Land and Water Boards of the Mackenzie Valley

Guidelines for Municipal Sludge Management for Passive Sewage Treatment Systems in the Northwest Territories

August 12, 2022

Table of Contents

Figures

Tables

Definitions

Deposit of Waste - As defined in section 1 of the MVRMA: a deposit of waste in any waters in the Mackenzie Valley or in any other place under conditions in which the waste, or any other waste that results from the deposit of that waste, may enter any waters in the Mackenzie Valley.

Discharge - a direct or indirect deposit or release of any Water or Wastewater to Water the Receiving Environment.

Effluent - a Wastewater Discharge.

Freeboard - the vertical distance between the Water or Wastewater line and the lowest elevation of the effective Water or Wastewater containment crest on the upstream slope of a containment structure.

Greywater - all liquid Waste from showers, baths, sinks, kitchens, and domestic washing facilities, but does not include Toilet Waste.

Receiving Environment – the natural environment[1] that, directly or indirectly, receives any deposit of Waste from a Project.[2]

Sewage – all Toilet Wastes and Greywater.

Sewage Disposal Facilities or Sewage Treatment Facilities – the area(s) and structures designated to contain and treat Sewage.

Sludge - the residual, semi-solid material that is produced as a by-product during treatment of Sewage.

Toilet Wastes – all human excreta and associated products, not including Greywater.

Waste – as defined in section 1 of the Waters Act:
a) a substance that, if added to water, would degrade or alter or form part of a process of degradation or alteration of the quality of the water to an extent that is detrimental to its use by people or by an animal, fish or plant, or

[1] "environment" is defined in section 2 of the MVRMA as: the components of the Earth and includes
(a) land, water and air, including all layers of the atmosphere;
(b) all organic and inorganic matter and living organisms; and
(c) the interacting natural systems that include components referred to in paragraphs (a) and (b).
[2] Where a project is located in a previously disturbed area, a licence and/or permit may include a project-specific definition of 'receiving environment.'

b) water that contains a substance in such a quantity or concentration, or that has been so treated, processed or changed, by heat or other means, that it would, if added to other water, degrade or alter or form part of a process of degradation or alteration of the quality of that water to the extent described in paragraph (a), and includes
c) a substance or water that, for the purposes of the Canada Water Act, is deemed to be waste, d) a substance or class of substances prescribed by regulations made under subparagraph 63(1)(b)(i),
e) water that contains a substance or class of substances in a quantity or concentration that is equal to or greater than a quantity or concentration prescribed in respect of that substance or class of substances by regulations made under subparagraph 63(1)(b)(ii), and
f) water that has been subjected to a treatment, process or change prescribed by regulations made under subparagraph 63(1)(b)(iii).

Wastewater – any Water that is generated by Undertaking activities or originates on-site, and which contains Waste, and may include, but is not limited to, Runoff, Seepage, Sewage, and Effluent.

Water – as defined in section 1 of the Waters Act: water under the administration and control of the Commissioner, whether in a liquid or frozen state, on or below the surface of land.

1.0 What is the Purpose of these Guidelines?

The purpose of this document is to provide recommendations and outline expectations for municipal staff regarding the monitoring and management of sewage sludge in the Northwest Territories (NWT).

2.0 What is Sludge?

2.1 Passive Sewage Treatment Systems

Most sewage waste treatment systems in the NWT use passive treatment in lagoon cells or retention ponds before discharging effluent[3] to the receiving environment. In passive treatment systems, sewage is typically pumped or trucked to natural or engineered lagoons where it is retained for treatment before being discharged to the receiving environment. To treat sewage, it generally needs to be kept in the lagoon for a particular length of time. Treatment occurs through several processes: the removal of solids by settling or filtration, the biodegradation of organic matter by microorganisms, and the ultraviolet disinfection of microorganisms by sunlight. Lagoons are generally operated in one of two ways: periodic discharge (Figure 1) or continual discharge (Figure 2).

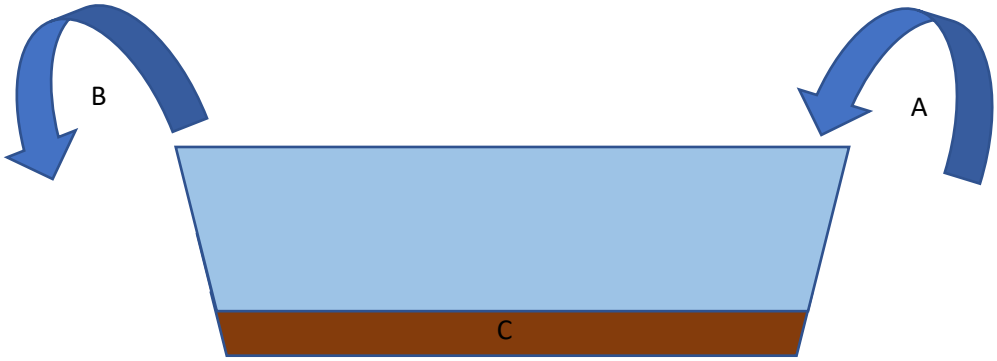


Figure 1 - Lagoon with Periodic Discharge. Sewage is pumped or piped into the lagoon (A) and retained for a long period of time until the lagoon is fully decanted (B). Sludge (C) generally accumulates on the bottom surface of the lagoon in these systems.

