Hz supply, must be readily accessible.

5 Alternatives Evaluation Scheme

5.1 Introduction

Prior to undertaking the evaluation of the alternatives, a scoring and weighting scheme was developed. This scheme was reviewed with CGS prior to the assessment of the alternatives.

The evaluation scheme examines the three broad areas of technical performance, economic efficiency and community acceptance. Several issues were considered within each of these broad areas, scores were assigned and weightings were applied to those scores. The following sections examine the issues that were considered during the evaluation of the alternatives.

5.2 Technical Performance

The examination of technical performance considered the ability to meet effluent requirements, both in the short and long term, and the effort required to achieve that level of performance. Section 3.4 of this report provides effluent criteria. These criteria represent a minimum level of performance that must be achieved. On this basis, effluent performance at commissioning is considered to be a pass-fail requirement. Alternatives will not receive further consideration if effluent requirements are not met.

Water licences are typically issued with a life of five years, which is much shorter than the design life of wastewater treatment facilities. Thus, there is the potential for changing performance requirements over the life of the facility. The vulnerability to potential changes in performance requirements has been examined. A weighting of three has been applied to this parameter recognizing, on one hand the uncertainty, while also considering the vulnerability should this eventually arise.

The need for the management of wastewater will continue after the end of the design life of the alternatives. There will be an eventual need to provide additional capacity. The ease of this expansion has been considered. A weighting of five has been applied to this parameter in recognition of the inevitability of this requirement, while also recognizing that this need will arise at least 20 years in the future.

Success of all of the alternatives requires appropriate operation. The effort required to achieve suitable performance has been considered. This assessment considers the amount of operator attention and the level of operator required capabilities and training. A weighting of seven has been applied to this parameter.

Treatment technologies that have been successfully applied in the Arctic represent a lower risk to the GN. A weight of seven has been applied to this parameter.

5.3 Economic Efficiency

Provision of an appropriate scheme for wastewater management for Cape Dorset will represent a substantial investment as well as a need for ongoing operating expenditures. Capital cost is an important consideration as CGS must fund the project out of the short-term budget, in an environment of many competing obligations. A weight of ten has been applied to capital cost.

There are risks of unanticipated expenditures over the life of the alternatives. An example of such a need is the response to an unanticipated failure. The evaluation of the risk of unanticipated spending has considered both the likelihood of such need and the potential costs. A low weight of three has been applied to this parameter as a reflection of the unreliability of this estimate.

Life cycle cost has been calculated using the present value of the estimated capital and operating expenditures required over the life of the project. A high weight of ten has been applied to this parameter as in recognition of the merits of alternatives that are economically efficient over the long term.

5.4 Community Acceptance

Concerns have been expressed by the community in relation to recent efforts to provide access to a lagoon at P Lake. Many of these concerns centered on road maintenance, snow removal and worker safety while performing these tasks. These concerns have been incorporated into the evaluation scheme from the perspective of the acceptance of the community of these maintenance issues. The question of the added effort required of the Hamlet to maintain access to the facility has been considered. A weight of six has been applied to this parameter.

Worker safety concerns have been considered. Issues that were considered include worker risks at the facility, safety concerns due to access to the site and the potential need for extended periods of work under harsh weather conditions. The highest weighting of ten has been applied to the question of worker safety.

There is a potential for nuisance to the community arising from the operation of the wastewater facilities. Potential issues include odours emanating from the site, as well as inconvenience at other locations in the community, such as the landfill site. A weight of six has been applied to this parameter.

5.5 Summary

The parameters, scoring scale and weights for each parameter are presented in the following table 5.1.

Table 5.1 - Alternatives Evaluation Scheme

Parameter	Scoring Scale	Score	Weight	Weighted Score
Technical				
Effluent at commissioning	Pass/Fail	Pass	N/A	
Vulnerability to changing criteria	1-10		3	
Ease of capacity expansion	1-10		5	
Required operating effort	1-10		7	
Previous success in the Arctic	1-10		7	
Financial				
Capital cost	1-10		10	
Risk of un-anticipated expenditure	1-10		3	
Life cycle cost	1-10		10	
Community Acceptance				
Access maintenance burden	1-10		6	
Worker safety	1-10		10	
Nuisance	1-10		3	
Total				

6 Rehabilitation of P-Lake Lagoon

6.1 Technical Performance

6.1.1 Effluent Performance at Commissioning

It is fully anticipated that a rehabilitated P-Lake lagoon will meet the effluent requirements presented in section 3.4. Thus, this alternative is retained for further evaluation.

6.1.2 Vulnerability to Changing Criteria

It is unlikely that more demanding effluent requirements can be achieved by this alternative without subsequent treatment in a wetland. There will be very limited space for any downstream wetland following expansion of the existing lagoon to provide storage to the end of the design period. Thus, it is unlikely that this alternative can meet more challenging criteria, should this requirement arise in the future. On this basis, a score of three has been applied for this parameter.

6.1.3 Ease of Expansion

Expansion of treatment capacity will be challenging and costly. Due to local topography, site areas are limited. A future increase in lagoon volume would require, as a minimum, the construction of a new watertight berm. In view of the limited potential for expansion and the large effort required, a score of four has been assigned for this parameter.

6.1.4 Operating Effort

One notable feature of lagoon based alternatives is the modest operating requirements. Operational efforts are generally limited to pump operation for lagoon decanting, sampling and berm surveillance. The proposed lift station and forcemain represents a degree of technical complexity that has not been previously incorporated into a lagoon system. Ongoing operation of the lift station would be automated, but the operators must be trained to manage departures from routine operation. Inappropriate response to unusual situations could have very undesirable outcomes, including freeze of the forcemain. A score of five has been assigned to this parameter.

6.1.5 Previous Experience in the Arctic

With regards to previous application in the Arctic, lagoon based wastewater treatment systems have been successfully applied in most communities in Nunavut. This installation would represent the first application in Nunavut of a lift station for truck hauled sewage. The largest operational risk with this lift station is freeze of the forcemain. Freeze of the forcemain will likely occur at some point over the operating life. Substantial effort and cost would be required to resolve a frozen forcemain. A score of four has been applied to this parameter.

6.2 Financial

6.2.1 Capital Cost

A capital cost estimate for this alternative has been developed by Altus Group and this estimate is attached as Appendix A to this report. This estimate may be summarized as follows:

- Site Works $5,623,000
- General requirements, freight and accommodations $2,609,000
- Contingencies $1,264,000
- **Total** **$9,496,000**

Rehabilitation of the P-Lake lagoon is the second most costly alternative with a capital requirements that is approximately 30% higher that the least costly alternative. On this basis, of score of seven is assigned for capital cost.

6.2.2 Risk of Unanticipated Expenditure

The most likely reason for the need for unanticipated spending for this alternative is leakage from a lagoon cell. The current lagoon and P-Lake has exhibited leakage, and the cause of this leakage has not been definitively determined. Suitable pre-design investigations, careful design and appropriate control during construction will mitigate this question, but not eliminate this risk.

The alternative of the rehabilitation of P-Lake includes the conveyance of wastewater with a lift station. There are serious concerns regarding the long-term reliability of this approach due to the risk of freeze of the forcemain. It is anticipated that the forcemain will freeze on more than one occasion over the life of the facility. There is no method to predict when such freeze will take place.

In view of both the history, potential risk and the impossibility to predict the frequency a score of three is applied for this parameter.

6.2.3 Life Cycle Cost

The evaluation of life cycle cost captures the capital cost presented in section 6.2.1 above, together with the estimated operating costs over the life of the facility.

The operation of a rehabilitated lagoon at P-Lake entails three groups of activities: lagoon operation, road maintenance and operation of a lift station and forcemain. Regarding the operation of the lagoon element of the system, the following annual expenditures are anticipated.

- Sampling and analysis $3,000
- Decanting (fuel and operation) $30,000
- Geotechnical inspection $15,000
- Minor repairs $10,000

Access to the lagoon is required for sampling, decanting, site inspection and berm maintenance. This requires, as a minimum that the existing road remain usable over the summer season. An annual allowance of $30,000 for gravel, grading and drainage maintenance is proposed. This is comparable to the allowance of summer maintenance presented in the 2015 feasibility study. It has been assumed that the use of a lift station will set aside the need for winter access. On this basis, it has been assumed that there will be no requirements for winter road maintenance.

Estimates have been developed for lift station operation. Included among these costs are building heating and ventilation and building maintenance. The following allowances are proposed for these items.

- Building HVAC $40,000
- Building maintenance $40,000

The above allowances are consistent with the 2015 feasibility study.

An estimate of the electrical power costs has been developed. This estimate is based upon the following assumptions.

- Annual volume pumped of 86,000 m^3 based upon facility mid-life capacity requirements.
- Total dynamic head for the pumping equipment of 100 m.
- Pumping efficiency of 60%.

It has been proposed, in the feasibility study, that the forcemain be protected from freeze through draining at the end of each pumping cycle to the lift station. The estimated volume of the forcemain is larger than the volume of a sewage collection truck. The quantity of sewage that will be pumped during each cycle is dependent upon a list of factors including forcemain size and length, storage volume at the lift station, number of trucks delivered prior to each pump cycle and pumping rate. Most of these factors cannot be established at this time without considerable pre-engineering effort. For the purposes of the current assessment, it will be assumed that the sewage will be pumped twice.

An appropriate rate for electrical power cannot be precisely defined, at this time. Electrical rates are a combination of consumption and peak demand. The current rate for consumption in Cape Dorset is $0.65 per kWhr. This does not include the peak demand portion. For the purposes of the current assessment it will be assumed that the total cost for electrical power will be $1.00 per kWhr. This cost is consistent with the 2015 feasibility study.

The above assumptions lead to an estimate of annual electrical costs for sewage pumping of $78,000.

The total of the above annual operating costs is $201,000, which is very similar to the amounts presented in the 2015 feasibility study for lift station related items.

It is anticipated that there will be a substantial operating cost associated with the forcemain. Reliable protection of the piping from freeze will require preheating of the forcemain prior to sewage pumping. This is the current operating strategy for the water supply pipeline in Cape Dorset. Despite preheating, the water supply pipeline has experienced some freeze-related challenges. An estimate of the electrical consumption associated with the forcemain has been developed based upon the following assumptions.

- Forcemain length of 1,000 m.
- An electrical heat trace with a capacity of 13.3 W/m will be used.
- The heat trace will operate continually for eight months of the year.
- An electrical rate of $1.00 per kW-hr, inclusive of both demand and consumption charges.

