Stantec

Biosolids Management Study

Draft

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1.0 INTRODUCTION

In August 2019, Town of Norman Wells engaged Stantec to develop a plan to estimate the sludge accumulated at the lagoon facility, characterize the sludge and develop a plan to manage the biosolids generated from the lagoon facility. This report describes the sludge survey results, characterization findings, biosolids management options evaluated, evaluation methodology and the recommendations for the biosolids management plan for the Town.

1.1 BACKGROUND

The community of Norman Wells (65° 17' N and 126° 50' W) is located in the Sahtu region of the Northwest Territories (NT) on the east bank of the Mackenzie River (**Figure 1.1**). It is approximately 685 km northwest of Yellowknife, NT.

Figure 1.1: Town of Norman Wells Sewage Lagoon

The wastewater treatment system in Norman Wells consists of a conveyance system for wastewater/sewage collection and an engineered Sewage Lagoon at Seepage Lake for wastewater treatment (**Figure 1.2**). The wastewater conveyance system includes an above-grade utilidor (with piping) and below-grade piping, sewage haul trucks, a sewage lift station, and a sewage forcemain. The Sewage Lagoon at Seepage Lake is located approximately 1 km north of the town centre. Initially, Seepage Lake was a natural wetland that was converted to an engineered Sewage Lagoon in 1987. The Sewage Lagoon at Seepage Lake is a bermed lake lagoon with two primary cells and a retention cell (Stantec 2018).

The Sewage Lagoon at Seepage Lake consists of two primary lagoon cells (110 m long by 45 m wide, 0.5 ha/cell) and a retention cell (1,086 m long by 285 m wide, approximately 28 ha) (**Figure 1.2**). The primary lagoon cells and berms have clay composite liners. Trucked sewage is discharged to the primary lagoon cells via a chute from a truck turnaround pad. The sewage forcemain ends at the two primary cells and flow from the sewage forcemain is controlled with a valve for each of the primary cells. An emergency overflow structure connects the two primary cells together, and two emergency overflow structures connect them to the retention cell (**Figure 1.2**).

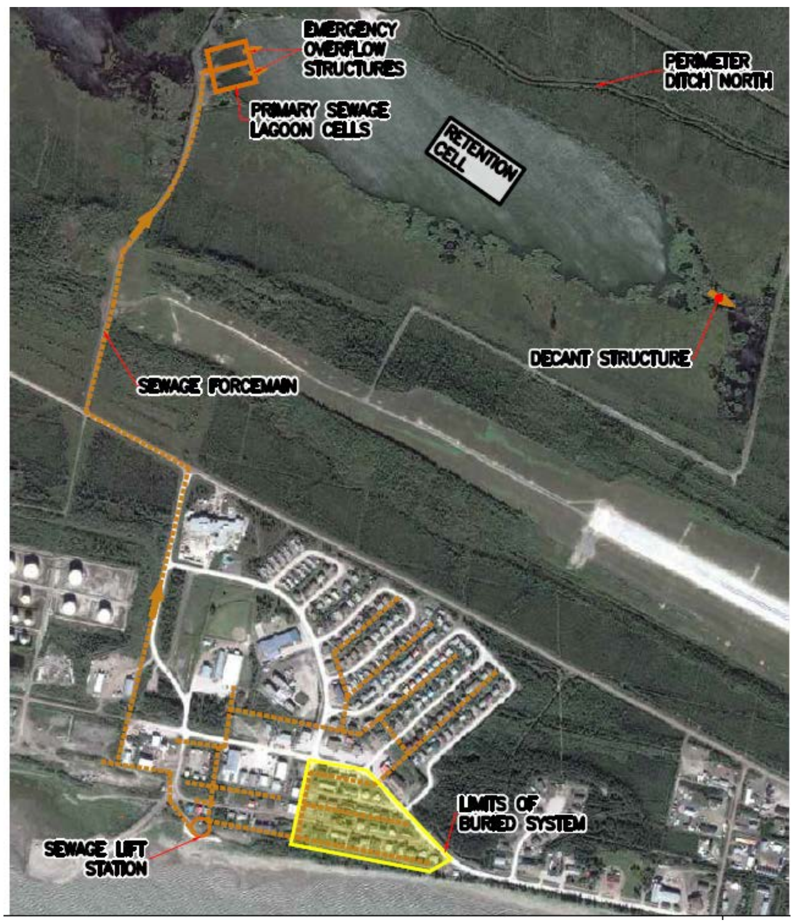

Figure 1.2: Town of Norman Wells Wastewater Flow Sequence

The Sewage Lagoon operates as a closed system and was designed to be discharged (decanted) annually into an adjacent natural wetland to the east through a control valve/decant structure where the Surveillance Network Program (SNP) station S07L3-002-1 is located (Water Licence Part D, Item 6) (**Figure 1.2**). Decanting has generally not occurred annually but every few years. The last decanting operation occurred in 2016 (Town of Norman Wells 2017), seven years after the previous decanting operation in 2009. The flow sequence of wastewater through the wastewater conveyance system is presented on **Figure 1.2**.

Construction details of the Lagoon system is given in the **Table 1.1.**

Table 1.1: Construction Details of the Lagoon System

Structure	Primary Cell 1	Primary Cell 2	Retention Cell
Liquid operating depth (m)	1.7	1.7	N/A
Active volume (m^3)	12,870	12,870	784,000
Hydraulic retention time (days)	6	6	365
Freeboard depth (m)	1	1	1
Berm height	2.6	2.6	2.8
Berm top width	3	3	51
Interior berm slope	2:1	2:1	2:11
Exterior berm slope	2:1	2:1	2:11

1.2 PROJECT SCOPE

Project scope include:

1. Coordinate an on-site sludge survey to estimate the accumulated sludge quantities. The sludge survey to be based on on-site sludge depth measurement from a number of locations.
2. Conduct a sampling program to collect samples from the accumulated sludge and preserve, transport and analyzed from a third-party laboratory. At least two composite samples should be collected covering both lagoon cells, where the sludge to be disposed from.
3. Analyze the sludge management options and recommendations. Analysis to include dewatering options and biosolids disposal options.

1.3 BIOSOLIDS QUANTITIES

1.3.1 Survey Methodology and Equipment

A sludge survey was completed for both Cell #1 and Cell #2 by Hydrasurvey in July 2019. To complete the survey, an infrared sludge interface detector (sludge gun) and RTK GNSS position were used to first map out the sludge blanket. The liners of the Cells #1 and #2 were then measured using a metered survey rod, along with GNSS positioning, at the same locations as the sludge gun. **Figure 1.3** shows a commercial grade inflatable inshore survey vessel that was used to access the lagoon cells. **Figure 1.4** shows the dual frequency multi-constellation (DFMC) RTK based and rover GNSS system used to for mapping the sludge blanket and the data collection. **Figure 1.5** shows an infrared sludge interface detector, along with an Ekman grab sampler and metered survey rod for sludge measurement.

Figure 1.3: Inflatable boat used to conduct sludge surveys in Norman Wells (Hydrasurvey, 2019)

Figure 1.4: GNSS base station setup (Hydrasurvey, 2019)

Figure 1.5: Sludge and liner measurement using sludge gun, GNSS and metered survey rod (Hydrasurvey, 2019)

The gridded interpolations of the liner depths/elevations as well as the infrared sludge detector data are summarized in **Section 1.3.2** The top of the sludge surface and lagoon liner surface were used to determine the sludge and water volumes.