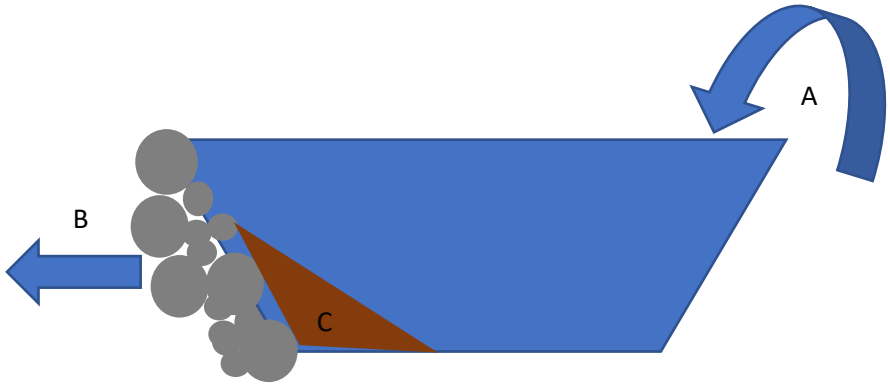


Figure 2 - Lagoon with Continual Discharge. Sewage waste is pumped or piped into the lagoon (A) and continuously flows out (B) of the system. Discharge can take place through a pipe, cobble berm, or other outlet structure. Some continually flowing systems discharge into the ground through an "exfiltration" pit. Sludge (C) can accumulate in continually flowing systems.

[3] The discharge of effluent from a lagoon/sewage treatment system is considered a deposit of waste.

As shown in Figure 1 Figure 2, most sewage treatment systems accumulate solids over time. These solids are known as sludge.

2.2 Sludge Accumulation in Passive Sewage Treatment Systems

While treatment systems are often designed to allow a certain volume of sludge to build up within the lagoon (Figure 1 and Figure 2), it is important to maintain a minimum volume of liquid sewage above the sludge level for treatment. Systems also require that a minimum freeboard (the distance between the lagoon surface and the berm height) is maintained so that there isn't a risk of the lagoon over-flowing. Therefore, at some point, the maximum sludge volume is reached, and sludge should then be removed, in order to maintain a minimum operational volume for effective sewage treatment in the lagoon (Figure 3). Sludge volume and accumulation must be monitored periodically to ensure that sewage treatment is not being compromised by sludge depth.

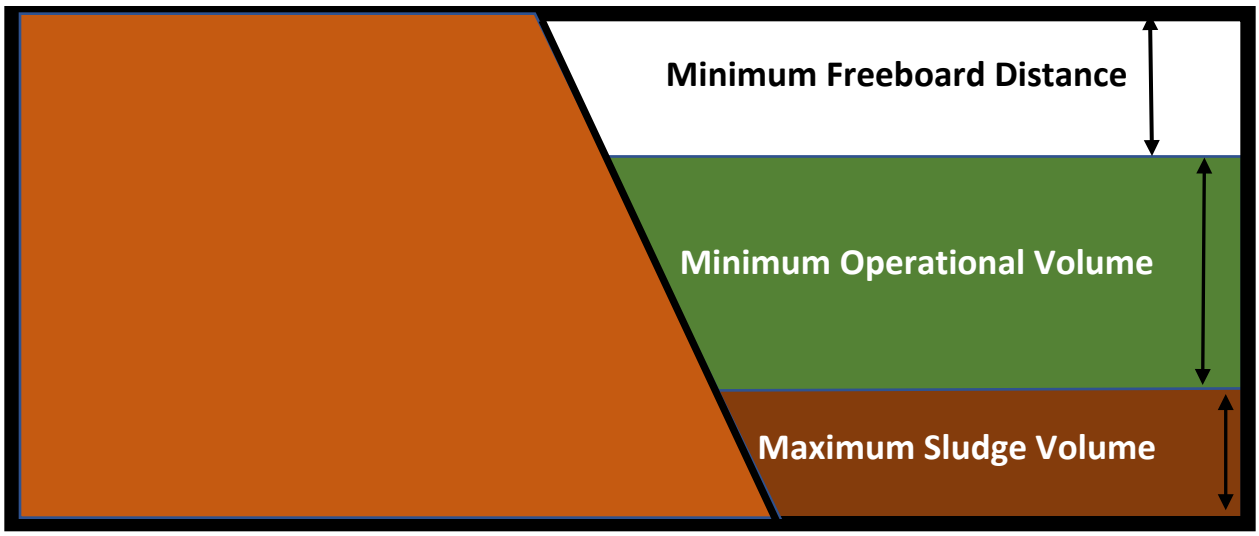


Figure 3 - Maximum Sludge Storage Volume. Lagoons typically have thresholds for accumulated sludge so that an operational volume of sewage and freeboard can be maintained.