The above assumptions lead to an estimate cost of electrical power for forcemain operation of $76,600.

Based on experience with the existing water supply pipeline in Cape Dorset, freeze incidents are anticipated to take place on an occasional basis. This opinion is reinforced by the observation that the forcemain is vulnerable to various single point failures including heat trace cable failure, loss of electrical power, failure of the drain mechanism and blockage of the piping by foreign objects. It has been assumed that a response to freeze of the forcemain will be required on a once in five year basis and an estimate of the cost of this response has been developed based upon the following assumptions:

- A four man crew will be required for a four week period.
- Manpower and small tools will cost $1,500 per day per person, inclusive of accommodations and meals.
- Equipment costs of $10,000 will arise.
- A mobilization cost of $20,000 will arise.

The above assumptions lead to an estimate of the cost of the response to freeze of the forcemain of $198,000.

It is further anticipated that there may be some requirements for recapitalization following freeze of the forcemain. Examples could include replacement of the heat trace or replacement of damaged piping. It is estimated that this response would be required following each incident and that a spending of $500,000 would be required.

The present value for ongoing operating expenses has been calculated for discount rates of 2%, 4% and 8%. These calculations are presented in Appendix B of this report. The results of these calculations may be summarized as follows.

Table 6.1 - Present Value for P-Lake Rehabilitation

Item	Discount Rate		
	2%	4%	8%
Capital	$9,496,000	$9,496,000	$9,496,000
Operations	$7,680,703	$6,312,295	$4,463,120
Total	$17,176,703	$15,808,295	$13,959,120

The alternative of rehabilitation of the P-Lake lagoon presents the lowest life cycle cost of all of the alternatives. On this basis, a score of ten is applied for this parameter.

6.3 Community Acceptance

6.3.1 Access Maintenance

The community has expressed specific concerns regarding the access road to the P-Lake lagoon and the challenges with maintaining winter access. The use of a lift station will reduce the need for access, but an ongoing need will remain. This need may become especially acute should there be a failure by a freezing of the forcemain. The ongoing need for access and the potential for unanticipated snow removal in response to forcemain failure results in a score of five for this parameter.

6.3.2 Worker Safety

There have been ongoing worker safety concerns relating to the use of the P-Lake lagoon. These concerns include the risks to sewage truck drivers and snow removal equipment operators due to the access road geometry. The incorporation of a lift station will reduce these risks, but a risk will remain, as ongoing access to the lagoon will be required. For these reasons, a score of six has been applied to this parameter.

6.3.3 Nuisance

There is some potential for community nuisance associated with all lagoon-based alternatives. The principle nuisance is odour, especially in the spring. The lagoon is sited more than 500 m from the residential areas of the community. On this basis, is not anticipated that there will be many complaints from residents arising from a lagoon at this site. A score of nine has been applied to this parameter.

6.4 Summary

The scores assigned for each parameter have been incorporated into the evaluation scheme, and the results are presented in the following table 6.2.

Table 6.2 - Evaluation Matrix for P-Lake Rehabilitation

Parameter	Scoring Scale	Score	Weight	Weighted Score
Technical				
Effluent at commissioning	Pass/Fail	Pass	N/A	
Vulnerability to changing criteria	1-10	3	3	9
Ease of capacity expansion	1-10	4	5	20
Required operating effort	1-10	5	7	35
Previous success in the Arctic	1-10	4	7	28
Financial				
Capital cost	1-10	7	10	70
Risk of un-anticipated expenditure	1-10	3	3	9
Life cycle cost	1-10	10	10	100
Community Acceptance				
Access maintenance burden	1-10	5	6	30
Worker safety	1-10	6	10	60
Nuisance	1-10	9	3	27
Total				**388**

7 Three Tier Lagoon

7.1. Technical Performance

7.1.1. Effluent Performance at Commissioning

It is fully anticipated that the Three Tier Lagoon will meet the effluent requirements presented in 3.4. Thus, this alternative is retained for further evaluation.

7.1.2. Vulnerability to Changing Criteria

It is unlikely that more demanding effluent requirements can be achieved by this alternative without subsequent treatment in a wetland. There is no natural wetland downstream of the site, and there is limited space. Thus, it is unlikely that this alternative can meet more challenging criteria, should this requirement arise in the future. On this basis, a score of three has been applied for this parameter.

7.1.3. Ease of Expansion

Expansion of treatment capacity would be challenging due to a lack of site area. All available site area is required to provide sufficient volume to meet needs to the end of the design horizon. A modest further increase in lagoon storage could be achieved by raising the berm height. In view of the limited potential for expansion and the large effort required a score of two has been assigned this parameter.

7.1.4. Operating Effort

One notable feature of lagoon based alternatives is the modest operating requirements. Operational efforts are generally limited to pump operation for lagoon decanting, sampling and berm surveillance. The lagoon site is directly accessible from the Hamlet road system and sewage would be dumped directly into the lagoon. A score of eight has been assigned for this parameter.

7.1.5. Previous Experience in the Arctic

With regards to previous application in the Arctic, lagoon based wastewater treatment systems have been successfully applied in most communities in Nunavut. A score of nine has been applied for this parameter.

7.2. Financial

7.2.1. Capital Cost

A capital cost estimate for this alternative has been developed by Altus Group and this estimate is attached as Appendix A to this report. This estimate may be summarized as follows.

• Site Works	$29,903,000
• General requirements, freight and accommodations	$13,875,000
• Contingencies	$6,724,000
• **Total**	**$50,502,000**

The estimated capital cost for this alternative is seven times higher than the least expensive alternative. On this basis, a score of two has been applied for this parameter.

7.2.2. Risk of Unanticipated Expenditure

The most likely reason for the need for unanticipated spending for this alternative is leakage from a lagoon cell. Suitable pre-design investigations, careful design and appropriate control during construction will minimize, but not eliminate, this risk. On this basis, a score of eight is applied for this parameter.

7.2.3. Life Cycle Cost

The evaluation of life cycle cost captures the capital cost presented in section 6.2.1 above, together with the estimated operating costs over the life of the facility. The following summarizes the operating costs anticipated over the life of the facility.

- Sampling and analysis $3,000
- Decanting (fuel and operation) $30,000
- Geotechnical inspection $15,000
- Minor repairs $10,000

The present value for ongoing operating expenses has been calculated for discount rates of 2%, 4% and 8%. These calculations are presented in Appendix B of this report. The results of these calculations may be summarized as follows.

Table 7.1 – Present Value for Three Tier Lagoon

Item	Discount Rate		
	2%	4%	8%
Capital	$50,502,000	$50,502,000	$50,502,000
Operations	$948,383	$788,239	$ 569,453
Total	$51,450,383	$51,290,239	$51,071,453

The life cycle cost for this alternative is approximately 3 times higher than the least costly alternative. On this basis, a score of 2 has been assigned for this parameter.

7.3. Community Acceptance

7.3.1. Access Maintenance

Operation of the Three Tier Lagoon would require the ongoing maintenance of road access to the site. The effort would represent a small increase the scope of road maintenance conducted by the Hamlet and no unusual challenges are anticipated. On this basis, a score of nine is assigned this parameter.

7.3.2. Worker Safety

As with any lagoon system, safety protocols and some degree of caution, on the part of operating staff, will be required to assure safe operation. This effort associated with worker safety is anticipated to be modest. The required precautions fall within the experience of current Hamlet staff. On this basis, a score of nine has been assigned this parameter.

7.3.3. Nuisance

It is anticipated that there will some odour related nuisance related to the operation of a lagoon at this site. Such nuisance will be confined to the vicinity of the lagoon. There is sufficient separation between the site and the planned residential areas of the community. On this basis, a score of nine has been applied to this parameter.

7.4. Summary

The scores assigned for each parameter have been incorporated into the evaluation scheme, and the results are presented in the following table 7.2

Table 7.2 - Evaluation Matrix for Three Tier Lagoon

Parameter	Scoring Scale	Score	Weight	Weighted Score
Technical				
Effluent at commissioning	Pass/Fail		N/A	
Vulnerability to changing criteria 1	1-10	3	3	9
Ease of capacity expansion	1-10	2	5	10
Required operating effort	1-10	8	7	56
Previous success in the Arctic	1-10	9	7	63
Financial				
Capital cost	1-10	2	10	20
Risk of un-anticipated expenditure	1-10	8	3	24
Life cycle cost	1-10	2	10	20
Community Acceptance				
Access maintenance burden	1-10	9	6	54
Worker safety	1-10	9	10	90
Nuisance	1-10	9	3	27
Total				**373**

8 Mechanical Treatment Plant

8.1. Technical Performance

8.1.1. Effluent Performance at Commissioning

It is fully anticipated that a mechanical wastewater treatment plant will meet the effluent requirements presented in section 3.4. Thus, this alternative is retained for further evaluation.

8.1.2. Vulnerability to Changing Criteria

A mechanical treatment plant will typically provide an effluent of much higher quality than the requirements presented in section 3.4 of this report. On this basis, future changes in effluent performance requirements are not viewed to be a challenge. A score of ten is assigned to this parameter.

8.1.3. Ease of Expansion

Expansion of treatment capacity at the end of the design period would require the installation of additional treatment equipment, together with the construction of tankage, building space and support services. A substantial capital re-investment would be required for these works. The proposed wastewater treatment facilities can be sited to provide space for this future need. In summary, provision of additional treatment is relatively easy to accomplish technically, but significant spending would be required. On this basis, a score of six has been applied to this parameter.

8.1.4. Operating Effort

The ongoing operation of a mechanical treatment plant requires an ongoing effort from the operating personnel. This includes process adjustments to assure effluent quality and mechanical maintenance to assure the continuing operation of the equipment. Thus, operating staff, with appropriate training and access to materials and spare parts, is required to achieve successful operation. The alternative of mechanical treatment is the most demanding alternative that is under consideration for Cape Dorset. In view of the effort required for ongoing operation, training and operator support a score of four has been assigned this parameter.

8.1.5. Previous Experience in the Artic

Mechanical wastewater treatment has been previously installed and operated in Nunavut. The most recent experience is in Pangnirtung. Success was not without challenges, but much has been learned about selection of appropriate processes and required operator support. A score of six has been applied for this parameter.

8.2. Financial

8.2.1. Capital Cost

A capital cost estimate for this alternative has been developed by Altus Group and this estimate is attached as Appendix A to this report. This estimate may be summarized as follows.