1.3.2 Results

Based on the survey data collected by Hydrasurvey, the estimated total sludge volume that would need to be removed from both Cells #1 and #2 was calculated using software that compared the measured and interpolated sludge depths with the depths of the lagoon liner obtained from engineered drawings and/or field. The estimated sludge volumes and mass to be removed from each cell are summarized in **Table 1.2.**

Table 1.2: Lagoon sludge survey results (Hydrasurvey, 2019)

Cell	Number of Samples Analyzed per Cell	Total Estimated Wet Sludge Volume (m^3)	Total Estimated Dry Sludge Volume (m^3)	Total Estimated Mass of Sludge to be Removed (BDT)*
Cell #1	1	2,957	302	311
Cell #2	1	2,705	195	201

*BDT stands for Bone Dry Tonnes

1.4 BIOSOLIDS QUALITY

1.4.1 Sludge Sampling

1.4.1.1 Sampling Methodology

In order to analyze the sludge characteristics from Cell #1 and Cell #2, one composite sludge sample per cell was collected for lab analysis. This section summarizes the methodology used for collecting the sludge samples. Sludge samples were collected from three to four different locations at each cell to provide a good representation of the sludge characteristics from each cell, below the water line in the lagoon, as shown in **Figure 1.6**.

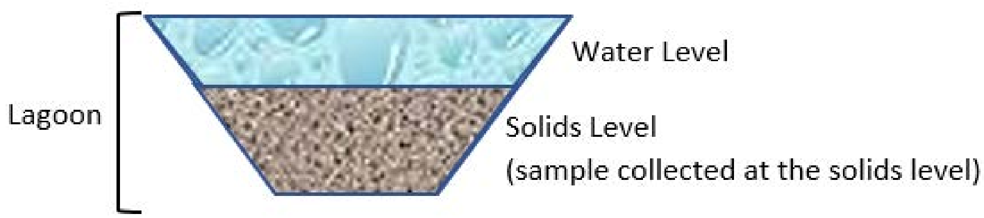

Figure 1.6: Sludge sample collection diagram

Sampling Equipment

The sampling equipment used for sludge collection consisted of the following:

- 6 Ziploc bags;
- 6 sample jars from ALS Laboratories Ltd. complete with the cooler;
- 2 standard sized buckets.
- 1 long pole (extendable up to 10 m).
- 2 measuring cup scoopers (2-cup capacity);
- Duct tape and scissors.

Sampling Steps:

The samples from Cell #1 and #2 were collected separately; however, the procedure was identical and was based on the steps as follows:

- A sludge collection device was prepared by duct taping one of the measuring cup scoopers to an extendable pole. This allowed for the collection of the sludge from the lagoon cells without the use of an inflatable boat.
- At each cell, specimens were collected from three to four different locations (depending on accessibility) and then placed into one of the two buckets. The intent was to collect several specimens from each cell to produce a representative composite sample.
- Once the specimens from the different locations within the cell were collected, the second measuring cup scooper was used to thoroughly mix the water and sludge mixture in the bucket. This produces

one composite sample for analysis. The mixture was then allowed to settle for 15 to 20 minutes to provide a fine layer of separation between the liquid phase (water) and the solids phase (soil).

- Following the settling of sludge within the mixture bucket, the water was decanted from the bucket by pouring it out into the second, empty bucket.
- Once the water was fully decanted from the sludge and water mixture, the sludge was placed evenly into the Ziploc bags and sample bottles to be shipped in the cooler to the lab for analysis.

Locations for Sample Collection at Each Cell

Figure 1.7 presents the different locations from which samples were collected at each cell, as denoted by the stars.

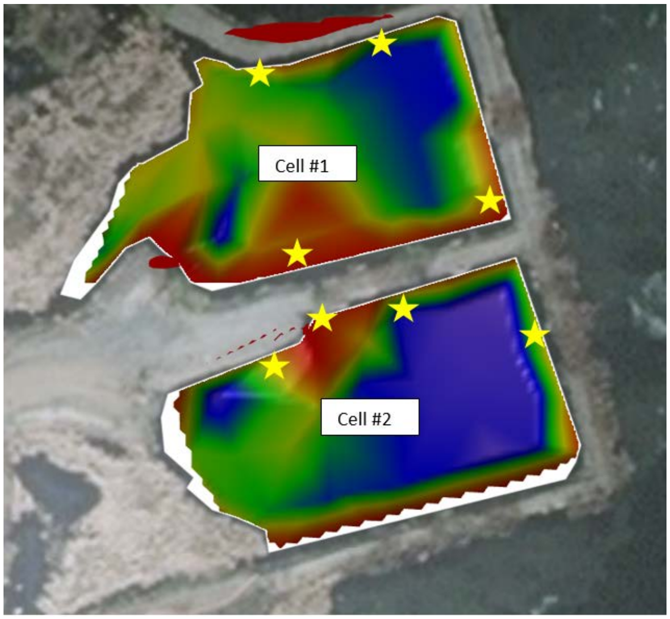

Figure 1.7: Cell #1 and Cell #2 Sample Collection Locations

1.4.1.2 Sampling Results

Following collection of the sludge samples from Cell #1 and Cell #2, a lab analysis was performed, and the results are summarized in **Table 1.3**.

Table 1.3: Cell #1 and Cell #2 Sludge Characterization Data

Parameter	Units	Samples	
		Cell #1	**Cell #2**
Physical Tests (Soil)			
% Moisture	%	87.0	89.5
Volatile Solids	%	34.3	35.9
Total Solids	%	13.6	10.2
Leachable Anions & Nutrients (Soil)			
Ammonia as N	mg/kg	1860	1880
Total Kjeldahl Nitrogen	%	1.41	1.29
Metals (Soil)			
Aluminum (Al)	mg/kg	33200	40700
Antimony (Sb)	mg/kg	2.97	2.97
Arsenic (As)	mg/kg	10.9	12.0
Barium (Ba)	mg/kg	257	303
Beryllium (Be)	mg/kg	0.68	0.78
Bismuth (Bi)	mg/kg	9.51	10.5
Boron (B)	mg/kg	5.8	7.9
Cadmium (Cd)	mg/kg	1.55	1.89
Calcium (Ca)	mg/kg	15000	15600
Chromium (Cr)	mg/kg	21.9	25.3
Cobalt (Co)	mg/kg	9.71	10.2
Copper (Cu)	mg/kg	405	455
Iron (Fe)	mg/kg	31600	34900
Lead (Pb)	mg/kg	23.7	30.6
Lithium (Li)	mg/kg	19.6	23.2
Magnesium (Mg)	mg/kg	6960	6620
Manganese (Mn)	mg/kg	165	196
Mercury (Hg)	mg/kg	0.235	0.308
Molybdenum (Mo)	mg/kg	18.5	16.6
Nickel (Ni)	mg/kg	47.9	49.9
Phosphorus (P)	mg/kg	7850	8420
Phosphorus (P)	ug/g	9290	9170
Potassium (K)	mg/kg	1290	1590
Selenium (Se)	mg/kg	3.73	3.66