2.3 Sludge Management

Sludge is a concentrated form of sewage, and by definition, a waste. It contains high levels of solids, microorganisms, organic matter, nutrients, and possibly other constituents like metals and emerging contaminants such as pharmaceuticals. Therefore, sludge needs to be properly managed, and before sludge is removed from a sewage treatment system, a municipality must have a plan to manage, and either re-use or dispose of, the sludge properly. This document provides guidance on how to develop this plan.

3.0 How is Sludge Monitoring and Management Regulated in the NWT?

In the NWT, a water licence is required for the deposit of municipal waste above certain thresholds (in accordance with the *Waters Regulations*). Most municipalities in the NWT have a water licence, issued by their regional Land and Water Board in the Mackenzie Valley or the Inuvialuit Water Board (Board) in the Inuvialuit Settlement Region. These water licences generally include conditions on how sewage, including sludge, must be managed and disposed of. Once a water licence is issued to a community, a Water Resource Officer (Inspector) with the Department of Environment and Natural Resources (ENR), Government of the Northwest Territories (GNWT) is responsible for ensuring the licensee complies with the conditions of a water licence.

3.1 Operation and Maintenance Plan

Municipal water licences generally require that sewage disposal facilities, which include sewage treatment systems and sludge management, have an up-to-date operation and maintenance (O&M) plan that reflects current practices. This plan is generally publicly reviewed and considered for approval by the Board. Typically, a municipality's methods for monitoring sludge are included in an O&M plan.

3.2 Sludge Management Plan

When a municipality needs to manage sludge (i.e., a minimum of 1 year prior to proposing to remove the sludge from the treatment system for treatment, possible re-use, and/or disposal), a sludge management plan must be submitted to their respective Board for approval. Talking with Board staff should start well before this submission to ensure all required information is included in the plan. Ample time is required for Board staff to check the plan for completeness prior to posting it for a public review. The municipality must then respond to any public review comments prior to Board staff bringing the plan to the Board for approval. Based on reviewer comments and the Board's decision, the plan may need to be revised and possibly be publicly reviewed again. Table 1 includes the typical requirements for a sludge management plan.

Table 1 - Sludge Management Plan Requirements

Item	Sludge Management Plan Requirement
Project Schedule	• Describe the predicted timeline for sludge removal, treatment, and re-use/disposal.
Removal Method	• Describe how the sludge will be removed, including equipment mobilized, staging areas used, and methods for ensuring the receiving environment will not be impacted by the activity.
Treatment Method	• Describe the method(s) being proposed for the treatment of sludge, including methods to ensure that the surrounding environment will not be impacted by the treatment method. • Note that any engineered structures may require the submission of a design and construction plan for public review and Board approval prior to construction, depending on water licence requirements. • Design and as-built drawings may need to be submitted pre- and post-construction.
End-Use	• Propose the intended end use(s) of the treated sludge, and the criteria by which the sludge will be deemed appropriate for re-use or disposal. • Include sampling methods for analyzing sludge quality
Contingencies	• Include any contingencies that are in place if the proposed methods for removal and/or treatment do not go as planned.

4.0 How is Sludge Monitored?

Monitoring sludge depth in municipal sewage treatment systems is important to help communities:

(a) understand how well a sewage treatment system is working; and

(b) plan for any future management, treatment, re-use, and disposal of sludge.

As discussed in Section 2.0, most sewage waste treatment systems in the NWT are designed to filter or settle out sewage waste solids as part of the sewage waste treatment process (Figure 1 and Figure 2), sludge accumulates over time. Most systems are designed to allow sludge to build up and can continue operating for a number of years without sludge accumulation impacting operations or sewage waste treatment. However, after a period of time, sludge may build up to a level where there isn't enough volume for proper treatment to occur (Figure 3).

As shown in Figure 4, a municipality can use sludge monitoring as one tool to assess whether the sewage treatment system is properly treating sewage. Sludge accumulation can be determined by directly measuring sludge depth, volume, and/or accumulation. Alternatively, the impact of sludge accumulation can be monitored indirectly by assessing the treatment efficacy and effluent quality of the sewage treatment system. If there isn't enough operational room for sewage treatment, poor effluent quality may result. If sludge or effluent monitoring indicates that sludge depth is becoming problematic, a sludge management plan must be developed.