• Building and process	$2,970,000
• Site work	$1,231,000
• General requirements, freight and accommodations	$1,949,000
• Contingencies	$945,000
• **Total**	**$7,096,000**

In terms of capital cost, this is the least costly alternative under consideration. On this basis, a score of ten has been applied to this parameter.

8.2.2. Risk of Unanticipated Expenditure

It is anticipated that there will be a low risk of the need for unanticipated spending over the life of this alternative. For this reason a score of nine has been applied to this parameter.

8.2.3. Life Cycle Cost

The evaluation of life cycle cost captures the capital cost presented in section 8.2.1 above, together with the estimated operating costs over the life of the facility. Operating costs estimates have been developed. These estimates draw upon recent experience in Pangnirtung. It has been assumed that two operators will be required. The estimated labour costs include salaries, northern allowance, employer's contribution to CPP and EI, group insurance and WCB. The following summarizes the estimates of operating costs.

• Operating labour	$206,200
• Training	$12,000
• Utilities, other than power	$11,700
• Electrical power	$300,000
• Heating fuel	$140,000
• Building maintenance	$22,000
• Process repairs	$51,500
• Chemicals	$33,700
• **Total**	**$777,100**

The present value for ongoing operating expenses has been calculated for discount rates of 2%, 4% and 8%. These calculations are presented in Appendix B of this report. The results of these calculations may be summarized as follows.

Table 8.1 – Present Value for Mechanical Treatment Plant

Item	Discount Rate		
	2%	**4%**	**8%**
Capital	$7,096,000	$7,096,000	$7,096,000
Operations	$12,706,699	$10,561,043	$7,629,682
Total	**$19,802,699**	**$17,657,043**	**$14,725,682**

The life cycle cost of this alternative is approximately 30% higher than the least costly alternative. On this basis, a score of eight has been applied to this parameter.

8.3. Community Acceptance

8.3.1. Access Maintenance

Operation of a mechanical wastewater treatment plant would require the ongoing maintenance of road access to the site. The effort would represent a small increase the scope of road maintenance conducted by the Hamlet and no unusual challenges are anticipated. On this basis, a score of nine is assigned this parameter.

8.3.2. Worker Safety

Training, safety protocols and some degree of caution, on the part of operating staff, will be required to assure safe operation. The scope of safety concerns within a treatment plant is larger than those associated with a lagoon due to the presence of mechanical equipment. These concerns are easy to identify and a suitable training program can be developed. On this basis, a score of seven has been assigned this parameter.

8.3.3. Nuisance

There is very low potential for public nuisance at the wastewater treatment plant site. Some odour issues may arise from the disposal of residuals (sludge) at the community landfill site. This nuisance would be mitigated by the distance separating the landfill from the residential area of the community. It is anticipated that there will be a general recommendation to the community to avoid the area of the effluent discharge from the treatment plant. A score of eight has been assigned this parameter.

8.4. Summary

The scores assigned for each parameter have been incorporated into the evaluation scheme, and the results are presented in the following table 8.2.

Table 8.2 - Evaluation Matrix for Mechanical Treatment Plant

Parameter	Scoring Scale	Score	Weight	Weighted Score
Technical				
Effluent at commissioning	Pass/Fail		N/A	
Vulnerability to changing criteria	1-10	10	3	30
Ease of capacity expansion	1-10	6	5	30
Required operating effort	1-10	4	7	28
Previous success in the Arctic	1-10	6	7	42
Financial				
Capital cost	1-10	10	10	100
Risk of un-anticipated expenditure	1-10	9	3	27
Life cycle cost	1-10	8	10	80
Community Acceptance				
Access maintenance burden	1-10	9	6	54
Worker safety	1-10	7	10	70
Nuisance	1-10	9	3	27
Total				**488**

9 Selection of Recommended Alternative

Various parameters and scores, as developed during the evaluation of the alternatives are summarized in the following table 9.1

Table 9.1- Alternatives Evaluation Summary

	Rehabilitate P-Lake	Three Tier Lagoon	Mechanical Plant
Evaluation matrix score	388	373	488
Capital Cost ($ millions)	9,496	50,500	7,096
Life cycle cost ($ millions)	15,808	51,290	17,657

As a first observation, the Three Tier Lagoon alternative carries a capital cost that is seven times higher than the least costly alternative. This alternative also received the lowest score from the evaluation matrix. On this basis, this alternative will be set aside.

The evaluation matrix provided the highest score for mechanical treatment. This alternative has the lowest capital cost, estimate at 25% lower than the rehabilitation of P-Lake. The operating costs for mechanical treatment are higher than those for P-Lake, but these operating costs are more predictable, both in terms of amount and timing. Life cycle cost, for a discount rate of 4%, is 12% higher than for rehabilitation of the P Lake lagoon.

There are other issues that must be considered in connection with the P-Lake lagoon alternative. Despite an ongoing effort that will be required to avoid freeze, it is expected that the forcemain will freeze on an occasional basis. The timing and frequency cannot be predicted. Freeze of the forcemain could place the forcemain out of service for an extended period. The response to the freeze would be costly and, in the interim, an alternative sewage disposal site would be required. This assessment has not included the costs of developing a sewage disposal alternative site, or the costs of incorporation of this site into the water licence.

On the basis of the highest evaluation score, lowest capital cost and predictable life cycle cost, the alternative of mechanical wastewater treatment is recommended. This recommendation is presented recognizing that the selection of an appropriate strategy for the management of wastewater in Cape Dorset is challenging. There are local factors that include topography, airport proximity and the siting of the community within the limited developable area that combine to create a very challenging situation for the application of the traditional approach of a lagoon. This recommendation has been developed around the unique situation found in Cape Dorset and should not be generally extrapolated to other sites in Nunavut.

10 Summary and Conclusions

10.1 Summary

1. CGS has commissioned this study to examine alternatives, and identify a feasible method for the management of wastewater in Cape Dorset.
2. A series of investigations have examined the various questions related to the management of wastewater in Cape Dorset. Section two of this report summarizes those reports provided to the study team by CGS.
3. Service conditions for a wastewater management facility have been defined. The key parameters among these service conditions included the following:
    - The population in 2041 is estimated to total 2,042 persons.
    - Annual sewage generation is estimated as 98,600 m3 by the year 2041.
    - The effluent requirements of BOD of less than 120 mg/L and TSS of less than 180 mg/L have been taken from the NWT Guidelines of 1982 for facilities with seasonal discharges. Facilities with continuous discharge must achieve BOD of less than 100 mg/L and TSS of less than 120 mg/L. There are currently no other published effluent guidelines.
    - Cape Dorset experiences a harsh climate with low winter temperatures.
4. The alternatives of rehabilitation of the P Lake lagoon, development of a lagoon on a new site and mechanical treatment have been examined.
5. The alternative of rehabilitation of the P Lake lagoon has been carried forward for further assessment. The issues that must be considered include the provision of sufficient storage within a water retaining structure and the matter of safe and reliable conveyance of sewage to the lagoon.
6. There are significant concerns related to the reliable operation of a lift station for the conveyance of sewage to the P-Lake lagoon. These concerns relate to the high freeze risk for the forcemain.
7. The alternative of developing a new lagoon on a new site has not been advanced as an appropriate site has not been identified following the preparation of a constraints map.
8. The alternative of development of a lagoon on the three-tier lagoon site was retained for further evaluation, as this site was retained following the preparation of the constraints map.
9. The alternative of mechanical treatment has been retained for further evaluation. It has been determined that the most appropriate from of mechanical treatment entails a suspended growth biological system that makes use of the MBR process.
10. A scheme was developed for the evaluation of the alternatives. This scheme technical performance, economic issues and community acceptance.
11. It is anticipated that all alternatives will meet the effluent criteria.
12. Capital cost was lowest for the mechanical treatment plant alternative. The capital cost for the three tier lagoon was approximately 7 times higher that mechanical treatment. The capital cost for mechanical treatment is estimated at 25% less that rehabilitation of the P-Lake lagoon.

13. The 20-year life cycle cost for mechanical treatment is estimated as 12% higher than rehabilitation of the P-Lake lagoon. This observation must be viewed with some degree of caution as the operating effort required to convey sewage to P-Lake is very difficult to reliably predict.
14. Mechanical treatment achieved the highest score. The second highest score was calculated for rehabilitation of P-Lake. The score for the P-Lake alternative was lower by 25%.

10.2 Conclusions

The conclusions of this study may be summarizes as followed.

1. Three alternative methods for the management of wastewater in Cape Dorset have been examined.
2. The alternative of mechanical treatment achieved the highest score. This alternative also presented the lowest capital cost.
3. The alternative of rehabilitation of the P-Lake lagoon presented lower 20 year life cycle cost that mechanical treatment. This finding must be considered with some caution as three are significant questions relating to the reliable conveyance of sewage to the lagoon site.

Based upon the above it is recommended that mechanical treatment be selected as the preferred strategy for the management of wastewater in Cape Dorset.

Appendix A – Cost Estimate

Cape Dorset Waste Water Feasibility Study

Cape Dorset, Nunavut

Class 'D' Estimate

Prepared for:
exp Services inc.
100-2650 Queensview Drive
Ottawa, ON
K2B 8H6

Prepared by:
ALTUS GROUP LIMITED
14 Colonnade Road, Suite 150
Ottawa, Ontario
K2E 7M6

Phone: 613.721.1333
Fax: 613.721-0121

Issued: May 5, 2017
Job No.: 101764

Altus Group
Street Smart. World Wise.

May 5, 2017 Job No. 101764

exp Services inc.
100-2650 Queensview Drive
Ottawa, ON
K2B 8H6

Attn: Steven Burden, P.Eng. Senior Manager, Infrastructure

Re: Cape Dorset Waste Water Feasibility Study, Class 'D' Estimate

Dear Steven,

We submit for your review our Class 'D' Estimate in accordance with the terms of our engagement.

The estimate includes all direct and indirect construction costs, subject to certain exclusions, and general conditions, as well as, contractor's overheads and profit. The provisions for contingencies are defined within the body of this report and are based on the information provided.

This report is not intended for general circulation, publication or reproduction for any other person or purpose without express written permission to each specific instance. Furthermore, this report was produced for the exclusive use of exp Services inc. and is not to be relied upon by any other party. Altus Group Limited does not hold any reporting responsibility to any other party.

Should you have any questions related to this report please do not hesitate to contact the undersigned at the address listed below.

Yours truly,

ALTUS GROUP LIMITED

Per: Paul Weatherby, MRICS, PQS
Associate

Per: Grant Mercer, MRICS, PQS, CET
Director

Contents

Page No.