Parameter	Units	Samples	
Silver (Ag)	mg/kg	0.97	1.59
Sodium (Na)	mg/kg	328	521
Strontium (Sr)	mg/kg	89.3	99.5
Sulfur (S)	mg/kg	18400	18900
Thallium (Tl)	mg/kg	1.21	1.33
Tin (Sn)	mg/kg	9.0	8.4
Titanium (Ti)	mg/kg	17.0	19.5
Tungsten (W)	mg/kg	<0.50	<0.50
Uranium (U)	mg/kg	5.95	6.17
Vanadium (V)	mg/kg	38.4	47.1
Zinc (Zn)	mg/kg	483	532
Zirconium (Zr)	mg/kg	3.8	3.9

A discussion of the above quality is presented in **Section 5.1.**

2.0 BIOSOLIDS PROCESSING AND UTILIZATION OPTIONS

2.1 SLUDGE VS BIOSOLIDS

The definitions of municipal biosolids, municipal sludge and treated septage vary across Canada. However, Canadian Council of Ministers of the Environment (CCME) defines municipal sludge and municipal biosolids as follows:

- **Municipal sludge:** a mixture of water and non-stabilized solids separated from various types of wastewater as a result of natural or artificial processes.
- **Municipal biosolids:** organic-based products which may be solid, semi-solid or liquid and which are produced from the treatment of municipal sludge. Municipal biosolids are municipal sludge which has been treated to meet to jurisdictional standards, requirements or guidelines including the reduction of pathogens and vector attraction.

Since there are no specific jurisdictional criteria for biosolids in the territory, CCME and US EPA biosolids criteria was used where applicable for the purpose of this report.

In addition to the financial capabilities of any given Town, the application of appropriate technology for biosolids processing and or utilization depends on the geology, terrain, climate and availability of the human resources to operate and maintain such facilities. Norman Wells conditions related to biosolids management are described herein.

2.2 CLIMATE

Norman Wells has a subarctic climate with summer lasting for about three months. Although winter temperatures are usually below freezing, every month of the year has seen temperatures above 0°C (32 °F). Rainfall averages 171.7 mm (6.76 in) and snowfall 161.5 cm (63.58 in). On average, there are 92.9 days, October to April, when the wind chill is below -30, which indicates that frostbite may occur within 10 – 30 minutes. There is an average of 35.9 days, November to April, when the wind chill is below -40, which indicates that frostbite may occur within 5 – 10 minutes.

Based on the 1981 to 2010 Canadian Climate Normals, the average annual precipitation in Norman Wells is 294.4 millimetres (mm), including 171.7 mm as rain and 161.5 centimetres (cm) as snow (Government of Canada 2018). As outlined in **Table 2.1**, the average daily temperature for January is -26.1°C (the coldest month) and July is 17.1°C (the warmest month; Government of Canada 2018).

Table 2.1: Climate for Norman Wells, NT (Government of Canada 2018)

Month	Average Daily Temperature (°C)	Precipitation (mm)
January	-26.1	15.6
February	-24.0	14.9
March	-18.4	10.7
April	-5.1	11.1
May	6.4	19.0
June	15.0	42.7
July	17.1	41.8
August	13.8	41.8
September	6.6	33.1
October	-4.7	26.7
November	-18.7	18.7
December	-23.4	18.2

2.3 GEOLOGY AND TERRAIN

Norman Wells area varies from low-lying forested plain to alpine mountainous terrain along the Norman Range, with bedrock exposures concentrated along the mountain ridges, and stream or lake outcrops. The geological interpretation in poorly exposed portions of the Mackenzie Plain has been enhanced by examination of public-domain seismic-reflection lines, archived with the National Energy Board. Cordilleran deformation from the southwest has triggered uplift of Cambrian and younger strata along reverse or thrust faults in the Franklin Mountains. The variation in trend of significant faults is believed to be due to the reactivation of older normal faults. To the southwest of the Norman Range, the Mackenzie Plain is dominated by folded Devonian and Cretaceous siliciclastic strata that have largely been planned off by glacial activity. The presence of the Saline River Formation, an evaporitic unit, in the hanging wall of larger faults suggests its involvement as a local detachment surface. An unconformity at the base of Upper Cretaceous strata cuts more deeply into underlying Lower Cretaceous and Devonian strata to the northeast, a reflection of uplift along the Keele Arch before deposition of the Slater River Formation.

Norman Wells terrain include river valley flat terrains leading to foothills and up to the mountain range.

2.4 HUMAN RESOURCES

A total of 315 people identified as Indigenous, and of these, 195 were First Nations, 80 were Métis, 15 were Inuit and 20 gave multiple Indigenous responses. The main languages in the town are North Slavey and English. Of the population, 78.1% is 15 and older, with the median age being 32.8, slightly less than the NWT averages of 79.3% and 34.0.

2.5 BIOSOLIDS PROCESSING VS BIOSOLIDS UTILIZATION

Biosolids processing can be categorized into two groups:

1. Technologies that reduce quantity, and
2. Technologies that improve quality

On the other hand, biosolids utilization include final disposal or utilization. Generally, more biosolids processing will result in more options being available for final utilization/disposal. The most common biosolids processing categories include:

1. Thickening (removing of water, end result varies but generally > 6% solids)
2. Dewatering (removing of water, end result varies but generally > 15% solids)
3. Drying (removing of water, end result varies but generally >60% solids), and
4. Digestion (stabilization).

An example schematic indicating the increased number of options resulting from further processing of biosolids is shown in the **Figure 2.1**.

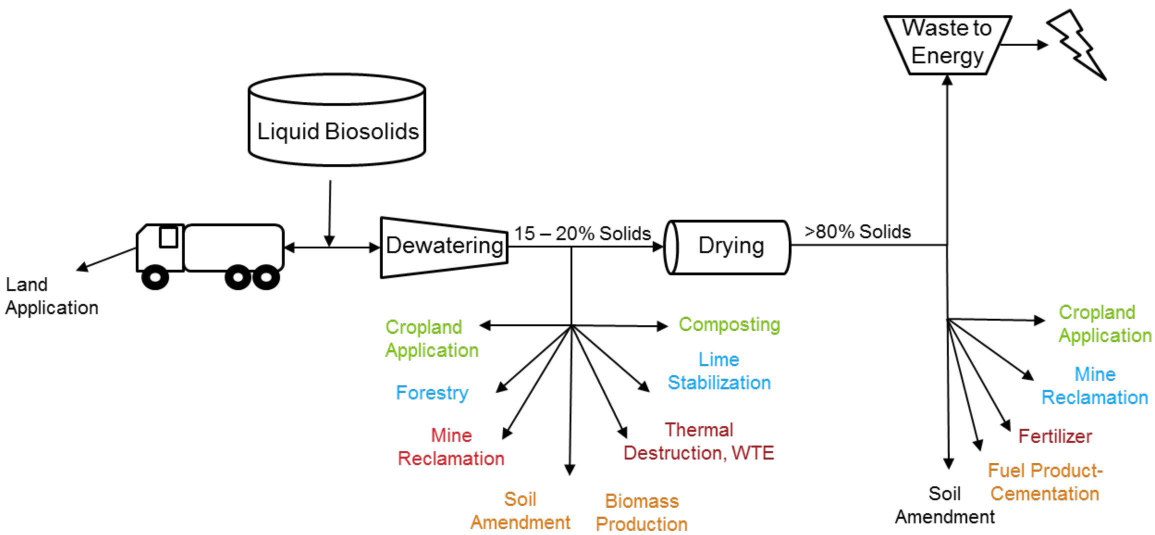

Figure 2.1: Biosolids Processing and Utilization Options

2.6 BIOSOLIDS PROCESSING OPTIONS

Biosolids can be dewatered utilizing dewatering technologies that are available in Norman Wells. Geotubes has also been a technology that is being used in the north to dewater sludges. Geotubes are particularly attractive to the Norman Wells as this is not a continuous operation. Biosolids stabilization or drying is not applicable as these technologies are suitable for where long term continuous sludge processing is required. As a result, dewatering utilizing:

- Rental equipment (such as centrifuge)

- Geotubes, and
- Freeze/thaw will be evaluated.