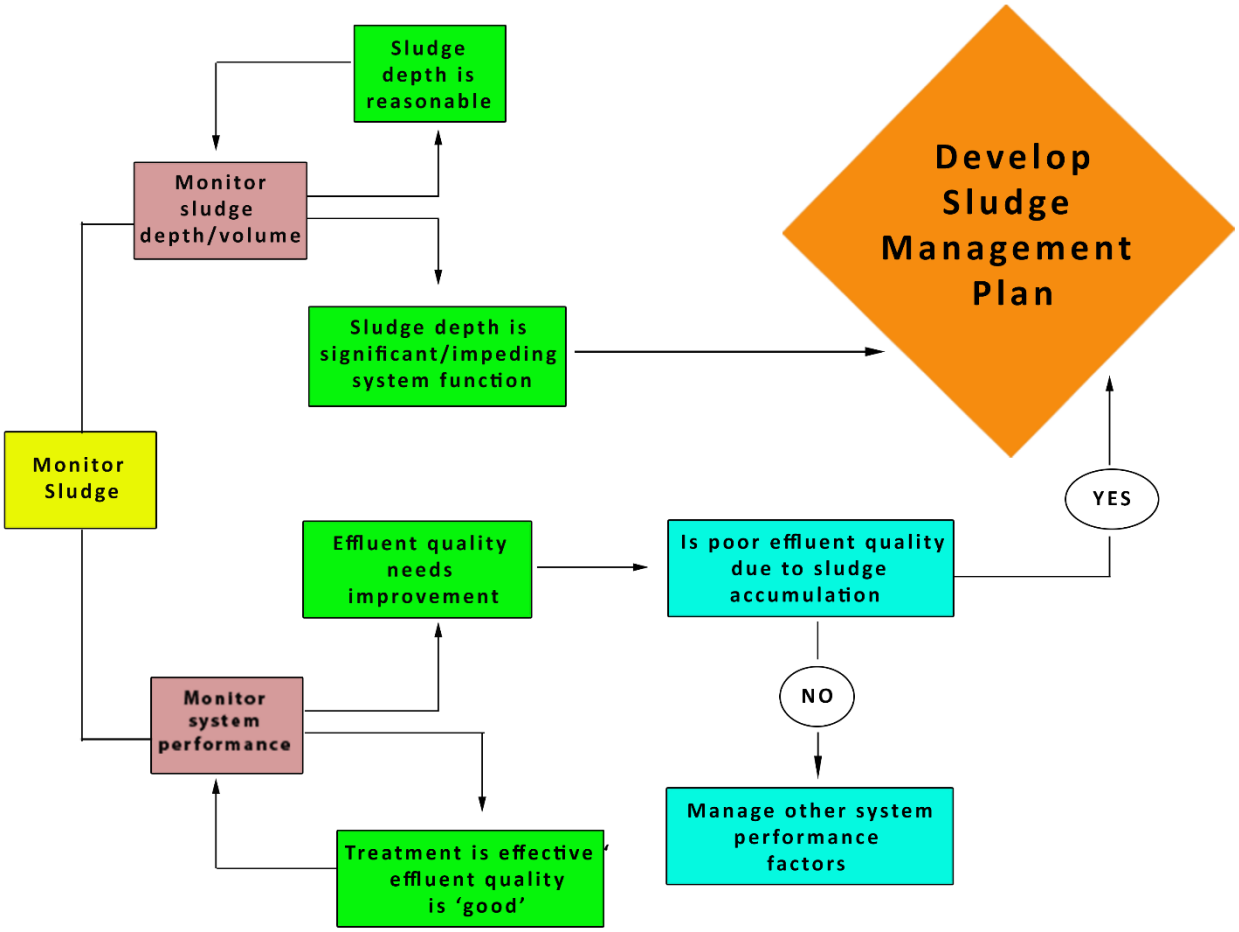


Figure 4 - Decision Matrix for Monitoring Sludge and Assessing Sewage Waste Treatment.

4.1 Sludge Depth Monitoring

In sewage treatment systems that are designed to settle out solids and accumulate sludge, sludge depth should be monitored on a regular basis. Periodically monitoring the depth of sludge enables a municipality to understand several aspects of the treatment system is, including:

(a) how quickly sludge is accumulating over time;

(b) how much volume remains available for retention and treatment of sewage above the sludge layer; and

(c) how soon sludge may have to be removed.

There are different ways to monitor sludge depth, depending on a community's access to the sewage treatment system, the configuration of the system, and the training level of staff. Some of the options for sludge depth monitoring include, but are not limited to, the following.

Sludge Judge

The Sludge Judge® (Figure 5) is a popular and inexpensive way to monitor sludge depth and volume. It consists of a long clear PVC pipe with a flap foot valve on the bottom. When it is lowered into a lagoon cell, the foot valve causes the liquid level inside the pipe to drop relative to the water level outside the pipe, allowing the depth from the water level to the sludge blanket to be recorded. Sludge depth can be alternatively measured by pushing the sludge judge to the bottom of the lagoon floor, which also shows the depth of sludge. A detailed description of how to use the Sludge Judge® for depth and volume measurements is included in Appendix B.

Figure 5 - Sludge Judge®.

Source: https://www.wateronline.com/doc/sludge-judge-0001

Secchi Disk

A Secchi disk (Figure 6) is a black-and-white-coloured disk on a rope that is usually used to monitor water clarity. However, it can be used to monitor the distance between the water surface and the top layer of sludge by lowering the disk until it meets resistance at the top of the sludge blanket. This or any other weighted disk on a rope can be used to assess a very approximate measurement between the water surface and the top of the sludge blanket.

Figure 6 - Secchi Disc.

Source: https://magnoliafisheries.com/secchi-disk-explained/

Infrared Sensors

Several types of infrared sensors for sludge depth monitoring exist, like the Sludge Gun® shown in Figure 7. These sensors are used to calculate the distance between the water surface and the top layer of sludge. These instruments can be expensive and can also be less accurate when the lagoon contains a high concentration of solids.

Figure 7 - Sludge Gun®.