1 Introduction

1.1 General Information

This Class 'D' Estimate is intended to provide a realistic budget based on the information provided. The estimate reflects our opinion as to the fair market value for the construction of this proposed project and is not intended to predict the lowest bid.

The details outlining inclusions and assumptions are specifically described and itemized within the estimate details provided in the Appendices of this report. This report includes all direct and indirect construction costs with the following exclusions as noted in section 1.2 below.

1.2 Exclusions

The following items are not included in this report:

- Soft costs and professional fees including associated expenses
- Owner's fees and/or administration expenses
- Legal fees and expenses
- Fees for building and/or development permits
- Sole sourcing of materials, services and equipment
- Interest and/or finance charges
- Moving / relocation Cost, if applicable
- If applicable, work with any contaminated soil or hazardous materials, unless identified
- Premium for accelerated schedule or work after standard business hours
- Requirement for use of local materials and/or labour
- Operating and/or maintenance expenses
- Construction (change order) allowance
- Goods and Services Tax (GST)
- It is assumed power is available at building site line

2 Project Details

2.1 General Information

From the information provided, we have measured quantities where possible and applied unit rates considered competitive for a project of this nature, based on historical and current cost data for this type of project. Where design information was limited, we have had discussions with the relevant design disciplines and/or made assumptions based on our experience with projects of a similar type, size, and standard of quality.

2.2 Location

The location cost base for this estimate is the Cape Dorset, Nunavut.

2.3 Measurement and Pricing

The estimate has been prepared using generally accepted principles as to format, method of measurement and pricing. Quantities and project statistics have been calculated in general accordance with the Canadian Institute of Quantity Surveyors' Method of Measurement.

The unit rates within our report are considered competitive and are based on our experience with similar projects, and/or quotes provided by subcontractors as noted. Pricing shown reflects probable construction costs obtainable in Cape Dorset, Nunavut, on May 5, 2017. Where applicable, unit rates include labour, material, equipment, and subcontractor's overheads and profit. In instances where design information was limited, we have made reasonable assumptions based on our experience on projects of a similar nature and discussions with the design team when possible.

2.4 Taxes

Provincial Sales Tax (PST) is included where applicable in the unit rates. However, the Goods and Services Tax (GST) has not been included.

2.5 General Requirements and Fees

The General Requirements and Fee included within the estimate for the General Contractor are calculated as a percentage of the hard costs. The General Requirements are based on our assumptions of the anticipated construction approach and construction schedule for the project. The General Requirements percentage includes the cost associated with bonding and insurance, however excludes development and/or building permit costs.

2 Project Details

2.6 Procurement Methodology

We have assumed that the project will be procured with a General Contractor approach under a CCDC standard form of contract. We have assumed a minimum of five General Contractor bids and at least three major subtrade/supplier bids received for all trade categories to establish competitive bidding and tender results. The estimate is a determination of fair market pricing and not a prediction of lowest bid in any trade category. Please note that should the above minimum bidding conditions not occur on this project, construction bids received could vary significantly from the estimated costs included within this report.

2.7 Schedule / Phasing

This report is based on the project being completed and/or bid as single phase. The rates used in this report are based on current dollars and any allowance for escalation beyond the date of this report will be included as an Escalation contingency. The unit rates in our estimate are based on construction activities occurring during standard business working hours and proceeding within a non-accelerated schedule.

3 Contingencies

3.1 General

The effective use of contingencies in construction cost planning requires a clear understanding of estimating risks in both a project specific and general construction market sense. The appropriate level of contingency is dependent on the amount of information available, knowledge of the design teams' methods and philosophy, the timing of the estimate preparation relative to the project design and construction schedule, and the anticipated complexity of the construction work.

3.2 Design and Pricing

A design and pricing contingency of 12.0% has been included in the estimate. This contingency covers the design and pricing evolution during the remaining design stages of the project, please note this contingency is not intended to cover additional scope or additional functional program requirements.

3.3 Escalation

An escalation contingency of 3.0% has been included in the estimate. This contingency is intended to address anticipated changes in construction costs due to market fluctuations between the date of this report and the anticipated tender date of spring 2018.

3.4 Construction Contingency (Post Contract)

No construction contingency has been included in the estimate. It is the intention of this contingency to cover post contract change orders.

4 General Statement of Liability

4.1 Probable Costs and Ongoing Cost Control

Altus Group Limited does not guarantee that tenders or actual construction costs will not vary from this estimate. Acute market conditions, proprietary specifications, or competition/collaboration among contractors may cause tenders to vary from reasonable estimates based on normal and abnormal competitive conditions.

Altus Group Limited recommends the owner and/or design team review the cost estimate report including line item descriptions, unit prices, allowances, assumptions, exclusions, and contingencies to ensure the appropriate design intent has been accurately captured within the report.

It should be noted that the cost consultants are not qualified to confirm that construction work and design is in accordance with approved plans and specifications.

5 Project Statistics

5.1 Project Statistics

	Description	
1	Existing Site Expansion	97,250 m3
2	P-Lake Rehabilitation	94,000 m3
3	New Waste Water Treatment Plant	400 m2

Based on information supplied by the Design team, the gross floors areas have been reviewed and measured by Altus Group Limited in accordance with the Canadian Institute of Quantity Surveyors' Method of Measurement. The site developed area is the area of the site less the footprint of the building.

Appendix A

Existing Site Expansion Cost Estimate Summary & Details

ELEMENTAL COST SUMMARY

CLASS 'D' ESTIMATE

EXISTING SITE EXPANSION

Altus Group

Project: Cape Dorset Wastewater Feasibility Study - Estimate 1	File: PW-GM-R0
Location: - Cape Dorset NU	Date: 05/04/2017
Owner/Client: Government of Nunavut	Project Number: 101764
Architect: exp Services inc.	Lagoon Capacity 97,500 m3

Element	Ratio to GFA	Elemental Quantity	Elemental Unit Rate	Elemental Amount	Cost/sf	Total	%
A SHELL							
A1 SUBSTRUCTURE					**$0.00**		
A11 Foundation	0.00	0 m3	$0.00	$0	$0.00		
A12 Basement Excavation	0.00	0 m3	$0.00	$0	$0.00		
A13 Special Conditions	0.00	0 Sum	$0.00	$0	$0.00	**$0**	**0.0%**
A2 STRUCTURE					**$0.00**		
A21 Lowest Floor Construction	0.00	0 m3	$0.00	$0	$0.00		
A22 Upper Floor Construction	0.00	0 m3	$0.00	$0	$0.00		
A23 Roof Construction	0.00	0 m3	$0.00	$0	$0.00	**$0**	**0.0%**
A3 EXTERIOR ENCLOSURE					**$0.00**		
A31 Walls Below Grade	0.00	0 m3	$0.00	$0	$0.00		
A32 Walls Above Grade	0.00	0 m3	$0.00	$0	$0.00		
A33 Windows & Entrance	0.00	0 m3	$0.00	$0	$0.00		
A34 Roof Covering	0.00	0 m3	$0.00	$0	$0.00		
A35 Projections	0.00	0 Sum	$0.00	$0	$0.00	**$0**	**0.0%**
B INTERIORS							
B1 PARTITIONS & DOORS					**$0.00**		
B11 Partitions	0.00	0 m3	$0.00	$0	$0.00		
B12 Doors	0.00	0 no.	$0.00	$0	$0.00	**$0**	**0.0%**
B2 FINISHES					**$0.00**		
B21 Floor Finishes	0.00	0 m3	$0.00	$0	$0.00		
B22 Ceiling Finishes	0.00	0 m3	$0.00	$0	$0.00		
B23 Wall Finishes	0.00	0 m3	$0.00	$0	$0.00	**$0**	**0.0%**
B3 FITTING & EQUIPMENT					**$0.00**		
B31 Fitting & Fixtures	0.00	0 m3	$0.00	$0	$0.00		
B32 Equipment	0.00	0 m3	$0.00	$0	$0.00		
B33 Conveying Systems	0.00	0 no.	$0.00	$0	$0.00	**$0**	**0.0%**
C SERVICES							
C1 MECHANICAL					**$0.00**		
C11 Plumbing & Drainage	0.00	0 m3	$0.00	$0	$0.00		
C21 Fire Protection	0.00	0 m3	$0.00	$0	$0.00		
C13 HVAC	0.00	0 m3	$0.00	$0	$0.00		
C14 Controls	0.00	0 m3	$0.00	$0	$0.00	**$0**	**0.0%**
C2 ELECTRICAL					**$0.00**		
C21 Service & Distribution	0.00	0 m3	$0.00	$0	$0.00		
C22 Lighting, Devices & Heating	0.00	0 m3	$0.00	$0	$0.00		
C23 Systems & Ancillaries	0.00	0 m3	$0.00	$0	$0.00	**$0**	**0.0%**
NET BUILDING COST (Excluding Site)					**$0.00**	**$0**	**0.0%**
D SITE							
D1 SITE WORK					**$306.70**		
D11 Site Development	1.00	97,500 m3	$306.70	$29,903,000	$306.70		
D12 Mechanical Services	0.00	0 m3	$0.00	$0	$0.00		
D13 Electrical Services	0.00	0 m3	$0.00	$0	$0.00	**$29,903,000**	**68.3%**
D2 ANCILLARY WORK					**$0.00**		
D21 Demolition	0.00	0 Sum	$0.00	$0	$0.00		
D22 Alterations	0.00	0 Sum	$0.00	$0	$0.00	**$0**	**0.0%**
NET BUILDING COST (Including Site)					**$306.70**	**$29,903,000**	**68.3%**
Z MARKUPS							
Z1 GENERAL REQUIREMENTS					**$142.31**		
Z11 General Requirements 20.00%				$5,980,600	$61.34		
Z12 Freight & Accommodations 22.00%				$7,894,400	$80.97	**$13,875,000**	**31.7%**
TOTAL CONSTRUCTION ESTIMATE (Excluding Contingencies)					**$449.01**	**$43,778,000**	**100.0%**
Z2 CONTINGENCIES					**$68.97**		
Z21 Design Contingency 12.0%				$5,253,400	$53.88		
Z22 Escalation Contingency 3.0%				$1,470,900	$15.09		
Z23 Construction Contingency 0.0%	EXCLUDED			$0	$0.00	**$6,724,300**	
SALES TAX (HST) 0%	EXCLUDED			$0	$0.00	**$0**	
TOTAL CONSTRUCTION ESTIMATE (Including Allowances)					**$517.97**	**$50,502,300**	

LC:	**97,500 m3**	**per m3**	**$517.97**
LC:	**127,433 cy**	**per cy**	**$396.31**

Project: Cape Dorset Wastewater Feasibility Study - Estimate 1
Location: - Cape Dorset NU
Owner/Client: Government of Nunavut
Architect: exp Services inc.