It should be noted that some utilization options such as marginal land application, dewatering prior to application may not be necessary.

2.6.1 Geotubes

Geotube dewatering tubes, sometimes known as geobags, are used for sludge dewatering projects of all sizes and there is good reason - simplicity and low cost. There are no belts, gears, or complicated mechanics. Geotube containers use an engineered textile that is designed for dewatering of high moisture content sludge and sediment. They are available in many sizes, depending on volume and space requirements.

Geotube technology operates in number of steps as described below:

- Step #1 **(Sludge conditioning) -** Dredge the sludge and condition the sludge with polymer to flocculate solids that will assist the dewatering process.
- Step #2 **(Filling) -** The Geotube container is filled with chemically conditioned sludge. Flocculated solids are retained by the fabric.
- Step #3 **(Dewatering) -** In the dewatering phase, excess water simply drains by gravity from the Geotube container. This filtrate will be re-directed to the long-term storage cell for further treatment.
- Step #4 **(Consolidation)-** Further consolidation of the sludge will happen due to various natural processes such as evaporation, freeze/thaw, etc.

After the consolidation phase (Step 4), the sludge will be suitable for a number of applications including landfill or marginal land application.

Regardless of the dewatering technology and the chemical conditioning selected, the following are very critical considerations:

- Optimum location and the preparation of the area for dewatering area and storage: Dewatering area has to be optimum with respect to receiving sludge from all places of the lagoon and accessible for vehicles and equipment and safe.
- Centrate or drainage management and release back to the lagoon in an environmentally acceptable manner and in compliance with the regulations. Centrate (if centrifuge is used) and filtrate (if geotubes are used) contain many contaminants such as pathogenic organisms, heavy metals, etc. and should be managed and discharged back to the lagoon.

Geotubes vary in circumference and length, and the setup used for sludge processing will depend on space availability and operational requirements. Based on the wet sludge volumes to be processed at Norman Wells and available products on the market, **Table 2.2** presents the potential geotube parameters and associated capacities that can be accommodated by each specific tube. As shown in **Table 2.2**, due to the variety of geotube lengths and perimeters available on the market, various combinations can be selected, making the application of geotubes for sludge processing a highly customizable design based on specific project requirements. While multiple choices are available, the ultimate selection will depend on available footprint and economic feasibility associated with each combination.

Table 2.2: Potential Geotube Options for Norman Wells

Cell	Length of Tube (m)	Geotube Circumference (m)	Available Capacity per Geotube (m^3)	Required Number of Geotubes
Cell #1	30	23	635	5
	30	27	772	4
	46	18	711	4
	46	23	952	3
	46	27	1158	3
	61	14	627	5
	61	18	948	3
	61	23	1269	2
	61	27	1544	2
	76	14	784	4
	76	18	1185	3
	76	23	1586	2
	76	27	1931	2
Cell #2	30	23	635	4
	30	27	772	4
	46	18	711	4
	46	23	952	3
	46	27	1158	2
	61	14	627	4
	61	18	948	3
	61	23	1269	2
	61	27	1544	2
	76	14	784	4
	76	18	1185	2
	76	23	1586	2
	76	27	1931	1

In **Table 2.2**, vendor recommendations are highlighted. Based on the vendor quotes, total area required are 8,400 m^2. In selecting the area, it is better Geotube area is as close as to the lagoon as both sludge pumping and filtrate pumping back distances are closer.

A sample picture is provided in **Figure 2.2** from the City of Iqaluit operation in 2019.

Figure 2.2: **City of Iqaluit Lagoon Sludge Management: Geotubes Being Filled**

Geotube sludge dewatering requires, lagoon sludge pumping to the Geotubes and filtrate or decant pumped back to the lagoon. **Figure 2.3** shows the sludge pumping operation in the City of Iqaluit and the decant/filtrate being pumped back to the lagoon.

Figure 2.3: **City of Iqaluit Lagoon Sludge Management: Sludge Pumping**

Figure 2.4: **City of Iqaluit Lagoon Sludge Management: Filtrate Collection**

2.6.2 Freeze/Thaw Dewatering

Freeze-thaw dewatering works on the principle that when sludge freezes, water molecules crystallize together forcing the solids and other impurities to the boundary of the ice crystal, where they become compressed or dehydrated (Metcalf and Eddy, 2003). During the thaw period, meltwater drains away freely through the network of channels between the consolidated particles, leaving a dewatered sludge. Simple gravity meltwater drainage during the thawing stage can reduce the volume of sludge by 85 to 96%, leaving a sludge cake ranging from 20% up to 82% solids. Sludge freeze-thaw beds together with a storage facility, such as a lagoon, tank, or digester to store the sludge in summer, can be used as the sole method of dewatering in cold regions.

Freeze-thaw can also reduce the concentration of pathogens and indicator organisms in wastewater sludges. It is postulated that cell injury and death caused by freeze-thaw is the result of two predominant mechanisms: osmotic effects resulting in cell dehydration, and intracellular ice formation, resulting in cell damage or rupture.

However, if the sludge to be freeze dried as is (without dewatering) a large freeze/thaw area will be required. Preliminary estimate is approximately 300,000 m^2 is required and is not recommended for the Town of Norman Wells.

2.6.3 Mechanical Dewatering with Rental Equipment

Mechanical equipment can be rented such as trailer mounted centrifuge with power supply for one time operation such as this. However, handling and storage of dewatered solids and or final utilization still required. Overall, it is our experience that Geotube dewatering is more economical.

2.6.4 Dewatering Recommendation

Considering the above, it is recommended to utilize Geotube technology to dewater the sludge from the existing lagoons at the Town of Norman Wells.

3.0 REGULATORY ASPECTS

Despite the many useful resources contained in the sewage sludge including organics and nutrients, the major sewage sludge characteristics that could potentially negatively impact environmental or public health include:

- Pathogenic micro-organisms,
- Heavy metals,
- Contaminants of Emerging Concerns, and
- Aesthetics such as odor and public perception issues.

As a result, many jurisdictions have developed regulations, guidelines and standards that govern the processing and utilization/disposal of sewage sludge generated from wastewater treatment facilities.