Source: https://sludgecontrols.com/our-products/portable-sludge-level-detector/

Sonar

Some communities have used fish/depth-finder technologies for determining sludge depths. These consist of wireless sonar devices, controlled from a smartphone or tablet. This type of device (Figure 8) allows various sludge-depth profiles to be created for a lagoon system from the safety of the shore. From a health and safety perspective, these are the best option for sludge measurements, as they don't require staff to boat on the lagoon.

Figure 8 - Wireless Sonar Depth Finder.

Source: https://store.vexilar.com/sonarphone-w-transducer-t-pod-phone-not-included.html

4.2 Sludge Accumulation Monitoring in Filtration or Flowing Systems

Some municipal sewage treatment systems continually filter sewage through an exfiltration trench or berm (Figure 2). These systems should be visually monitored to ensure that sludge is not plugging the trench/berm and that liquid sewage is still able to flow. If the trench/berms are periodically bare during operations, these systems should be sprayed down to loosen the sludge, or if a very thick blanket develops, sludge may have to be removed mechanically and then managed.

4.3 Water Quality Monitoring

Monitoring effluent quality from a sewage treatment system may provide information regarding how well the system is treating sewage, and therefore whether the sludge needs to be managed. Most municipal water licences in the NWT include a Surveillance Network Program (SNP) that requires the community to sample and monitor the quality of effluent from the sewage treatment system. If enough sludge builds up, the quality of sewage effluent may show a significant decline (i.e., have higher concentrations of solids and/or organic matter than usual) for two reasons. Either (1) the system does not have enough volume and/or retention time to physically and biologically treat sewage, or (2) a continual-discharge location is blocked by sludge. It should also be noted, as shown in Figure 4, that sludge accumulation may not be the only reason for poor treatment performance in a passive treatment system; sludge management must only be conducted when it is confirmed to have accumulated to (or will soon accumulate to) a problematic level that affects treatment.

4.4 Health and Safety

While it is important to monitor sewage treatment and sludge, the health and safety of municipal staff should be prioritized. Less-intrusive (i.e., on-shore) monitoring options should be prioritized, favouring remote monitoring whenever possible. The frequency of monitoring should be chosen depending on how well the treatment system is performing and how fast sludge is accumulating.

Staff should take these health and safety precautions before conducting any monitoring of a sewage treatment system:

- Have up-to-date immunizations that are recommended for working near domestic sewage;
- Wear proper personal protection equipment (PPE – see Figure 9) while monitoring is conducted, including but not limited to, full-body protection from biological and chemical hazards (i.e. boot covers, full suit, gloves, face, eye and mouth protection);
- Dispose of PPE properly, and clean clothing thoroughly post-monitoring; and
- Clean equipment after using.

Figure 9 - Personal Protective Equipment (PPE) for Working near Sewage.

Source: https://www.broadbentinc.com/employee-health-safety-highest-priority-broadbent

5.0 How is Sludge Managed and Treated?

5.1 Planning for Sludge Management

Figure 4 illustrates how a municipality may reach a point where they should start to plan to remove and treat sludge. Figure 10 illustrates the planning, regulation, and implementation of a sludge management plan. As discussed in Section 3.0, municipalities should communicate early and often with their respective Board staff and Inspector to ensure that all necessary considerations are made related to the options for sludge removal, sludge treatment, and sludge re-use; all aspects of the sludge management plan must be approved by the respective regional Board in advance of the scheduled work.