File: PW-GM-R0
Date: 05/04/2017
Project Number: 101764
Lagoon Capacity (m3): 97,500

Description	Quantity		Rate	Amount
D11 Site Development				
New Reservoir Cell #1:	32,500	m3	191.26	
Cell construction				
Cut/excavation (quantity provided by others)	25,200	m3	20.00	504,000
Allowance for rock excavation (assumed 50%)	12,600	m3	80.00	1,008,000
Fill (quantity provided by others)	112,800	m3	35.00	3,948,000
150mm sand bedding	2,310	m3	80.00	184,800
Supply of either HDPE (40mil) (quantity provided by	15,400	m2	8.00	123,200
Freight from Winnipeg (included in summary)	15,400	m2	0.00	0
Installation of the membrane	15,400	m2	5.00	77,000
Misc. workings (allowance):	1	sum	24,500	
Chain-link fencing @ top of berm	1	allow	15,000.00	15,000
12.0m gated entrance	1	no	3,000.00	3,000
New silt fence	150	m	10.00	1,500
Gabion mat erosion protection at subframe outlet	2	no.	2,500.00	5,000
Additional items such as:	15,400	m2	20.00	308,000
One or two guys to backfill the trench as the liner install				
The weather must be suitable for liner installation, preferably sunny with zero to low chance of rain. Rain, wind and snow may delay or prohibit liner installation. Minor delay that is out of the installer control may incur an additional daily and/or mobilization cost.				
6-8 guys to unroll the liners and backfill the trench as liner installation				
Equipment with at least 2600-lbs lifting capacity and can go in and out of the pond				
At least a 10k generator				
Unforeseen items such as :	15,400	m2	2.50	38,500
Prevailing wage and may change if applicable.				
Providing housing and meals as well in a work camp. (included in summary)				
3-4 down days for each day worked.				

Altus Group

Project: Cape Dorset Wastewater Feasibility Study - Estimate 1		File:	PW-GM-R0
Location: - Cape Dorset NU		Date:	05/04/2017
Owner/Client: Government of Nunavut		Project Number:	101764
Architect: exp Services inc.		Lagoon Capacity (m3):	97,500

Description	**Quantity**		**Rate**	**Amount**
New Reservoir Cell #2:	32,500	m3	192.45	
Cell construction				
Cut/excavation (quantity provided by others)	29,400	m3	20.00	588,000
Allowance for rock excavation (assumed 50%)	14,700	m3	80.00	1,176,000
Fill (quantity provided by others)	106,700	m3	35.00	3,734,500
150mm sand bedding	2,310	m3	80.00	184,800
Supply of either HDPE (40mil) (quantity provided by	15,400	m2	8.00	123,200
Freight from Winnipeg (included in summary)	15,400	m2	0.00	0
Installation of the membrane	15,400	m2	5.00	77,000
Misc. workings (allowance):	1	sum	24,500	
Chain-link fencing @ top of berm	1	allow	15,000.00	15,000
12.0m gated entrance	1	no	3,000.00	3,000
New silt fence	150	m	10.00	1,500
Gabion mat erosion protection at subframe outlet	2	no.	2,500.00	5,000
Additional items such as:	15,400	m2	20.00	308,000
One or two guys to backfill the trench as the liner install				
The weather must be suitable for liner installation, preferably sunny with zero to low chance of rain. Rain, wind and snow may delay or prohibit liner installation. Minor delay that is out of the installer control may incur an additional daily and/or mobilization cost.				
6-8 guys to unroll the liners and backfill the trench as liner installation				
Equipment with at least 2600-lbs lifting capacity and can go in and out of the pond				
At least a 10k generator				
Unforeseen items such as :	15,400	m2	2.50	38,500
Prevailing wage and may change if applicable.				
Providing housing and meals as well in a work camp. (included in summary)				
3-4 down days for each day worked.				

Altus Group

Project: Cape Dorset Wastewater Feasibility Study - Estimate 1		File:	PW-GM-R0
Location: - Cape Dorset NU		Date:	05/04/2017
Owner/Client: Government of Nunavut		Project Number:	101764
Architect: exp Services inc.		Lagoon Capacity (m3):	97,500

Description	Quantity	Rate	Amount
New Reservoir Cell #3:	32,500 m3	243.69	
Cell construction			
Cut/excavation (quantity provided by others)	31,900 m3	20.00	638,000
Allowance for rock excavation (assumed 50%)	15,950 m3	80.00	1,276,000
Fill (quantity provided by others)	150,000 m3	35.00	5,250,000
150mm sand bedding	2,310 m3	80.00	184,800
Supply of either HDPE (40mil) (quantity provided by	15,400 m2	8.00	123,200
Freight from Winnipeg (included in summary)	15,400 m2	0.00	0
Installation of the membrane	15,400 m2	5.00	77,000
Misc. workings (allowance):	1 sum	24,500	
Chain-link fencing @ top of berm	1 allow	15,000.00	15,000
12.0m gated entrance	1 no	3,000.00	3,000
New silt fence	150 m	10.00	1,500
Gabion mat erosion protection at subframe outlet	2 no.	2,500.00	5,000
Additional items such as: One or two guys to backfill the trench as the liner install The weather must be suitable for liner installation, preferably sunny with zero to low chance of rain. Rain, wind and snow may delay or prohibit liner installation. Minor delay that is out of the installer control may incur an additional daily and/or mobilization cost. 6-8 guys to unroll the liners and backfill the trench as liner installation goes Equipment with at least 2600-lbs lifting capacity and can go in and out of the pond At least a 10k generator	15,400 m2	20.00	308,000
Unforeseen items such as : Prevailing wage and may change if applicable. Providing housing and meals as well in a work camp. (included in summary) 3-4 down days for each day worked.	15,400 m2	2.50	38,500

Altus Group

Project: Cape Dorset Wastewater Feasibility Study - Estimate 1		File:	PW-GM-R0
Location: - Cape Dorset NU		Date:	05/04/2017
Owner/Client: Government of Nunavut		Project Number:	101764
Architect: exp Services inc.		Lagoon Capacity (m3):	97,500

Description	Quantity		Rate	Amount
Access road construction	1	sum	9,512,500.00	
Cut/excavation (quantity provided by others)	96,300	m3	20.00	1,926,000
Allowance for rock excavation (assumed 50%)	48,150	m3	80.00	3,852,000
Fill (quantity provided by others)	106,700	m3	35.00	3,734,500
TOTAL D11 Site Development	**97,500**	**m3**	**306.70**	**29,903,000**

Appendix B

P-Lake Rehabilitation Cost Estimate Summary & Details

ELEMENTAL COST SUMMARY

CLASS 'D' ESTIMATE

P-LAKE REHABILITATION

Project: Cape Dorset Wastewater Feasibility Study - Estimate 2		File:	PW-GM-R0
Location: - Cape Dorset NU		Date:	05/04/2017
Owner/Client: Government of Nunavut		Project Number:	101764
Architect: exp Services inc.		Lagoon Capacity	94,000 m3

Element	Ratio to GFA	Elemental Quantity	Elemental Unit Rate	Elemental Amount	Cost/sf	Total	%
A SHELL							
A1 SUBSTRUCTURE					**$0.00**		
A11 Foundation	0.00	0 m3	$0.00	$0	$0.00		
A12 Basement Excavation	0.00	0 m3	$0.00	$0	$0.00		
A13 Special Conditions	0.00	0 Sum	$0.00	$0	$0.00	**$0**	**0.0%**
A2 STRUCTURE					**$0.00**		
A21 Lowest Floor Construction	0.00	0 m3	$0.00	$0	$0.00		
A22 Upper Floor Construction	0.00	0 m3	$0.00	$0	$0.00		
A23 Roof Construction	0.00	0 m3	$0.00	$0	$0.00	**$0**	**0.0%**
A3 EXTERIOR ENCLOSURE					**$0.00**		
A31 Walls Below Grade	0.00	0 m3	$0.00	$0	$0.00		
A32 Walls Above Grade	0.00	0 m3	$0.00	$0	$0.00		
A33 Windows & Entrance	0.00	0 m3	$0.00	$0	$0.00		
A34 Roof Covering	0.00	0 m3	$0.00	$0	$0.00		
A35 Projections	0.00	0 Sum	$0.00	$0	$0.00	**$0**	**0.0%**
B INTERIORS							
B1 PARTITIONS & DOORS					**$0.00**		
B11 Partitions	0.00	0 m3	$0.00	$0	$0.00		
B12 Doors	0.00	0 no.	$0.00	$0	$0.00	**$0**	**0.0%**
B2 FINISHES					**$0.00**		
B21 Floor Finishes	0.00	0 m3	$0.00	$0	$0.00		
B22 Ceiling Finishes	0.00	0 m3	$0.00	$0	$0.00		
B23 Wall Finishes	0.00	0 m3	$0.00	$0	$0.00	**$0**	**0.0%**
B3 FITTING & EQUIPMENT					**$0.00**		
B31 Fitting & Fixtures	0.00	0 m3	$0.00	$0	$0.00		
B32 Equipment	0.00	0 m3	$0.00	$0	$0.00		
B33 Conveying Systems	0.00	0 no.	$0.00	$0	$0.00	**$0**	**0.0%**
C SERVICES							
C1 MECHANICAL					**$0.00**		
C11 Plumbing & Drainage	0.00	0 m3	$0.00	$0	$0.00		
C21 Fire Protection	0.00	0 m3	$0.00	$0	$0.00		
C13 HVAC	0.00	0 m3	$0.00	$0	$0.00		
C14 Controls	0.00	0 m3	$0.00	$0	$0.00	**$0**	**0.0%**
C2 ELECTRICAL					**$0.00**		
C21 Service & Distribution	0.00	0 m3	$0.00	$0	$0.00		
C22 Lighting, Devices & Heating	0.00	0 m3	$0.00	$0	$0.00		
C23 Systems & Ancillaries	0.00	0 m3	$0.00	$0	$0.00	**$0**	**0.0%**
NET BUILDING COST (Excluding Site)					**$0.00**	**$0**	**0.0%**
D SITE							
D1 SITE WORK					**$59.82**		
D11 Site Development	0.00	1 Sum	$5,502,580.00	$5,502,580	$58.54		
D12 Mechanical Site Services	0.00	1 Sum	$0.00	$0	$0.00		
D13 Electrical Site Services	0.00	1 Sum	$120,140.00	$120,140	$1.28	**$5,622,720**	**68.3%**
D2 ANCILLARY WORK					**$0.00**		
D21 Demolition	0.00	0 Sum	$0.00	$0	$0.00		
D22 Alterations	0.00	0 Sum	$0.00	$0	$0.00	**$0**	**0.0%**
NET BUILDING COST (Including Site)					**$59.82**	**$5,622,720**	**68.3%**
Z MARKUPS							
Z1 GENERAL REQUIREMENTS					**$27.75**		
Z11 General Requirements	20.00%			$1,124,500	$11.96		
Z12 Freight & Accommodations	22.00%			$1,484,400	$15.79	**$2,608,900**	**31.7%**
TOTAL CONSTRUCTION ESTIMATE (Excluding Contingencies)					**$87.57**	**$8,231,620**	**100.0%**
Z2 CONTINGENCIES					**$13.45**		
Z21 Design Contingency	12.0%			$987,800	$10.51		
Z22 Escalation Contingency	3.0%			$276,600	$2.94		
Z23 Construction Contingency	0.0%	EXCLUDED		$0	$0.00	**$1,264,400**	
SALES TAX (HST)	0%	EXCLUDED		$0	$0.00	**$0**	
TOTAL CONSTRUCTION ESTIMATE (Including Allowances)					**$101.02**	**$9,496,020**	