All of the northern territories (Yukon, Northwest Territories, and Nunavut) have legislation in place for the regulation and enforcement of waste disposal into water. The administration of the legislation is covered by Regional Water Boards. None of the territories have explicit legislation applying to the municipal sewage sludge. The input to the Water License was received from many stakeholders including the following regulatory bodies:

- Environment and Climate Change Canada (ECCC)
- Fisheries and Oceans Canada (FOC)

The main interests of ECCC and FOC is the water withdrawal and the marine discharge water quality criteria including potential marine discharges from any activities associated with the biosolids management. Conditions within the Mackenzie Valley and Water Board License related to the biosolids management may include:

- A preparation of an operation and maintenance manual for the Sewage Sludge Management Facility in accordance with the Guidelines for the Preparation of an Operation and Maintenance Manual for Sewage and Solid Waste Disposal Facilities in the Northwest Territories (GNWT, 1996).
- Measurement and recording of the monthly and annual volumes of sludge removed from the Wastewater Treatment Facilities.
- Provision of GPS co-ordinates (in degrees, minutes and seconds of latitude and longitude) of all locations of sources of Water utilized and Waste deposited under this Licence.
- Quarterly and annual monitoring of sludge generated from the wastewater facilities for following parameters:
  - Biochemical Oxygen Demand
  - Total and fecal coliform
  - Total Suspended Solids
  - Temperature
  - Conductivity
  - pH

- Nitrogen species
- Total phosphorus and orthophosphate
- ICP metals

As can be seen above, current regulations do not specifically encourage or discourage specific biosolids processing or utilization/disposal options. However, the Canadian Council for Ministers of the Environment (CCME) has a "Canada Wide Approach for the Management of Wastewater Biosolids". The approach has been developed by the Biosolids Task Group (BTG). The development of the approach included: legislative review, investigation of greenhouse gas emissions related to municipal biosolids management and emerging substances of concern in biosolids, and consultation with key stakeholders.

The desired outcome of the initiative was a harmonized policy and regulatory framework for municipalities and others who manage biosolids that protects the environment and human health and instills public confidence. The BTG of the CCME acknowledge in the document that: "An ongoing challenge to managing municipal biosolids is that, irrespective of end use, there are benefits, risks, and specific considerations for every municipal biosolids management option".

The policy statement states: "The Canadian Council of Ministers of Environment (CCME) promotes the beneficial use of valuable resources such as nutrients, organic matter and energy contained within municipal biosolids, municipal sludge and treated septage. With beneficial uses based upon sound management that includes:

- Substantiation of the resource value (efficacy),
- Adherence to federal, provincial and municipal standards and regulations,
- Strategies to minimize potential risks to the environment and human health,
- Minimizing emissions of greenhouse gases.

Beneficial use includes land application of municipal biosolids and treated septage to grow vegetation when it is done according to applicable regulations and best management practices. The BTG has prepared a Guidance Document for Beneficial Use of Municipal Biosolids, Municipal Sludge and Treated Septage to assist municipalities in meeting the policy statement and supporting principles.

3.1 BIOSOLIDS CLASSIFICATION

In the United States, as part of the mandate of Clean Water Act of 1987, US EPA developed 40 CFR Part 503 (the Rule or Regulation), Standards for the Use or Disposal of Sewage Sludge, establishes standards, which consist of general requirements, pollutant limits, management practices, and operational standards, for the final use or disposal of sewage sludge generated during the treatment of domestic sewage in a treatment works. Standards are included for sewage sludge applied to the land, placed on a surface disposal site, or fired in a sewage sludge incinerator. Also included are pathogen and alternative vector attraction reduction requirements for sewage sludge applied to the land or placed on a surface disposal site.

In addition, the standards include the frequency of monitoring and recordkeeping requirements when sewage sludge is applied to the land, placed on a surface disposal site, or fired in a sewage sludge incinerator. Under this regulation, biosolids that are intended for land application and surface disposal was classified under Biosolids Rule of 1993 as Class A and Class B and are described below. In the absence of their own regulations, many jurisdictions in the world including many Provincial regulatory bodies in Canada has adopted this approach.

3.1.1 Class A Biosolids

Class A contains low levels of metals, very low levels of pathogens, and do not attract vectors. There are no requirements regarding buffer zones, crop type, crop harvesting and site access if used in small quantities by the general public. When used in bulk, Class A biosolids are subjected to buffer requirements. Some of the general characteristics associated with Class A include:

- A stable end-product and the highest rating for biosolids,
- Can be land applied without any pathogen-related restriction at the site,
- Can be marketed to the public for application to lawns and gardens.

As an example, Province of British Columbia, Ministry of Environment, Class A Biosolids pathogen limit is Fecal coliforms < 1,000 MPN/g. The other jurisdictions also use very similar parameters.

3.1.2 Class B Biosolids

Class B sludge is treated but can contain compliant amounts of pathogens. Class B requirements include to protect public health and the environment from pathogens. Application of Class B biosolids is subjected to buffer requirements, public access limitations and application and crop harvesting restrictions. Some of the general characteristics associated with Class B include:

- Have a more limited application,
- Typically require a ‘resting period’ prior to use of land by public or for agricultural crops,
- Types of crops it can be applied on may be limited.

As an example, Province of British Columbia, Ministry of Environment, Class B Biosolids pathogen limit is Fecal coliforms < 2,000,000 MPN/g.

In addition to pathogenic parameters, the concentration of heavy metals is also specified for Class A and Class B biosolids and are listed in the following table (**Table 3.1**).

Table 3.1: Class A and Class B Biosolids Metal Concentrations

Metal	Class A Biosolids, Micro-g/g*	Class B Biosolids, µg/g	Norman Wells Average mg/g
Arsenic	13	75	11.5
Cadmium	3	20	1.7
Chromium	100	1,060	23.6
Cobalt	34	150	10.0
Copper	400	2,200	430
Lead	150	500	27.2
Mercury	2	15	0.3
Molybdenum	5	20	17.6
Nickel	62	150	48.9
Selenium	2	14	3.7
Zinc	500	1,850	507.5

* Estimated based on a total of 200 dry tonnes/ha application rate

It should be noted that based on the metal concentrations, the primary sludge generated from Norman Wells meets the Class B criteria. Sludge meets metal Class A criteria except for Molybdenum. The implication of this is that further treatment of the Town of Norman Wells biosolids to further reduce pathogens and vector attraction should most likely result in meeting US EPA Class A biosolids requirements for both metals and pathogens.

3.2 STAKEHOLDER DIALOGUE

There are large number of stakeholders who have an interest in the Town of Norman Wells's Sewage Sludge Management Plan. Previous studies has identified a number of both regulatory and community stakeholders and are listed below. This list will be finalized in consultation with the Town personnel, prior to the starting of the stakeholder dialogue.

Regulatory Stakeholders

- Mackenzie Valley Land and Water Board
- Indigenous and Northern Affairs Canada (INAC)
- Environment and Climate Change Canada (ECCC)
- Fisheries and Oceans Canada (DFO)

It is anticipated that as part of the stakeholder dialogue, the draft sewage sludge management plan will be circulated for review and input. In addition, a workshop will be convened with the stakeholders to receive the input and comments.

4.0 AVAILABLE OPTIONS FOR FINAL UTILIZATION

4.1 INTRODUCTION

This section provides an overview of the fundamental categories of options for ultimate use and/or disposal of biosolids generated by the Town of Norman Wells. The benefits and drawbacks of each option are explained and relevance to the Town of Norman Wells is discussed. The following options are included in the analysis:

- ***Land Application and Soil Amendment Alternatives***
  - Agricultural land application
  - Land application to non-agricultural land
  - Biomass production
  - Composting
  - Soil Product production
  - Lime stabilization
  - Biosolids drying and use of end-product
  - Use for landfill cover
  - Lagoon Storage
- ***Energy Production Alternatives***
  - Biocell
  - Biosolids for fuel:
    - Cement kiln
    - Coal fired power plant
  - Thermal Options
    - Biosolids incineration (Thermal oxidation)
    - Gasification
    - Bio-oil production
    - Wet Oxidation
    - Solid fuel processes
    - Liquification (fertilizer)
    - Biocrude Production

Energy production alternatives are not applicable to the Town of Norman Wells as this is a one-time application and the sludge is not produced continuously. Therefore, energy production alternatives are not discussed any further. Applicable options are discussed below.