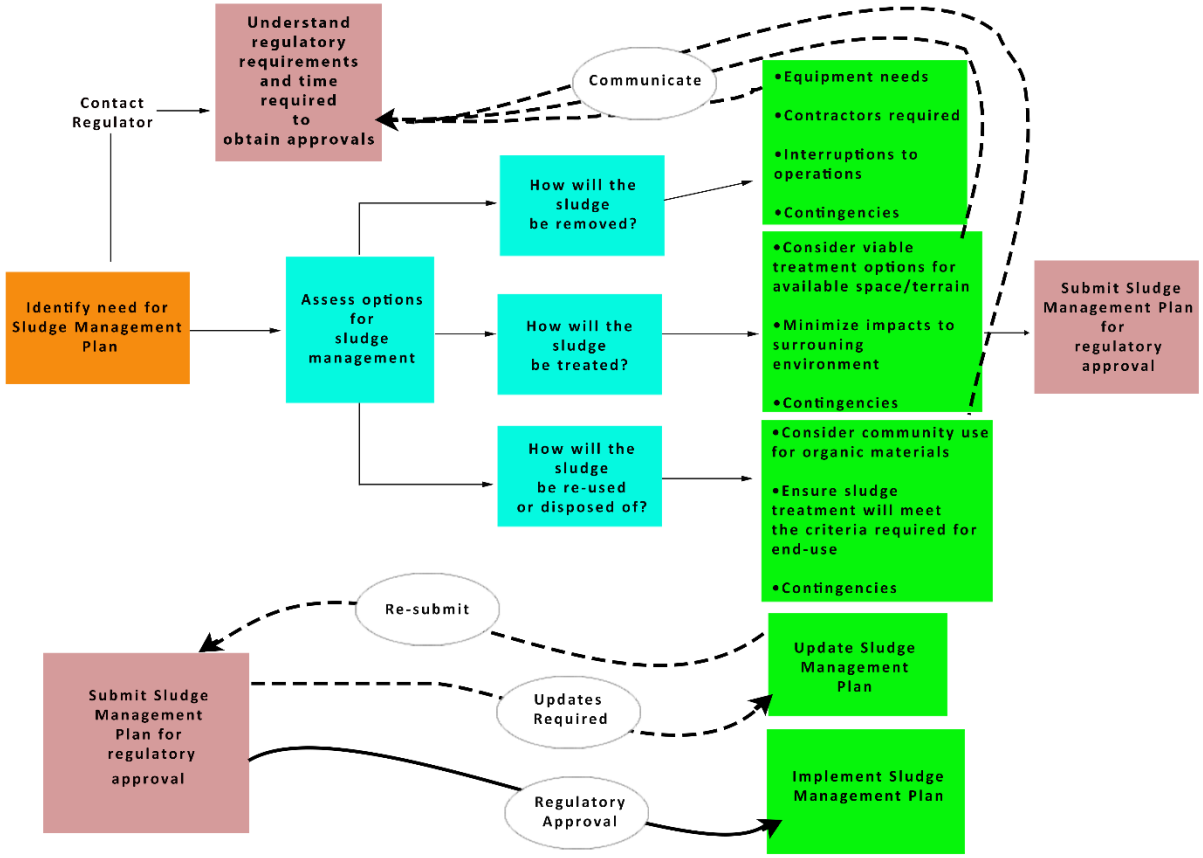


Figure 10 - Development of a Sludge Management Plan

Once removed from a sewage treatment system, sludge must be properly managed and/or treated, if required.

5.2 Sludge Treatment

The NWT does not have specific requirements for how sludge must be managed and/or treated, and there are a variety of ways this can be done. A municipality can propose a way to manage and/or treat sludge in a sludge management plan, as long as it meets the requirements of their respective Board. Sludge must always be managed and treated in a way that ensures the surrounding environment (i.e., the quality of surface water and/or groundwater nearby) will not be adversely affected.

One of the primary goals of sludge management is to dewater or dry the sludge. This can be accomplished using various techniques such as drying pits, composting, landfarming, or using drying or separating technology, such as geotubes. Ideally, removing water from the sludge should happen in an area adjacent to the sewage treatment system, so that any water draining from the sludge runs back to the main lagoon system. This is because the water contains components that could impact the surrounding environment.

If required, the level of treatment will depend on how the community intends to re-use or dispose of the sludge. In some cases, sludge might simply be removed from the lagoon and then disposed of. In other cases, a community might identify a use for sludge, such as landfill cover, in which case it must be treated to meet certain quality criteria.

5.3 Sludge Re-Use

Treated sludge may be a useful resource for a community because it can be used as organic material and/or land cover. A municipality can propose to re-use treated sludge for a variety of applications that suit their needs and meet applicable regulations. Generally, and depending on the final use, re-used sludge should meet:

- The remediation criteria in the *Government of the Northwest Territories' (GNWT) Environmental Guideline for Contaminated Site Remediation*; and
- The criteria for Fecal coliforms and Salmonella in *the Canadian Council for Minister's of the Environment Guidelines (CCME) for Compost Quality*.

The GNWT Environmental Guideline for Contaminated Site Remediation include the criteria that numerous parameters must meet, for a variety of end-uses. For example, sludge used in an industrial application (i.e., landfill cover) would have to meet less stringent criteria than if it were to be used on an agricultural area. The proposed end-use and associated criteria must be approved in a sludge management plan, or stipulated in the conditions of a water licence.

Sludge analysis should include, but not be limited to the following parameters, depending on the end-use:

- Petroleum hydrocarbons F1-F4;
- Ammonia + ammonium;
- Fecal coliform;
- E. coli;
- Salmonella;
- Mercury;
- Total metals;

- Nitrate; and
- Total Kjeldahl nitrogen.

Additional analyses may be required, depending on site-specific conditions in a municipality. If treated sludge does not meet the criteria, as specified in an approved sludge management plan or conditions of a water licence, it must be further treated until criteria are met. Otherwise, sludge must be disposed of as specified by regional regulators.

APPENDICES

Appendix A: Resources for Municipal Sludge Management

Canada-Wide Approach for the Management of Wastewater Biosolids
(https://ccme.ca/en/res/biosolids_cw_approach_e.pdf)

Guidance Document for the Beneficial Use of Municipal Biosolids, Municipal Sludge and Treated Septage
(https://publications.gc.ca/collections/collection_2013/ccme/En108-4-56-2012-eng.pdf)

Sonar Sludge-Depth Measurement
www.aquaclear.com

Waters Act
https://www.justice.gov.nt.ca/en/files/legislation/waters/waters.a.pdf

Government of the Northwest Territories' Environmental Guideline for Contaminated Site Remediation

https://www.enr.gov.nt.ca/sites/enr/files/guidelines/siteremediation.pdf

Canadian Council for Minister's of the Environment Guidelines for Compost Quality