LC:	**94,000 m3**	**per m3**	**$101.02**
LC:	**122,858 cy**	**per cy**	**$77.29**

Altus Group

Project: Cape Dorset Wastewater Feasibility Study - Estimate 2		File:	PW-GM-R0
Location: - Cape Dorset NU		Date:	04-May-17
Owner/Client: Government of Nunavut		Project Number:	101764
Architect: exp Services inc.		Lagoon Capacity (m3)	94,000

Description	**Quantity**		**Rate**	**Amount**
D11 Site Development				
Reconstruct existing P-Lake sewage lagoon berm	1	sum	581,500.00	
Existing berm to remain in place	1	nil	0.00	0
Cut/excavation not required	0	m3	20.00	0
Fill (approximately 200m long)	12,000	m3	35.00	420,000
150mm sand bedding	510	m3	80.00	40,800
Supply of either HDPE (40mil) (approximately 170x20m)	3,400	m2	8.00	27,200
Freight from Winnipeg (included in summary)	3,400	m2	0.00	0
Installation of the membrane	3,400	m2	5.00	17,000
Additional items such as:	3,400	m2	20.00	68,000
One or two guys to backfill the trench as the liner install				
The weather must be suitable for liner installation, preferably sunny with zero to low chance of rain. Rain, wind and snow may delay or prohibit liner installation.				
Minor delay that is out of the installer control may incur an additional daily and/or mobilization cost.				
6-8 guys to unroll the liners and backfill the trench as liner installation goes				
Equipment with at least 2600-lbs lifting capacity and can go in and out of the pond				
At least a 10k generator				
Unforeseen items such as :	3,400	m2	2.50	8,500
Prevailing wage and may change if applicable.				
Providing housing and meals as well in a work camp. (included in summary)				
3-4 down days for each day worked.				

Project: Cape Dorset Wastewater Feasibility Study - Estimate 2
Location: - Cape Dorset NU
Owner/Client: Government of Nunavut
Architect: exp Services inc.

File: PW-GM-R0
Date: 04-May-17
Project Number: 101764
Lagoon Capacity (m3) 94,000

Description	Quantity	Rate	Amount
New secondary P-Lake sewage lagoon berm	1 sum	392,050.00	
Cut/excavation (assumed not required)	0 m3	20.00	0
Fill (quantity provided by others)	7,500 m3	35.00	262,500
150mm sand bedding	510 m3	80.00	40,800
Supply of either HDPE (40mil)	2,500 m2	8.00	20,000
Freight from Winnipeg (included in summary)	2,500 m2	0.00	0
Installation of the membrane	2,500 m2	5.00	12,500
Additional items such as:	2,500 m2	20.00	50,000
One or two guys to backfill the trench as the liner install goes			
The weather must be suitable for liner installation, preferably sunny with zero to low chance of rain. Rain, wind and snow may delay or prohibit liner installation. Minor delay that is out of the installer control may incur an additional daily and/or mobilization cost.			
6-8 guys to unroll the liners and backfill the trench as liner installation goes			
Equipment with at least 2600-lbs lifting capacity and can go in and out of the pond			
At least a 10k generator			
Unforeseen items such as :	2,500 m2	2.50	6,250
Prevailing wage and may change if applicable.			
Providing housing and meals as well in a work camp. (included in summary)			
3-4 down days for each day worked.			
New access road & truck turn around construction from primary lagoon to secondary lagoon	300 m	1,900.00	
Cut/excavation (allowance)	6,000 m3	20.00	120,000
Allowance for rock excavation	3,000 m3	80.00	240,000
Fill (allowance)	6,000 m3	35.00	210,000
Allowance to scarify and regrade existing road	1 allow	250,000.00	250,000

Project: Cape Dorset Wastewater Feasibility Study - Estimate 2
Location: - Cape Dorset NU
Owner/Client: Government of Nunavut
Architect: exp Services inc.

File: PW-GM-R0
Date: 04-May-17
Project Number: 101764
Lagoon Capacity (m3) 94,000

Description	Quantity	Rate	Amount
Lift station	1 Sum	808,830.00	
Building c/w associated building M&E requirements	60 m2	6,000.00	360,000
Lift station equipment - pre-assembly & dis-assembling, testing, management, etc.	1 ls	250,400.00	250,400
Transfer pump - duplex			
Lift pump - duplex			
Grinder			
Flow meter			
Piping fittings, valves, c/w insulation, etc.			
Truck discharge connection and flexible coupling connections			
Pumping station controls			
Normal Power			
Panels and feeders	1 no	16,400.00	16,400
Reconnection and testing at site	1 no	3,200.00	3,200
Emergency Power			
Allowance for diesel generator, panel, transfer switch, feeders, tank and control wiring	1 ls	145,000.00	145,000
Reconnection and testing at site	1 no	5,300.00	5,300
Motor Controls & Wiring			
Sewage transfer pump connection	1 no	1,000.00	1,000
Sewage lift pump connection	1 ls	2,300.00	2,300
Reconnection and testing at site	1 no	5,600.00	5,600
Miscellaneous			
Permits, inspections & job setup	1 no	5,600.00	5,600
Allowance for miscellaneous raceways and wiring	1 ls	1,730.00	1,730
Reconnection, verification, test and commission at site	1 no	11,200.00	11,200
Allowance for As-built drawings & manuals	1 no	1,100.00	1,100

Project: Cape Dorset Wastewater Feasibility Study - Estimate 2
Location: - Cape Dorset NU
Owner/Client: Government of Nunavut
Architect: exp Services inc.

File: PW-GM-R0
Date: 04-May-17
Project Number: 101764
Lagoon Capacity (m3) 94,000

Description	Quantity		Rate	Amount
Storage tank	1	sum	2,800,200.00	
Tank base	1	no.	50,000.00	50,000
Outdoor storage tank c/w insulation	1	ls	167,100.00	167,100
Force main c/w excavation to 1.5m depth, pipe support, insulation, etc.	1,000	m	2,250.00	2,250,000
Allowance for rock excavation (.5 m of rock for ¼ of the length)	250	m3	80.00	20,000
Heat tracing to last	1,000	m	200.00	200,000
Testing and inspection	1	ls	21,700.00	21,700
Site coordination, management, etc.	1	ls	43,800.00	43,800
Perimeter lighting - Pole light c/w wiring	2	no	19,000.00	38,000
Lighting control	1	ls	2,100.00	2,100
Control and monitoring - conduit and wiring	1	ls	7,500.00	7,500
Allowance for drainage improvements	1	allow	100,000.00	100,000
TOTAL D11 Site Development	**1**	**Sum**	**5,502,580.00**	**5,502,580**
D12 Mechanical Site Services				
Measured Above	1	nil	0.00	0
TOTAL D12 Mechanical Site Services	**1**	**Sum**	**0.00**	**0**
D13 Electrical Site Services				
Incoming Power				
Incoming service - pole mounted transformer, incoming Feeder and terminations - Hydro charges	1	no	93,438.00	93,440
103mm rpvc conduit	1	ls	8,900.00	8,900
Incoming Communications				
Incoming service - Allowance for Utility charges	1	no	4,500.00	4,500
Site Lighting & Power				
External lighting c/w wiring - allowance	1	no	13,300.00	13,300
TOTAL D13 Electrical Site Services	**1**	**Sum**	**120,140.00**	**120,140**
TOTAL D1 SITE WORK				**5,622,720**

Appendix C

New Waste Water Treatment Plant Cost Estimate Summary & Details

ELEMENTAL COST SUMMARY

CLASS 'D' ESTIMATE

NEW WASTE WATER TREATMENT PLANT

Altus Group

Project: Cape Dorset Wastewater Feasibility Study - Estimate 3	File: PW-GM-R0
Location: - Cape Dorset NU	Date: 05/04/2017
Owner/Client: Government of Nunavut	Project Number: 101764
Architect: exp Services inc.	Gross Floor Area: 400 m2