4.2 LAND APPLICATION AND SOIL AMENDMENT ALTERNATIVES

Conventional chemical fertilizers are used to increase plant yield. Biosolids fill this same objective but also provide additional benefits to the soil while requiring less energy for production (compared to that of chemical fertilizer production). These advantages of biosolids over conventional fertilizers are outlined in **Table 4.1**.

Table 4.1: Comparison of Chemical Fertilizer and Biosolids

Fertilizer Comparison	Chemical Fertilizer	Biosolids
Provides Nitrogen	√	√
Supplies Micronutrients	-	√
Slowly releases nutrients	Occasionally	√
Introduces Organic matter	-	√
Increases soil water holding capacity	-	√
Emits GHGs during production	√	-*
Rehabilitates damaged soil	-	√
Sequesters carbon	-	√

* There is net reduction in GHG emissions

Biosolids contain plant nutrients, such as nitrogen, phosphorous, and sulphur, in organic and inorganic forms. The inorganic forms are immediately available to plants. Nutrients in the organic form are released slowly as the biosolids decompose in the soil, providing plants with nutrients throughout the year when additional fertilizer application is prohibited. The slow release of nutrients gives biosolids an advantage over chemical fertilizers, which only supply nutrients for a short period. Biosolids also supply needed micronutrients such as zinc, copper, boron, molybdenum, manganese, and iron. The availability of these nutrients results in plant growth yields much higher than what can be achieved through conventional fertilizers.

The recently completed CCME policy statement recognizes the valuable nutrients and organic matter content of biosolids and encourages municipalities to take advantage of the beneficial uses for biosolids in development of their biosolids management plans. Available land application alternatives are presented and the applicability to the Town of Norman Wells conditions are discussed here.

4.2.1 Agricultural Land Application

One end-use option is to land-apply the biosolids on private land as a fertilizer and soil conditioner. The agronomic biosolids application rate can be customized to supply the optimal amount of nutrients for the planned cropping system to minimize environmental impacts due to nutrient runoff. Benefits of land application on agricultural and forest land have been demonstrated in numerous research and full-scale projects. Land application of biosolids is a widespread practice (examples include Calgary, Winnipeg, Regina, Vancouver and Seattle). In many jurisdictions, agricultural land application is considered a more environmentally responsible approach to biosolids management relative to other available alternatives.

The key advantages and disadvantages of land application of biosolids are given in **Table 4.2.**

Table 4.2: The Advantages and Disadvantages of Land Application of Biosolids

Advantages	Disadvantages
Offset commercial fertilizer use, expense, and reduce GHG emissions from inorganic fertilizer production	Transporting the solids to a rural land application Site
Sequester carbon in soil	Strict provincial regulatory standards limit for Application
Reclamation of land: mine, fire damage, deforestation, roadside rehabilitation	Potential for odour
Improved plant yield due to presence of essential macro and micro nutrients	Public perception
Slow release of nutrients from organic forms allowing fertilization for longer periods of time	Large land area required
Increase soil organic matter which improves soil structure and water holding capacity	Individual permits required for each land application site
Increased earthworm and soil microbial activity	

Typically, agricultural land application uses thickened (4 to 8%) biosolids to apply to land utilizing liquid application trucks (manure spreaders). A picture showing liquid biosolids application to agricultural land is presented here as **Figure 4.1.**

Figure 4.1: Liquid Biosolids being Applied to Agricultural Land

Sludge thickening removes some of the water contained in biosolids to produce a product with 4% to 8% solids concentration. The dewatering process removes a greater amount of water resulting in an even greater solids concentration of between 15 and 30%. Town of Norman Wells expected dewatered biosolids concentration is 15%. The increase in solids concentration is accompanied by a volume reduction. A doubling in biosolids solids concentration results in an approximate halving of total volume.

Land application of dewatered biosolids offers similar benefits as the application of liquid biosolids. It is technically feasible to land apply dewatered biosolids (up to 30%) using available solid injection equipment. A picture showing dewatered biosolids being spread on agricultural land is included here as **Figure 4.2.**

Figure 4.2: Dewatered Biosolids being Applied to Agricultural Land

One potential advantage of application of dewatered biosolids includes the reduction in transportation costs (due to the reduction in biosolids volume transported). In addition, the processing and transport of dewatered biosolids (not weather or seasonal dependent) could be de-coupled from the application window by storing dewatered biosolids on-site prior to application. Some of the advantages of land application of dewatered biosolids include:

- Possible to transport to the area of application most of the year (subject to roads),
- There is a significantly larger application window available,
- Safer to work with (due to working with solids as opposed to liquid),
- Easier to manage accidents compared to liquids.

These advantages need to be weighed against the additional cost of dewatering. With little or no agriculture industry in Norman Wells, this technology is not suitable.

4.2.2 Land Application to Non-Agricultural Land

The feasible non-agricultural land application alternatives include:

- Biomass/biofuel production,
- Landfill closure and daily cover,
- Marginal land conversion, and
- Mine reclamation.
- Of the non-agricultural land application options, biosolids use in marginal land conversion, mine reclamation, and biomass production may be applicable for the Town of Norman Wells.
- The advantages and disadvantages of non-agricultural land application are presented in **Table 4.3.**

Table 4.3: Advantages and Disadvantages of Non-Agricultural Land Application of Biosolids

Description	Comments	Advantages	Disadvantages
Non-agricultural land application: Use of thickened and dewatered biosolids in non-agricultural applications.	Trucked biosolids require spreading and, in some applications, incorporation into soil.	Low capital costs.	Regulatory approval uncertain.
	Main end applications include mine reclamation, marginal land enhancement and Silviculture.	Potential nutrient recycling in Silviculture.	Longer distance hauling will be required in the future increasing GHG emissions.
		Can be applied in large quantities in mine reclamation applications.	One-time applications.
		Environmental and public relational benefits.	Applications such as mine reclamation is one-time applications only.

Biomass production such as willow coppice production and marginal land conversion application rates are much closer to the agricultural land application rates (~25 DT/ha range). However, one-time applications such as landfill closure and mine reclamation options have a very high application rate (150 to 200 DT/ha or more).

Mining has been a central industry in Canada for more than 100 years. However, only recently has legislation been adopted holding miners accountable for the decommissioning and remediation of mining sites. Subsequently, more than 10,000 abandoned mine sites require rehabilitation across Canada (NOAMI, 2009).

Mining activities degrade the soil, producing large areas of disturbed land. Re-vegetation of cleared areas is necessary to improve aesthetics and reduce spreading of mine tailings and soil erosion. Re-establishment of vegetation on disturbed sites proves difficult for many reasons including the following:

- Lack of nutrients due to low cation exchange capacity,
- Disturbed soils have poor water-holding capacity creating drought conditions for plants,
- Phytotoxicity due to the presence of metals and acidic pH drainages,
- Little to no soil biological activity.

Biosolids have a documented success record as an amendment in remediation operations in other jurisdictions. Biosolids contain 50%–60% organic matter and high nutrient concentrations necessary for re-establishment of plant life. Addition of organic matter improves the water-holding capacity of the soil and provides a matrix to bind and store nutrients. Slow release of nutrients from the biosolids matrix supports the plants for longer than conventional fertilizers, keeping the mine site stabilized. Biosolids are applied at rates much higher than agronomic levels because the biosolids are used to establish a soil-like system instead of merely supplementing an already productive agricultural soil system. **Figure 4.3** shows photographs of the Sechelt gravel mine site before and after remediation with biosolids.