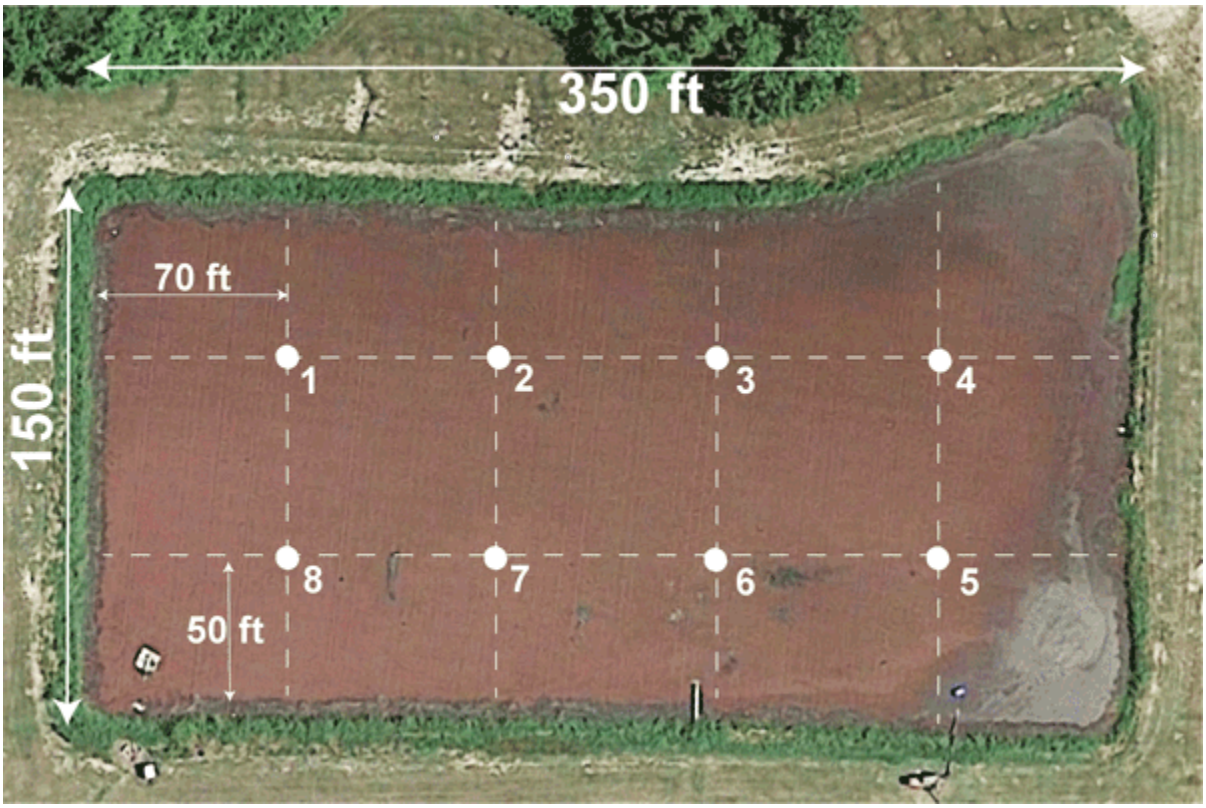
https://ccme.ca/en/res/compostgdlns_1340_e.pdf

Appendix B: Instructions for Using a Sludge Judge

A Sludge Judge® or sludge measuring tube is a clear plastic tube with measurement markings and a check valve on the bottom. It generally comes in 5-foot sections that can be attached together so that it's long enough for the lagoon depth.

Measurement Layout:

Sludge depth measurements should be taken based on a grid format and should be taken in the same locations each year. The bottom surface area of the lagoon must be estimated, and an estimate of acreage produced. Then, the number of required sludge depth sampling locations can be determined. It is recommended that the sampling locations are marked with survey flags or distinct landmarks.



Ideally a sewage lagoon will have a stationary point over the lagoon that will allow sludge depth measurement from land; however, many lagoons require entering the lagoon with a boat to sample over the sludge.

Health and Safety:

To prepare for sludge depth measuring, you will need:

- A boat (a flat bottom boat is more stable than a canoe or V-bottom boat);

- Appropriate personal and functional floatation devices (PFDs) for each sampling team member;
- Sludge Judge, sludge measuring tube, or a similar measuring device (ensure that the check valve is operating properly);
- A solid, long rod or pole with measured increment markings beginning at zero to measure total depth from top of water level to bottom of the lagoon (note: the Sludge Judge could also be used for this purpose);
- Appropriate Personal Protective Equipment (PPE) which includes but is not limited to latex or nitrile gloves, CSA certified rubber boots, coveralls, safety goggles, etc.; and
- Notebook and pen to record measurements for each sampling location.

There must be at least one person on the shore of the sewage lagoon at all times with a throwable flotation device that is connected to a line. Also, staff should have a charged cellphone with signal reception to request emergency assistance if required. It is recommended to have two people in the boat, one person to anchor the boat and record data and another person to use the sludge measurement tube to determine measurements. All individuals must be wearing functional floatation devices and appropriate personal protective equipment.