Element	Ratio to GFA	Elemental Quantity	Elemental Unit Rate	Elemental Amount	Cost/m2	Total	%
A SHELL							
A1 SUBSTRUCTURE					**$1,040.00**		
A11 Foundation	1.00	400 m2	$1,040.00	$416,000	$1,040.00		
A12 Basement Excavation	0.00	0 m3	$0.00	$0	$0.00		
A13 Special Conditions	0.00	0 Sum	$0.00	$0	$0.00	**$416,000**	**6.8%**
A2 STRUCTURE					**$2,600.00**		
A21 Lowest Floor Construction	0.00	0 m2	$0.00	$0	$0.00		
A22 Upper Floor Construction	0.00	0 m2	$0.00	$0	$0.00		
A23 Roof Construction	1.00	400 m2	$2,600.00	$1,040,000	$2,600.00	**$1,040,000**	**16.9%**
A3 EXTERIOR ENCLOSURE					**$200.00**		
A31 Walls Below Grade	0.00	0 m2	$0.00	$0	$0.00		
A32 Walls Above Grade	0.00	0 m2	$0.00	$0	$0.00		
A33 Windows & Entrance	0.00	0 m2	$0.00	$0	$0.00		
A34 Roof Covering	0.00	0 m2	$0.00	$0	$0.00		
A35 Projections	0.00	1 Sum	$80,000.00	$80,000	$200.00	**$80,000**	**1.3%**
B INTERIORS							
B1 PARTITIONS & DOORS					**$0.00**		
B11 Partitions	0.00	0 m2	$0.00	$0	$0.00		
B12 Doors	0.00	0 no.	$0.00	$0	$0.00	**$0**	**0.0%**
B2 FINISHES					**$0.00**		
B21 Floor Finishes	0.00	0 m2	$0.00	$0	$0.00		
B22 Ceiling Finishes	0.00	0 m2	$0.00	$0	$0.00		
B23 Wall Finishes	0.00	0 m2	$0.00	$0	$0.00	**$0**	**0.0%**
B3 FITTING & EQUIPMENT					**$0.00**		
B31 Fitting & Fixtures	0.00	0 m2	$0.00	$0	$0.00		
B32 Equipment	0.00	0 m2	$0.00	$0	$0.00		
B33 Conveying Systems	0.00	0 no.	$0.00	$0	$0.00	**$0**	**0.0%**
C SERVICES							
C1 MECHANICAL					**$1,978.75**		
C11 Plumbing & Drainage	1.00	400 m2	$1,437.50	$575,000	$1,437.50		
C21 Fire Protection	1.00	400 m2	$3.75	$1,500	$3.75		
C13 HVAC	1.00	400 m2	$437.50	$175,000	$437.50		
C14 Controls	1.00	400 m2	$100.00	$40,000	$100.00	**$791,500**	**12.9%**
C2 ELECTRICAL					**$1,605.83**		
C21 Service & Distribution	1.00	400 m2	$675.25	$270,100	$675.25		
C22 Lighting, Devices & Heating	1.00	400 m2	$157.45	$62,980	$157.45		
C23 Systems & Ancillaries	1.00	400 m2	$773.13	$309,250	$773.13	**$642,330**	**10.4%**
NET BUILDING COST (Excluding Site)					**$7,424.58**	**$2,969,830**	**48.3%**
D SITE							
D1 SITE WORK					**$3,078.75**		
D11 Site Development	0.00	1 Sum	$413,000.00	$413,000	$1,032.50		
D12 Mechanical Site Services	0.00	1 Sum	$693,800.00	$693,800	$1,734.50		
D13 Electrical Site Services	0.00	1 Sum	$124,700.00	$124,700	$311.75	**$1,231,500**	**20.0%**
D2 ANCILLARY WORK					**$0.00**		
D21 Demolition	0.00	0 Sum	$0.00	$0	$0.00		
D22 Alterations	0.00	0 Sum	$0.00	$0	$0.00	**$0**	**0.0%**
NET BUILDING COST (Including Site)					**$10,503.33**	**$4,201,330**	**68.3%**
Z MARKUPS							
Z1 GENERAL REQUIREMENTS					**$4,873.75**		
Z11 General Requirements	20.00%			$840,300	$2,100.75		
Z12 Freight & Accommodations	22.00%			$1,109,200	$2,773.00	**$1,949,500**	**31.7%**
TOTAL CONSTRUCTION ESTIMATE (Excluding Contingencies)					**$15,377.08**	**$6,150,830**	**100.0%**
Z2 CONTINGENCIES					**$2,362.00**		
Z21 Design Contingency	12.0%			$738,100	$1,845.25		
Z22 Escalation Contingency	3.0%			$206,700	$516.75		
Z23 Construction Contingency	0.0%	EXCLUDED		$0	$0.00	**$944,800**	
SALES TAX (HST)	0%	EXCLUDED		$0	$0.00	**$0**	
TOTAL CONSTRUCTION ESTIMATE (Including Allowances)					**$17,739.08**	**$7,095,630**	

GFA:	**400 m2**	**per m2**	**$17,739.08**
GFA:	**4,306 sf**	**per sf**	**$1,648.01**

Altus Group

Project: Cape Dorset Wastewater Feasibility Study - Estimate 3	File: PW-GM-R0
Location: - Cape Dorset NU	Date: 04-May-17
Owner/Client: Government of Nunavut	Project Number: 101764
Architect: exp Services inc.	Gross Floor Area (m2): 400

Description	Quantity		Rate	Amount
A1 SUBSTRUCTURE				
A11 Foundations				
Steel rock socketed piles (assumed) c/w caps and cross bracing	80	no.	5,200.00	416,000
TOTAL A11 Foundations	**400**	**m2**	**1,040.00**	**416,000**
A12 Basement Excavation				
Assumed no work required	1	nil	0.00	0
TOTAL A11 Excavation	**0**	**Sum**	**0.00**	**0**
A13 Special Conditions				
Assumed no work required	1	nil	0.00	0
TOTAL A13 Special Conditions	**0**	**Sum**	**0.00**	**0**
TOTAL A1 SUBSTRUCTURE				**416,000**
A2 STRUCTURE				
A21 Lowest Floor Construction				
Modular unit construction - see roof construction	1	nil	0.00	0
TOTAL A21 Lowest Floor Construction	**0**	**m2**	**0.00**	**0**
A22 Upper Floor Construction				
Assumed no work required	1	nil	0.00	0
TOTAL A22 Upper Floor Construction	**0**	**m2**	**0.00**	**0**
A23 Roof Construction				
Modular building	5	units	208,000.00	
Unit construction	400	m2	2,500.00	1,000,000
Modular installation & assembly on site	5	units	8,000.00	40,000
TOTAL A23 Roof Construction	**400**	**m2**	**2,600.00**	**1,040,000**

Project: Cape Dorset Wastewater Feasibility Study - Estimate 3 | File: PW-GM-R0
Location: - Cape Dorset NU | Date: 04-May-17
Owner/Client: Government of Nunavut | Project Number: 101764
Architect: exp Services inc. | Gross Floor Area (m2): 400

Description	Quantity		Rate	Amount
TOTAL A2 STRUCTURE				**1,040,000**
A3 EXTERIOR ENCLOSURE				
A31 Walls Below Grade				
Assumed no work required	1	nil	0.00	0
TOTAL A31 Walls Below Grade	**0**	**m2**	**0.00**	**0**
A32 Walls Above Grade				
Modular unit construction - see roof construction	1	nil	0.00	0
TOTAL A32 Walls Above Grade	**0**	**m2**	**0.00**	**0**
A33 Windows & Entrances				
Modular unit construction - see roof construction	1	nil	0.00	0
TOTAL A33 Windows & Entrances	**0**	**m2**	**0.00**	**0**
A34 Roof Covering				
Modular unit construction - see roof construction	1	nil	0.00	0
TOTAL A34 Roof Covering	**0**	**m2**	**0.00**	**0**
A35 Projections				
Exit stairs and landings	2	no.	29,600.00	
Exit landings	20	m2	300.00	6,000
Steel rock socketed piles (assumed) c/w caps and cross bracing to last	6	no.	5,200.00	31,200
Stairs	2	flts	5,000.00	10,000
Railings	30	m	400.00	12,000
Steel rock socketed piles (assumed) c/w caps and cross bracing	4	no.	5,200.00	20,800
TOTAL A35 Projections	**1**	**Sum**	**80,000.00**	**80,000**
TOTAL A3 EXTERIOR ENCLOSURE				**80,000**
TOTAL A SHELL				**1,536,000**

Description	Quantity		Rate	Amount
B1 PARTITIONS & DOORS				
B11 Partitions				
Modular unit construction - see roof construction	1	nil	0.00	0
TOTAL B11 Partitions	**0**	**m2**	**0.00**	**0**
B12 Doors				
Modular unit construction - see roof construction	1	nil	0.00	0
TOTAL B12 Doors	**0**	**no.**	**0.00**	**0**
TOTAL B1 PARTITIONS & DOORS				**0**
B2 FINISHES				
B21 Floor Finishes				
Modular unit construction - see roof construction	1	nil	0.00	0
TOTAL B21 Floor Finishes	**0**	**m2**	**0.00**	**0**
B22 Ceiling Finishes				
Modular unit construction - see roof construction	1	nil	0.00	0
TOTAL B22 Ceiling Finishes	**0**	**m2**	**0.00**	**0**
B23 Wall Finishes				
Modular unit construction - see roof construction	1	nil	0.00	0
TOTAL B23 Wall Finishes	**0**	**m2**	**0.00**	**0**
TOTAL B2 FINISHES				**0**

Project: Cape Dorset Wastewater Feasibility Study - Estimate 3
Location: - Cape Dorset NU
Owner/Client: Government of Nunavut
Architect: exp Services inc.

File: PW-GM-R0
Date: 04-May-17
Project Number: 101764
Gross Floor Area (m2): 400

Description	Quantity		Rate	Amount
B3 FITTINGS & EQUIPMENT				
B31 Fittings & Fixtures				
Modular unit construction - see roof construction	1	nil	0.00	0
TOTAL B31 Fittings & Fixtures	**0**	**m2**	**0.00**	**0**
B32 Equipment				
Assumed no work required	1	nil	0.00	0
TOTAL B32 Equipment	**0**	**m2**	**0.00**	**0**
B33 Conveying Systems				
Assumed no work required	1	nil	0.00	0
TOTAL B33 Conveying Systems	**0**	**no.**	**0.00**	**0**
TOTAL B3 FITTINGS & EQUIPMENT				**0**
TOTAL B INTERIORS				**0**

Altus Group

Project: Cape Dorset Wastewater Feasibility Study - Estimate 3
Location: - Cape Dorset NU
Owner/Client: Government of Nunavut
Architect: exp Services inc.

File: PW-GM-R0
Date: 04-May-17
Project Number: 101764
Gross Floor Area (m2): 400

Description	Quantity		Rate	Amount
C1 MECHANICAL				
C11 Plumbing & Drainage				
Plumbing and drainage for pre-fab structure including assembly & disassembling, testing, management, etc.	400	m2	187.50	75,000
Treatment Plant Equipment including assembly & disassembling, testing, management, etc.	1	ls	500,000.00	500,000
Transfer pump - duplex				
Storage tank				
Piping fittings, valves, c/w insulation, etc.				
Pumping controls				
TOTAL C11 Plumbing & Drainage	**400**	**m2**	**1,437.50**	**575,000**
C12 Fire Protection				
Fire Protection				
Building sprinkler and standpipe coverage-not required				
allowance for building fire extinguishers	1	ls	1,500.00	1,500
TOTAL C12 Fire Protection	**400**	**m2**	**3.75**	**1,500**
C13 HVAC				
Treatment plant HVAC	400	m2	437.50	175,000
TOTAL C13 HVAC	**400**	**m2**	**437.50**	**175,000**
C14 Controls				
HVAC control - BACNet and equipment controls	1	ls	40,000.00	40,000
TOTAL C14 Controls	**400**	**m2**	**100.00**	**40,000**
TOTAL C1 MECHANICAL				**791,500**

Project: Cape Dorset Wastewater Feasibility Study - Estimate 3
Location: - Cape Dorset NU
Owner/Client: Government of Nunavut
Architect: exp Services inc.