A major advantage of remediating mine sites with biosolids is the potential for greenhouse gas (GHG) credits. A large carbon sequestration credit can be achieved by re-establishing a productive land site. One disadvantage of reclamation as an end-use option is that a disturbed site requires a limited number of solids applications to restore the site. Once a site has been rehabilitated, another site must be identified for continued biosolids reuse.

Figure 4.3: Before-and After Picture of Reclamation at Sechelt Gravel Mine (Van Ham)

There are some gravel pits within the Town of Norman Wells and therefore a potential exists for use of biosolids or compost for gravel pit reclamation.

4.2.3 Biomass Production (Willow Coppice)

Coppice refers to the commercial production of trees through short-rotating growth and harvest periods. Once established, trees are harvested every 1 to 4 years for biomass. The wood biomass is chipped and combusted for energy production. The heat value of willow is 19.92 kJ g-1 dry matter. The amount of carbon released during cultivation and transport of trees is roughly equal to the carbon input into the soil. This is due to the fact that the new trees in the rotation are propagated from the stumps of harvested trees. The underground biomass or roots remain and decompose adding carbon to the soil. Therefore, coppice production is carbon-neutral and burning of wood chips can offset fossil fuels to reduce emission of GHGs to achieve a negative carbon footprint.

Application of biosolids provides many benefits to the production of short rotation woody crops (SRWC) for biomass. Substituting inorganic N fertilizer with biosolids can increase biomass production and decrease operational costs. A secondary benefit is that the organically bound fraction of nutrients in biosolids are released slowly, making them available for longer into the SRWC rotation when additional amendment application is prohibitive.

Figure 4.4: 3-month old Willow (left) and Harvesting of Willow (right)

Due to the polar climate tree growth in the Town is very limited and biomass production may not be a viable alternative.

4.2.4 Composting

Composting typically requires mixing biosolids with a carbonaceous bulking agent such as sawdust, wood chips, or ground woody yard debris. Composting can be a treatment process using time and temperature to produce a final product that meets Class A pathogen reduction criteria and is highly marketable. Advantages and disadvantages of composting are given in **Table 4.4**.

Table 4.4: Advantages and Disadvantages of Composting

Description	Comments	Advantages	Disadvantages
Co-composting with Municipal Solid Waste: Composting of dewatered biosolids taken from the Clover Bar lagoon and composting with either acceptable MSW and or woodchips/grass clippings.	The options include the in vessel composting, Gore membrane and windrow composting.	Staff familiar with the operation.	Subject to availability of acceptable quality MSW or wood chips.
	End markets include number of niche markets including agriculture fertilizer, bedding materials, industrial absorbents, soil blending materials, erosion control applications.	Possible to utilize some of the existing infrastructure.	Requires large foot print for the curing and storage area (moisture deficit outdoor environment in Winter)
		Class A biosolids.	Variable demand subject to weather.
		Marketable in number of niche markets.	Increased odor generation.
		Can be used for mine reclamation and/or landfill reclamation.	
		Nutrient recycling.	
		Environmental and public relational benefits.	

As the existing information indicates, if the compost meets Class A requirements, composts can be utilized in:

1. Landfill cover,
2. Gravel pit and possible marginal land reclamation,
3. In green houses, and
4. Limited landscaping applications

Composting is not recommended for the Town of Norman Wells as this is a one time application and the equipment and infrastructure (Pads etc.) cannot be justified.

4.2.5 Soil Product Production

Biosolids blended with sawdust, woodchips, yard clippings, or crop residues make excellent mulches and topsoils for horticultural and landscaping purposes. The proposed project soil product will consist of 2 parts dewatered cake, 2 parts sawdust, and 1-part sand assuming Class A biosolids are produced. Alternatively, thermally dried biosolids can be mixed with smaller amounts of amendment. Sand is used to increase porosity, provide structure, and improve drainage. The sawdust is a bulking agent that provides airspace, makes the mixture more permeable, and serves as a moisture absorbent. In addition, the sawdust helps mediate the C:N ratio. A maximum C:N ratio of 30:1 prevents drawing nitrogen from the plants when using the biosolids as a soil conditioner as well as minimizing the release of nitrous oxide (N_2O), a potent GHG. The off-gassing of properly aerated and conditioned biosolids is primarily CO_2 and water vapor.

Production of a topsoil amendment requires minimal processing. Dewatered Class A cake or dried product is manually mixed with sawdust and sand at the appropriate ratio. The material is then screened to produce the final product.

Due to the limited supply of sand and due to the potential low demand for the end product, it may not be a viable technology for the Town of Norman Wells.

4.2.6 Lime Stabilization (Alkaline Stabilization)

Alkaline treatment processes typically raise the pH of biosolids above 12 for 2 hours to reduce pathogens. According to the U.S. EPA, lime stabilization has been demonstrated to effectively eliminate odours, improve bacterial and pathogenic organism control, and provide stable material for application to agricultural land. However, if the pH drops below 11, biological decomposition will resume and produce odour.

The principle advantages of alkaline stabilization over other processes are low cost and simplicity of operation. The liming agent provides the pathogen kills, negating the necessity for digestion. Lime stabilization can also accommodate major fluctuations in solids production. More advanced processes include time and temperature to provide further pathogen reduction and produce a Class A process. A disadvantage to alkaline processes is that the quantity of biosolids required for disposal is not reduced; in fact, the opposite occurs, and the mass of the solids increases with lime addition. This can increase the cost for transport.

Due to the remote location of the Town of Norman Wells, lime transportation will be prohibitively expensive and would not be environmentally friendly due to long distance transportation. Therefore, lime stabilization may not be an attractive option for the Town of Norman Wells.

4.2.7 Use as Landfill Cover

Biosolids land application for use at a landfill could fit two purposes: incorporation of biosolids into the final vegetative cover design and the use of biosolids as a landfill gas mitigation barrier. In the case of the vegetative cover, biosolids provide soil tilth, as well as some initial slow release fertilizer to any vegetation (e.g. native grasses) that is planted. For the landfill gas mitigation, biosolids in the final cover would be used to provide a “seed” of bacteria that convert methane to carbon dioxide and water. Many jurisdictions require landfill cover materials to at least meet Class A criteria to minimize the risk of pathogen exposure to the human and wildlife. Therefore, composting (that will convert sludge to Class B biosolids or Class B biosolids to Class A Compost) of biosolids is an acceptable method to apply as landfill cover.

This can be a very attractive option for the Norman Wells.

4.2.8 Lagoon Storage

Lagoon storage is a simple and economical method, however, cannot be considered as a sustainable final utilization option. Sludge lagoon could be a source of significant odor and could contribute to the groundwater pollution unless protective measures such as liners and groundwater monitoring is implemented. Many communities are in the process of elimination of sludge storage lagoons. Lagoon storage cannot be considered a final utilization option and therefore not considered a suitable long-term option.

Table 4.5 summarizes and compares land application and soil amendment alternatives.