Weather Conditions:

Sludge depth measurements should be taken during optimal weather conditions after the sewage lagoon has completely thawed. depth measurements should be taken during the summer, after the lagoon has completely thawed. A calm day with stable weather conditions (wind, rain, etc.) will help with the process.

A team of three people should work to take measurements:

1. One person to stay on the shore to watch and act as a rescuer if needed (See A, Figure 11);
2. The second to be in the boat, to stabilize it and record depth measurements (See B, Figure 11); and
3. The third to also be in the boat to use the Sludge Judge and measuring rod to take measurements (See C, Figure 11).

All team members, including those on shore, should wear appropriate flotation devices.

Conducting Measurements:

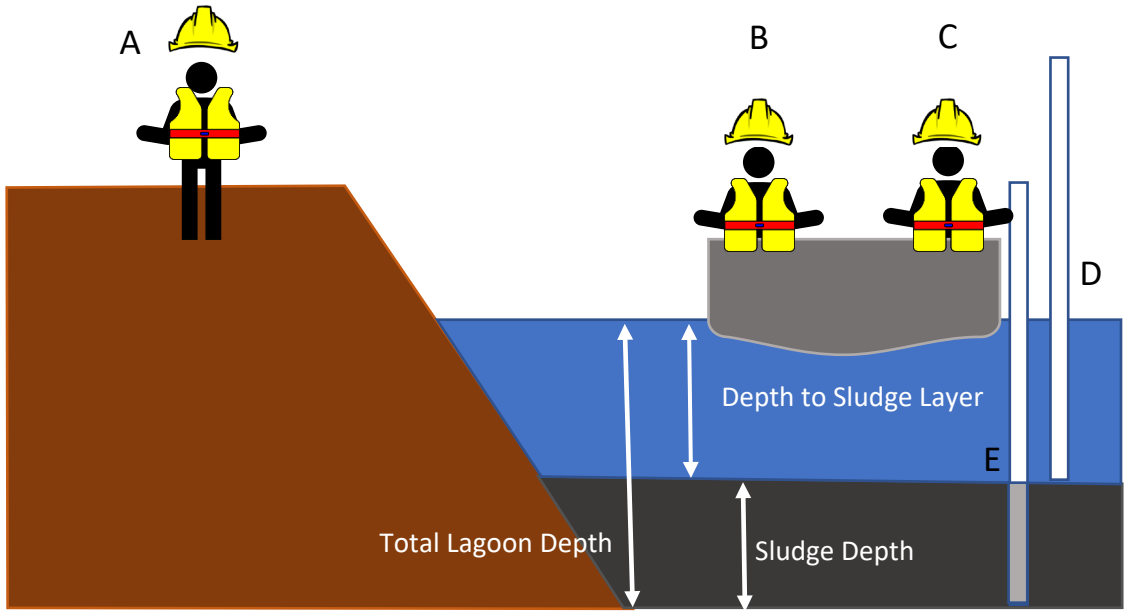


Figure 11 - Conducting Sludge Measurements with a Sludge Measuring Tube

To take accurate depth measurements, follow these instructions:

1. Proceed to the first sampling location. Ensure that this location is properly documented.
2. Lower the sludge measurement tube into the sewage lagoon slowly without moving the tube up and down. Carefully observe the liquid level in the measurement tube as it is lowered, when the tube has reached the sludge layer, the liquid level inside the tube will drop slightly below the liquid level outside the tube (See D, Figure X).
3. Pull on the rope of the sludge measurement tube to secure the check valve and remove the tube from the sewage lagoon.
4. Using the increment markings on the sludge measurement tube, record the depth from the surface of the liquid to the top of the sludge layer. Note that there should be 1 to 2 inches of sludge at the bottom of the tube which ensures that the sludge layer has been reached.
5. Insert the pole vertically at the same location. The marked increments at the end of the pole that is inserted into the lagoon should begin at zero. Push the pole through the sludge layer until the bottom of the sewage lagoon is reached and record this depth (See E, Figure X).
6. Subtract the depth of the liquid layer from the total depth of the sewage lagoon. This is the thickness of the sludge layer.
7. Repeat Steps 2 through 6 for the remainder of the sampling locations.

If no solid, long rod or pole is available for Step 5, the sludge measurement tube may be used. However, it should be noted that this alternative method is not as accurate.

1. Insert the sludge measurement tube vertically at the same location.
2. Once the bottom of the sewage lagoon is reached, pull on the rope of the sludge measurement tube to secure the check valve and remove the tube from the sewage lagoon.
3. The distance from the bottom of the tube to the top of the sludge is the sludge layer thickness.
4. Record this measurement.

Record Keeping:

Records should be kept of all measurements for reference. An example form is provided on the following page.

Lagoon I.D.:			
Completed by:			
	Name	Signature	Date
(A)	(B)	(C)	(C) minus (B)
Grid Point No.	Distance from Liquid Surface to Top of Sludge	Distance from Liquid Surface to Lagoon Bottom (Soil)	Thickness of Sludge Layer
	(cm)	(cm)	(cm)
1			
2			
3			
4			
5			
6			
7			
8			
9			