File: PW-GM-R0
Date: 04-May-17
Project Number: 101764
Gross Floor Area (m2): 400

Description	Quantity		Rate	Amount
C2 ELECTRICAL				
C21 Service & Distribution				
Normal Power				
Incoming feeder, etc. included in site services	1	ls	0.00	0
Meter socket (meter by utility)	1	no	4,100.00	4,100
Normal power distribution, equipment and feeders	1	ls	82,700.00	82,700
Reconnection and testing at site	1	no	10,100.00	10,100
Emergency Power				
Allowance for diesel generator, panel, transfer switch, feeders, tank and control wiring	1	ls	145,000.00	145,000
Reconnection and testing at site	1	no	5,300.00	5,300
Motor Controls & Wiring				
Motor Controls & Wiring	1	ls	9,400.00	9,400
Reconnection and testing at site	1	no	3,500.00	3,500
Miscellaneous				
Grounding	1	no	1,100.00	1,100
Grounding - at site	1	no	3,300.00	3,300
Permits, inspections & job setup	1	no	5,600.00	5,600
TOTAL C21 Service & Distribution	**400**	**m2**	**675.25**	**270,100**
C22 Lighting, Devices & Heating				
Lighting				
Lighting fixtures	1	ls	30,840.00	30,840
Combination of exit light & battery unit	2	no	610.00	1,220
Fixture wiring	1	ls	7,950.00	7,950
Lighting control, switches, photo cell & motion sensors	1	ls	3,120.00	3,120
Reconnection and testing at site	1	no	6,400.00	6,400
Branch Devices				
Branch devices	1	ls	8,850.00	8,850
Misc. connections	1	ls	1,400.00	1,400
Reconnection and testing at site	1	no	3,200.00	3,200
TOTAL C22 Lighting, Devices & Heating	**400**	**m2**	**157.45**	**62,980**

Project: Cape Dorset Wastewater Feasibility Study - Estimate 3
Location: - Cape Dorset NU
Owner/Client: Government of Nunavut
Architect: exp Services inc.

File: PW-GM-R0
Date: 04-May-17
Project Number: 101764
Gross Floor Area (m2): 400

Description	Quantity		Rate	Amount
C23 Systems & Ancillaries				
Fire Alarm System				
Allowance for fire alarm system c/w wiring	1	ls	10,000.00	10,000
Reconnection , verification and testing at site	1	no	5,900.00	5,900
Security System				
Allowance for CCTV camera c/w wiring	4	no	1,900.00	7,600
Allowance for access control c/w wiring	1	ls	6,900.00	6,900
Head end equipment	1	ls	8,000.00	8,000
Reconnection and testing at site	1	no	5,100.00	5,100
Communications				
Communications outlets c/w wiring	1	ls	2,100.00	2,100
Communication backboard and empty conduit	1	ls	900.00	900
Active hardware - by others	1	ls	0.00	0
Reconnection and testing at site	1	no	1,500.00	1,500
Miscellaneous				
Disconnect relevant electrical circuits to dismantle modular WTP unit for shipping	1	ls	2,400.00	2,400
Allowance for As-built drawings & manuals	1	no	1,100.00	1,100
WT Processing				
Instrumentation equipment, devices, wiring & programming	1	sum	108,300.00	108,300
Allowance for miscellaneous conduits, raceways and wiring	1	ls	54,950.00	54,950
Reconnection, verification, test and commission at site	1	no	93,400.00	93,400
Allowance for As-built drawings & manuals	1	no	1,100.00	1,100
TOTAL C23 Systems & Ancillaries	**400**	**m2**	**773.13**	**309,250**
TOTAL C2 ELECTRICAL				**642,330**
TOTAL C SERVICES				**1,433,830**
NET BUILDING COST (EXCLUDING SITE)				**2,969,830**

Project: Cape Dorset Wastewater Feasibility Study - Estimate 3		File:	PW-GM-R0
Location: - Cape Dorset NU		Date:	04-May-17
Owner/Client: Government of Nunavut		Project Number:	101764
Architect: exp Services inc.		Gross Floor Area (m2):	400

Description	Quantity	Rate	Amount
D11 Site Development			
Site modifications	1 allow	75,000.00	75,000
Filling station platform & building	36 m2	8,000.00	288,000
Tank base	1 no.	50,000.00	50,000
TOTAL D11 Site Development	**1 Sum**	**413,000.00**	**413,000**
D12 Mechanical Site Services			
Sewage on Site			
Storage tank	1 no	375,000.00	375,000
Piping c/w support, insulation, heating tracing, etc.	100 m	3,000.00	300,000
Testing and inspection	1 ls	6,500.00	6,500
Site coordination, management, etc.	1 ls	12,300.00	12,300
TOTAL D12 Mechanical Site Services	**1 Sum**	**693,800.00**	**693,800**
D13 Electrical Site Services			
Incoming Power			
Incoming service - pole mounted transformer, incoming			
Feeder and terminations - Hydro charges	1 no	95,000.00	95,000
103mm rpvc conduit	1 ls	9,000.00	9,000
Incoming Communications			
Incoming service - Allowance for Utility charges	1 no	5,000.00	5,000
Site Lighting & Power			
External lighting c/w wiring - allowance	1 no	15,700.00	15,700
TOTAL D13 Electrical Site Services	**1 Sum**	**124,700.00**	**124,700**

Appendix B – 20 Year Life Cycle Cost

20 Year Life Cycle Cost

Rehabilitation of P-Lake Lagoon

Year	Spending						Discount Rate		
	Lagoon	Lift Station	Forcemain			Total	2%	4%	8%
			Annual	Freeze	Repair				
1	58,000	201,000	76,600			335,600	329,020	322,692	310,741
2	58,000	201,000	76,600			335,600	322,568	310,281	287,723
3	58,000	201,000	76,600			335,600	316,243	298,347	266,410
4	58,000	201,000	76,600			335,600	310,043	286,872	246,676
5	58,000	201,000	76,600	198,000	500,000	1,033,600	936,163	849,544	703,451
6	58,000	201,000	76,600			335,600	298,003	265,230	211,485
7	58,000	201,000	76,600			335,600	292,160	255,028	195,819
8	58,000	201,000	76,600			335,600	286,431	245,220	181,314
9	58,000	201,000	76,600			335,600	280,815	235,788	167,884
10	58,000	201,000	76,600	198,000	500,000	1,033,600	847,912	698,263	478,757
11	58,000	201,000	76,600			335,600	269,911	217,999	143,933
12	58,000	201,000	76,600			335,600	264,618	209,615	133,271
13	58,000	201,000	76,600			335,600	259,430	201,553	123,399
14	58,000	201,000	76,600			335,600	254,343	193,801	114,259
15	58,000	201,000	76,600	198,000	500,000	1,033,600	767,980	573,921	325,834
16	58,000	201,000	76,600			335,600	244,466	179,180	97,958
17	58,000	201,000	76,600			335,600	239,673	172,288	90,702
18	58,000	201,000	76,600			335,600	234,973	165,662	83,984
19	58,000	201,000	76,600			335,600	230,366	159,290	77,763
20	58,000	201,000	76,600	198,000	500,000	1,033,600	695,583	471,722	221,757
Sub-Total						9,504,000	7,680,703	6,312,295	4,463,120
Capital	9,496,000					9,496,000	9,496,000	9,496,000	9,496,000
Total						19,000,000	17,176,703	15,808,295	13,959,120

20 Year Life Cycle Cost

Three Tier Lagoon

Year	Spending	Discount Rate		
		2%	4%	8%
1	58,000	56,863	55,769	53,704
2	58,000	55,748	53,624	49,726
3	58,000	54,655	51,562	46,042
4	58,000	53,583	49,579	42,632
5	58,000	52,532	47,672	39,474
6	58,000	51,502	45,838	36,550
7	58,000	50,492	44,075	33,842
8	58,000	49,502	42,380	31,336
9	58,000	48,532	40,750	29,014
10	58,000	47,580	39,183	26,865
11	58,000	46,647	37,676	24,875
12	58,000	45,733	36,227	23,033
13	58,000	44,836	34,833	21,326
14	58,000	43,957	33,494	19,747
15	58,000	43,095	32,205	18,284
16	58,000	42,250	30,967	16,930
17	58,000	41,421	29,776	15,676
18	58,000	40,609	28,630	14,514
19	58,000	39,813	27,529	13,439
20	58,000	39,032	26,470	12,444
Sub Total		948,383	788,239	569,453
Capital	50,502,000	50,502,000	50,502,000	50,502,000
Total		51,450,383	51,290,239	51,071,453

20 Year Life Cycle Cost

Mechanical Treatment Plant

Year	O&M	Discount Rate		
		2%	4%	8%
1	777,100	761,863	747,212	719,537
2	777,100	746,924	718,473	666,238
3	777,100	732,279	690,839	616,887
4	777,100	717,920	664,268	571,192
5	777,100	703,843	638,720	528,881
6	777,100	690,043	614,153	489,705
7	777,100	676,512	590,532	453,430
8	777,100	663,247	567,819	419,843
9	777,100	650,243	545,980	388,743
10	777,100	637,493	524,981	359,948
11	777,100	624,993	504,789	333,285
12	777,100	612,738	485,374	308,597
13	777,100	600,724	466,706	285,738
14	777,100	588,945	448,756	264,572
15	777,100	577,397	431,496	244,974
16	777,100	566,075	414,900	226,828
17	777,100	554,976	398,942	210,026
18	777,100	544,094	383,598	194,469
19	777,100	533,425	368,845	180,063
20	777,100	522,966	354,658	166,725
Sub Total		12,706,699	10,561,043	7,629,682
Capital	7,096,000	7,096,000	7,096,000	7,096,000
Total		19,802,699	17,657,043	14,725,682