Table 4.5: Summary of Land Application and Soil Amendment Options

Alternative	Biosolids Classification Requirements	Application Rate, Tonnes/ha	End-Product
Agricultural Land Application	Class A or Class B	25-50	Crop or agricultural product
Land Application to Non-agricultural Land	Class A or Class B	150-200	Land reclamation
Biomass Production	Class A or Class B	25-50	Biomass/wood chips
Composting		No limit	Compost
Soil Product Production	Class A	No limit	Soil Product/Soil Conditioner
Lime Stabilization	Class A or Class B	25-50	Fertilizer
Biosolids Drying and use of End-product	Class A or Class B	Use as fuel has no limit, use as fertilizer 25-50	Fertilizer/Fuel
Use for Landfill Cover	Class A	150 – 200	Landfill cover
Lagoon Storage	Class A or Class B	Not applicable	Temporary storage

5.0 TECHNOLOGY SCREENING – FINAL UTILIZATION OPTIONS

One of the primary objectives of this section is to identify the preliminary requirements and propose screening criteria for the alternatives listed. Screening criteria (Pass/Fail Criteria) is important to screen the large number of sewage sludge utilization options available. Limiting the number of options for detailed analysis make it an effective and efficient process. In selecting the screening criteria, the Town of Norman Wells's commitment to public health safety and protection of the environment as well as sustainability was used as the guiding principles.

The proposed screening (pass/fail) criteria are summarized in **Table 5.1**.

5.1 SCREENING CRITERIA

Table 5.1: Preliminary Screening Criteria for Final Utilization Options

Category	Criterion 1	Criterion 2	Criterion 3	Criterion 4
Primary Options	Meets Beneficial use criteria	Uses Proven Technology	Proven economy for small systems	Applicable for Polar Climate

The description of pre-screening criteria is provided below:

Criterion #1: Meets Beneficial Use Criteria

As per the CCME beneficial criteria, beneficial uses include any form of energy recovery or other resources recovery such as organic and/or nutrients. However, in the case of Norman Wells, use of these materials for landfill cover can also be considered as a beneficial use.

Criterion #2: Proven Technology

The technologies should not be emerging technologies and must have proven track record with known biosolids processing for at least 5 years.

Criterion #3: Proven Economy for Smaller Systems

The technology must be proven with smaller systems like the Town of Norman Wells. Some technologies that are sustainable for larger facilities may not necessarily be economically sustainable for small facilities.

Criterion #4: Applicable for Polar Climate

Technologies that are suitable for warmer climates are not necessarily applicable for the polar climate. The technologies that pass these criteria should be acceptable for used in polar climate.

Screening (Pass/Fail) summary is shown in **Table 5.2.**

Table 5.2:Technology Screening Summary – Final Utilization Options

Option	Meets Beneficial use criteria	Uses Proven Technology	Proven economy for small systems	Applicable for Polar Climate
Agricultural Land Application	Yes	Yes	Yes	No
Land Application to Non-agricultural Land	Yes	Yes	Yes	Yes
Biomass Production	Yes	No*	Yes	No
Composting	Yes	No*	Yes	Yes
Soil Product Production	Yes	Yes	Yes	No
Lime Stabilization	Yes	Yes	No	Yes
Use for Landfill Cover	Yes	Yes	Yes	Yes
Lagoon Storage	No	Yes	Yes	Yes

*Not suitable due to non-continuous sludge generation

The technology options that passed the pre-screening process is summarize below:

1. Land application to non-agricultural land
2. Composting, and
3. Use as landfill cover.

5.2 DESCRIPTION OF SCREENED OPTIONS

The above options are described below within the Norman Wells context.

Land application to non-agricultural land

Land application to non-agricultural land include marginal land reclamation, gravel pits and other mine reclamation. In a general sense, marginal refer to land of poor quality for agriculture or susceptible to erosion or other degradation. There are significant marginal lands available within the vicinity of Norman Wells and as such this could be a suitable option. However, generally sludge must meet Class B criteria and Class A criteria is preferred. Generally, technologies such as composting can convert the Class B biosolids into Class A. Therefore, if composting or dewatering and drying is selected as the technology, land application to marginal lands could be a suitable option.

Composting

There are a number of composting technologies that are available with various levels of complexity and automation. The most common three categories include:

1. Windrow composting
2. Aerated Static Pile (ASP) composting

3. In-Vessel composting

In addition, generally the compost process can produce high quality compost (Class A or Class B) which are allowed to apply without restrictions controlling the public exposure. Therefore, for example, composting process will produce a product that can be applied as the landfill cover. Also, compost could also be utilized by the greenhouses within the Town.

However, due to the fact that this sludge generation from the lagoon is intermittent (as opposed to from a mechanical plant), capital expenditures required for equipment, land preparation and potential buildings cannot be justified.

Use as Landfill cover

Biosolids can be used as a landfill cover. However, as indicated above, raw biosolids are not suitable for landfill cover due to handling difficulties and due to potential health and environmental risks. However, after dewatering and drying biosolids are suitable for landfill cover. Therefore, it is recommended to keep this option for further analysis.

6.0 SCREENED OPTIONS

Based on the discussion above, following options are selected for further analysis. The final utilization could be any combination of depending on the demand in any given year:

- As landfill cover, and
- Marginal land reclamation.

Conceptual designs for the above options are described below.

6.1 RECOMMENDED CONCEPT

Based on the above analysis, it is recommended to utilize Geotube technology for dewatering and natural freeze/thaw drying. The dried solids to be used either as landfill cover and or marginal land reclamation.

6.2 PROPOSED OPERATING AREA

There are number of planning considerations that must be taken into account. The key considerations are given below:

- Access should be easy from the existing lagoons for both sludge pumping out of the lagoon and filtrate pumping/gravity flow back to the lagoons
- Must meet the Town of Norman Wells land use designations.

6.3 PROPOSED FACILITIES

Since this is a onetime operation, it is not recommended to purchase the equipment. The options are renting the required equipment and operation by Town personnel or the entire operation can be third-party contracted. Proposed facilities and major equipment include:

- Geotube land area approximately 8,400 m^2. Lined and sloped for the collection of filtrates.
- Geotubes (76 m X 18 m three tubes and 76m X 14 m four tubes) - Purchase
- Sludge pumps – Rental
- Polymer feed units - Rental
- Front end loader to move sludge towards the pump suction and to move dried material – rental

Given the limited, personnel capacity within the Town, it is recommended that the entire operation be tendered to a third-party contractor through a competitive process.

6.4 RECOMMENDED SCOPE OF WORK

Recommended scope of work for desludging the lagoons and dewatering utilizing Geotebe technology include:

- Permitting and environmental approvals
- Sludge characterization – confirmation
- Polymer selection and on-site tests
- Land preparation and liner installation
- Supply of Geotubes
- Transport, installation and uninstallation of following equipment:
  - Farm Tractors
  - Lagoon Pumps
  - Polymer feed unit
  - Flexible pipes
  - Filtrate pump and piping
- Rental of front-end loader to move sludge
- Supply of fuel/power supply and chemicals
- Lodging for the crew
- Portable toilet facilities for the crew
- Sample shipping and external laboratory analysis

6.5 BUDGET COST ESTIMATE

Desludging operation (equipment, manpower, mob/demob, food lodging etc)	$700,000
Geotube Pad Preparation and liner	$600,000
Geotube supply	$100,000
Miscellaneous (shipping, markup, lab costs etc)	$400,000
Final application (after drying)	$200,000

Estimated cost for the above scope of work is **$2.0**M.

6.6 OPERATIONAL CONSIDERATIONS

6.6.1 Final Utilization

Final dewatered product will be used for daily cover or for landfill closure. If there is demand, can also be utilized for application to improve soil quality within the marginal lands.